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AN OVERVIEW OF SUGARCANE: PRODUCTION, HARVESTING, BENEFITS, PRESERVATION, AND VALUE-ADDED PRODUCTS

Anju Rimal[1], Bishal Thagunna[2] and Jaspreet Kaur*[3]

[1,2]Pokhara Bigyan Tatha Prabidi Campus, Pokhara/ Nepal.
[3]RIMT University, India.

***Corresponding Author: Jaspreet Kaur**
RIMT University, India.

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ABSTRACT

Sugarcane juice also known as common man's drink and is widely consumed as a refreshment energy drink, and popular drink in Southeast Asia, South Asia and Latin America. Sugarcane juicecompetes with other soft drinks in the market pushed by health-conscious consumers, and the sugarcane growers profit financially. Sugarcane juice is a popular beverage rich in phenols, flavonoids, and other radical scavenging compounds. Sugarcane juice is high in nutrients because it contains natural sugars, minerals such as iron, magnesium, phosphorus, and calcium, and organicacids such as malic acid, succinic acid, acotinic acid, amino acid, protein, starch, gums, waxes, andnon-sugar phosphatides. Despite this numerous health benefits, it still underutilized in product formulation. The left over or waste (baggage) during the extraction of sugarcane juice is used for the manufacturing of biscuits. In this review various nutritional, health benefits, spoilage, preservation technique and product formulation from sugarcane juice is presented in order to maximize juice use in the future.

KEYWORDS: Global status, nutritional composition, preservation, spoilage, health benefits, and value-added products.

INTRODUCTION

Sugarcane is known worldwide for its high productivity, participation in high-tech processes, and high-quality raw material, and has undergone various changes throughout history (De Matos et al., 2019). Sugarcane (Saccharum officinarum Linn.) is a well‑known crop of the family Poaceae (Singh et al., 2015), received extensive attention as an alternative source of energy, biofuels, and biomaterials, as well as a food crop in rural areas. (Aguilar-Rivera et al., 2012). Saccharum comes from the Greek word 'Sakcharon,' which implies sugar, particularly sucrose. S. officinarum Linn is a tropical South Asian and Southeast Asian perennial grass (Singh et al., 2015).

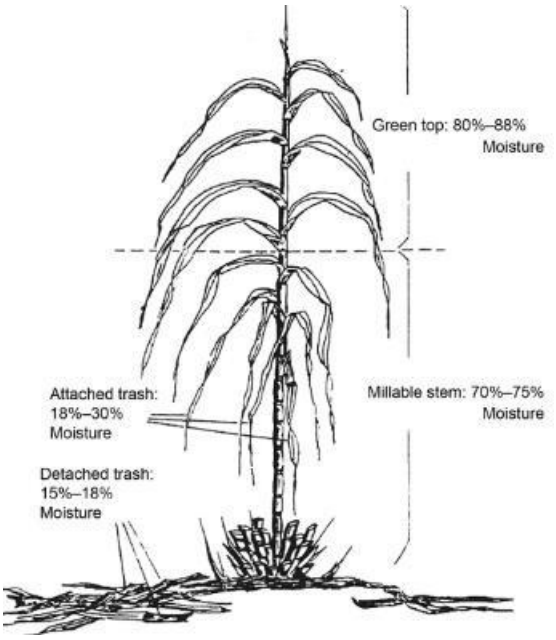

Figure: 2.1: Sugarcane plant (De Matos et al., 2019).

Cane, also known as chewing cane or noble cane, has a thick longitudinal stalk about 3 to 5 meters high and approximately 5 cm wide and is known for its sweet taste made possible by its high sucrose content (Mohan, 2017). It requires a well-drained soil of pH 7.5 - 8.5, with

high organic matter and a hot, humid environment. (Singh et al., 2015).

Production and Harvesting of sugarcane

Sugarcane (Saccharum officinarum L.) is an ancient human energy source. The world's sugarcane- growing countries are located between 36°N and 31°S latitude on the equator, spanning tropical and subtropical zones. Sugarcane is grown on 20.42 million ha in 107 countries, with a total production of 1333 million tons (Muhammad, 2005). Brazil is the world's top producer of sugarcane, followed by India and China. Thailand is the world's fourth-largest sugarcane grower in 2012 and 2013, producing 96.5 and 100 million tons of sugarcane, respectively (Pongpat et al., 2017). Harvesting of sugarcane is an essential part of the sugarcane production system (Ma et al.,2014). In many countries, sugarcane is harvested after 10-11 months (Krishnakumar and Chellamuthu, 2013). Sugarcanes were cut approximately 1 inch above the field surface and the stems were harvested at an average height of 20 inches.

Extraction of Sugarcane Juice

Sugarcane juice is extracted by crushing it between three roller crushers, filtered, (Krishnakumar & Chellamuthu, 2013) and served with or without ice (Na et al., 2013).

Sugarcane juice is a popular drink in Southeast Asia, South Asia, Latin America, and other places where sugarcane is commercially farmed (Karmakar et al., 2011). It is also known as the commonman's drink and is widely consumed as a refreshment energy drink, and is available everywhere of local market (Ali et al., 2015). Sugarcane juice is a vital commodity in the global market because it provides immense health benefits. In today's health-conscious and consumer-driven market, it competes with other soft drinks, and sugarcane farmers reap the economic benefits (Kaavya et al.,2019).

Figure: 1.1 Sugarcane juice (Ma et al., 2014).

Nutritional Value

Sugarcane juice is an important natural health drink in subtropical and tropical countries (Kaavya et al., 2019). Sugarcane juice is a popular beverage rich in phenols, flavonoids, and other radical scavenging compounds (Tarafdar, Kumar, et al., 2021). Sugarcane juice is high in nutrients because it contains natural sugars, minerals such as iron, magnesium, phosphorus, and calcium, and organic acids such as malic acid, succinic acid, acotinic acid, amino acid, protein, starch, gums, waxes, and non-sugar phosphatides.(Singh et al., 2012).

Table: 1 Nutritional value of sugarcane juice.

Water	Total sugar	Non-reducing sugar	Reducing Sugar	Ascorbic Acid	Iron	pH	Acidity	Total carbohydrate	carotene	Crude fiber	Ash	Fat	Protein	Reference
82.91%	16.328%	–	0.50%	3.39 mg/100ml	–	–	–	9.23 gm/100ml	–	–	–	–	–	(Sankhlaet al., 2012)
75-85	19.5	10-21%	0.3-3.0%	1.25mg/100gm	10mg	4.35	0.128%	–	6 µg	–	–	–	–	(Khare etal., 2012)
80-81.70%	17.6-19.0%		0.207 0.65%	–	–	5.28-5.54	0.24-0.39%	–	–	13.24 - 16.62 %	0.28 - 0.48 %	0.14 - 0.19 %	0.39 - 0.60 %	(Chauhanet al., 2002)
80.5-81.7%	–	59.14 – 63.18 %	4.36–5.43 %	6.05–6.16 mg/100g	–	5.1–5.4	0.13–0.18 %	–	–	–	–	–	–	(Suman etal., 2014)
	–	59.14 – 63.18 %	4.36–5.43	6.05–6.16 mg/100g	–	5.1–5.4	0.13–0.18 %	–	–	–	–	–	–	(R. K. Singh et al., 2012)
	–	10%–21%	0.3%–3%	–	–	–	–	–	–	10%–15%	0.2 %–0.6%	–	–	(Arif et al., 2019)

Health Benefits

Sugarcane juice contains natural sugars, minerals, and organic acids, which are nutritious and have a variety of medicinal properties. It strengthens the stomach, kidneys, heart, eyes, brain, and sex organs. (Sankhla et al., 2012). The juice of sugarcane is used as a remedy for jaundice (Karmakar et al., 2011), and is regularly consumed along with lemon juice by hepatitis patients (Ali et al., 2015). Sugarcane juice has a wide range of therapeutic characteristics, and it is frequently used in traditional medicine to treat jaundice. Sugarcane juice is beneficial for infrequent urination, as it keeps the urine flow clear and aids kidney function. 100 mL sugarcane juice contains 40 kcal of energy. (Na et al., 2013). According

to Khare et al. (2012), Sugarcane juice is rich in enzymes andhas many medicinal properties, such as reducing sore throats, colds, and flu, lowering glycemic index, and having no simple sugars, so diabetics patient enjoy this one drink without fear. Moreover, it is excellent for replacing aerated drinks and cola, as it instantly refreshes and energizes the body when exposed to heat and physical exertion.

Using sugarcane juice, radish juice, and herbs, (Kaur et al., 2018) investigated the preparation of a nutritional beverage. The most significant effect on the quality features of the radish beverage occurred from sugarcane juice, as it is already a potential preventative and healing source of nutrients. (Singh et al., 2012) Drinking sugarcane juice provides numerous health advantages, including cancer prevention, fight against prostate, an anti-breast cancer cell activity, and strengthening the kidneys, stomach, eyes, brain, heart, and sex organs. It also aids in the treatment of febrile illnesses such as fevers that cause significant protein loss. (Panigrahi et al., 2021), Sugarcane has been popularly referred to as "noble cane." It has a wide range of biological effects, including extending natural immunity against infections. It also includes a substantial amount of chlorophyll (1 mg/100 ml), making it one of the most promising anticancer, odor suppressor, and wound healer substances.

Spoilage of Sugarcane Juice

Despite the numerous advantages of sugarcane juice, its perishable nature offers obstacles in terms of stability, marketing, shelf life, and processing. This is owing to its high sugar content, which makes it an attractive source of energy for pathogenic microorganisms. The lactic acid bacterium (Leuconostoc mesenteroides), deteriorative enzymes, and fermentation by yeast and mold, as wellas other pathogens, are the three principal problems in sugarcane juice processing.(Tarafdar et al., 2021). Sugarcane juice is typically obtained by squeezing it, so improper washing of sugar cane leads to contamination and a high risk of microorganisms. These microbial contaminants have beenattributed to unclean handling of raw cane, inadequate cleaning of clothing, surfaces, ice, vendor hands, and airborne contamination causing nausea, vomiting, typhoid, abdominal cramps, and diarrhea (Ali et al., 2015).

Table: 2 Spoilage causing micro-organism.

Micro-organisms	Causes	References
Salmonella and E.coli	Unclean handling, improper cleaning ofsugarcane, inadequate cleaning of cutting items. Symptoms are Nausea, vomiting, abdominalcramps, diarrhea and typhoid	(Ali et al., 2015)
Leuconostoc mesenteroides	Sugarcane juice's viscosity changes duringstorage.	(Kohli et al., 2019)
Sacchar-omyces cerevisiae	Develop unwanted products	(Kohli et al., 2019)
Polyphenol oxidase	Causes browning	(Kohli et al., 2019)
Polyphenol oxidase	Discoloration, sedimentation during storage	(Chauhan et al., 2002)
Peroxidase and polyphenol oxidase	Enzymatic browning	(Bucheli and Robinson, 1994)
PPO and POD	Browning of juice	(Tarafdar et al., 2021)
Sucrose neutral invertase (SNI)	Breakdown of sucrose into glucose and fructose	(Tarafdar et al., 2021)

In (Ali et al., 2015), study, forty samples of sugar cane juice were analyzed for total plate count, total coliform bacteria, fecal coliform bacteria, Escherichia coli, yeasts, and molds from Peshawar City, Pakistan. The findings revealed that sugar cane juice sold on the street in all of the towns was hygienically unfit, as evidenced by high bacterial loads of 4 x 10 - 3 x 10 CFU/m. The concentrations of coliform bacteria in all samples ranged from 46 to 1100 MPN/ml. About 75% of the samples tested positive for Escherichia coli. Total coliforms were found in all ice samples tested, with verified Escherichia coli found in 37% of samples. Total plate counts of ice samples varied from 1 x 10 -2 x 10 CFU/m. The study concluded that all examined samples were contaminated with yeasts and molds. (Ali et al., 2015)

Preservation of cane juice

Despite its many benefits, sugarcane juice has a short shelf life due to its high sugar content, whichprovides an enticing energy source for pathogenic microbes. The delicate and perishable quality of sugarcane juice limits its commercialization and complicates its processing. (Tarafdar et al., 2021). As a result of sugarcane juice's high sugar content, fresh sugarcane juice undergoes fermentation immediately after extraction and turns brown due to the reactions of polyphenol oxidase in the process.(Huang et al., 2015). Since the sugar content is high a key challenge in industrial-scale production is the preservation and shelf-life stability of cane juice, and providing fresh juice all year long is an important consideration for food manufactures.(Ramachandran et al., 2017).

The development of a preservation technology that can prevent microbial growth and retain the freshness of raw sugarcane juice is a difficult problem for ensuring its wider distribution and availability. Due to this issue, various groups of researchers have attempted to preserve various kinds of sugarcane juice.

- **Hurdles technology:** Panigrahi et al. (2021) conducted a study in which juice was pasteurized at 80 C for 10 minutes and chemical preservatives such as KMS of 150 ppm and citric acid of 0.05 percent were added to the juice. To preserve cane juice, sterilization (80 C for 20 minutes) was performed, as well as packaging (glass / PET bottle) and irradiation. Juice's organoleptic characteristics were not greatly impacted by irradiation or packaging, and it was observed that juice had a shelf life of 60 days at room temperature and 90 days at low temperature.
- **Natural preservatives:** Juice can be preserved naturally by adding ingredients like ginger, lemon, and moringa leaf. Using a heat treatment at 72 °C for 15 s, good-quality sugarcane juice (100 ml) was made, and the addition of 3 ml lemon and 0.6 ml ginger improved the flavor and color. For one week at the refrigeration temperature, this combination provided a good level of storage stability (Kaavya et al., 2018).
- **Chemical preservatives:** The citric acid (0.3 percent), sodium benzoate (0.015 percent), potassium sorbate (0.025 percent), and sucrose (10 percent) were added as preservatives, and it was shown that the treatment helped to increase the shelf life to 15 days at room temperature (26 C) and 35 days at 100 C. (Singh et al., 2014).

Tarafdar et al. (2021) conducted a study on the effect of micro-fluidization at a pressure range of 50–200 MPa with 1–7 processing cycles on various enzymes present in sugarcane juice, including PPO, POD and sucrose neutral invertase (SNI) without affecting color and other quality attributes. In this, sugarcane stems were blanched at 95 degrees for 5 minutes, then immediately immersed in cool water at (25 ± 33 °C) before being transferred for juice extraction. Microfluidization reduced PPO and POD activity by 39.4–64.7 percent and 16.4–75.0 percent, respectively, while increasing Reducing sugar and decreasing total sugars by 11–54 percent. Similarly, up to 100 MPa pressure, chlorophyll content increased and exhibited no deterioration at greater pressures. The investigation concluded that the Juice color remained relatively consistent up to 150 MPa pressure.The amide II band in the structure of PPO and POD was more responsive to pressure treatment, while SNI can be decreased more efficiently at 50 and 100 MPa, according to FTIR spectra. According to genetic algorithm-based optimization, 159 MPa pressure/1 cycle is an appropriate processing condition for retaining sugarcane juice quality.

Sankhla et al. (2012) conducted four different experiments on sugarcane juice preservation. In the first experiment, the juice was pasteurized at 70 degrees, 80 degrees, and 90 degrees Celsius for 10 min, and the Concentration preservatives such as citric acid (0gm, 0.5gm, 1gm, and 1.5 gm/ 1,000 ml), similarly, potassium metabisulphite (KMS) (0ppm, 50ppm, 100ppm, 150ppm and 200 ppm).

As for the second experiment, three treatments were performed: Treatment 1 was untreated sugarcane juice, Treatment 2 was pasteurization at 80°C for 10 minutes with chemical treatment (potassium metabisulphite 150 ppm and citric acid 0.05%), Treatment 3 was pasteurization at 80°C for 10 minutes with chemical treatment (potassium metabisulphite @ 150 ppm and citric acid 0.05%), and Treatment 4 was sterilization at 80°C for 20 minutes.

Similarly, packaging information is included in experiment four. Sugarcane juice samples (T1, T2, and T3) were packaged in glass bottles, PET bottles, and LDPE pouches.

In experiment 4, all of the packed samples were irradiated with three different doses: 0.25, 0.5, and 1.0 kGy. According to the results of the above experiment, pasteurization temperature of 80 degrees for 10 minutes when combined with chemical treatments (KMS @ 150 ppm and citric acid @ 0.05 percent) and sterilization temperature of 80 degrees for 20 minutes with 1.0 kGy irradiation doses,packed in best packaging material glass and pet found to be best in maintaining the shelf life of juice up to 60 days at room temperature and 90 days at low temperature.

Value added products

Sugarcane juice is the first raw material used in the production of sugar and other valuable products such as jaggery, raw sugar or brown sugar, and molasses, and it is also added to various products such as syrup, powder sugar, and so on (Singh et al., 2015).

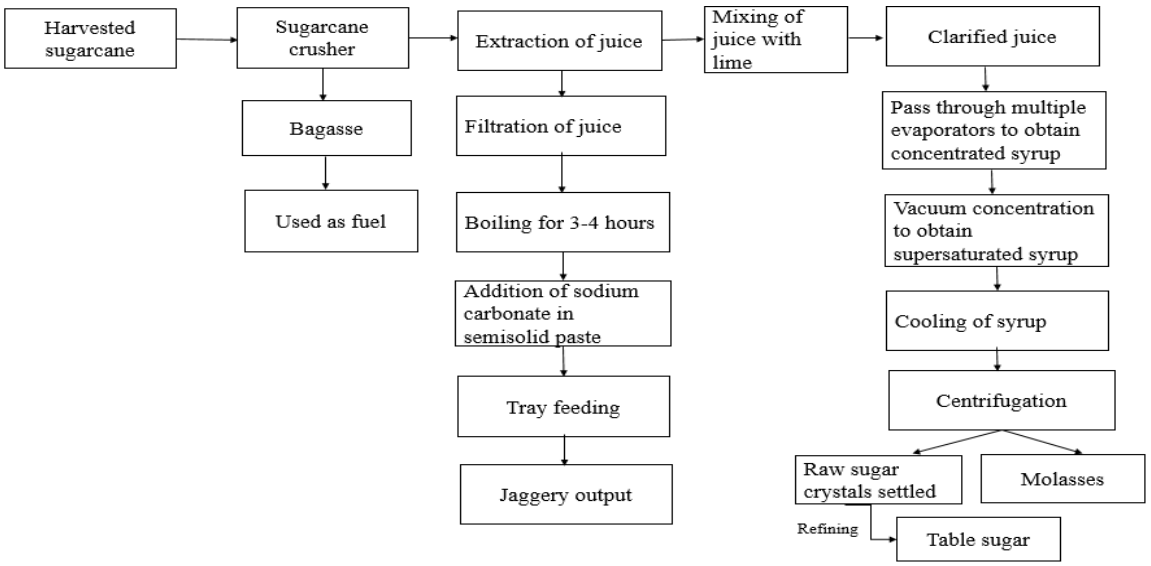

Figure 1.2: Processing of sugarcane products (Singh *et al.*, 2015).

Syrup

The obtained raw juice was filtered using muslin cloths and a strainer before being frozen at -18 C. prior to the studies, the frozen juice was thawed at room temperature to about 30℃. The four methods of clarification were used in this investigation, and the juices that were clarified were then filtered using muslin rather than a filter press, filter paper, or centrifuge. To create 68 Bx syrup, clear fluids clarified using each of the four procedures were cooked at 100–102℃ with a hot plate and magnetic stirrer (Laksameethanasan et al., 2012).

Sugarcane juice powder

In a 2013 experiment by Hari et al. sugarcane juice was extracted and then blended with various bulking agents, including gum Arabic, lactose monohydrate, soluble starch, etc., through layers of fine sieves. The result was syrup. The experiment makes use of glass spray dryers designed for laboratories. For the spray drying, a co-current system and 1.0 mm atomizer nozzle were employed. The juice was continuously swirled with a magnetic stirrer to prevent bulking additives from settling during spray drying. The powder that accumulated in the glass cyclone collector and collection container was gathered as it yielded. The resulting powder was stored in airtight containers at 4°C.

Jaggery

Gur (jaggery), an ancient traditional sweetening ingredient, is an excellent alternative to sugar and many artificial sweeteners as it is high in vitamins and minerals and is used for blood purification and infection treatment in Ayurvedic medicine. (Mohan and Agrawal, 2020). According to the Bureau of Indian Standards, solid jaggery contains between 5% and 7% moisture, and it comes in three varieties: liquid jaggery, solid jaggery, and granular jaggery. Solid jaggery is made by cooking clarified sugar cane juice at its striking point temperature at 116 to 120°C and pouring into molds of various sizes and shapes. (Kumar and Kumar, 2018).

Biscuit

Sugarcane bagasse obtained from the sugarcane juice center was used in the manufacturing of biscuits. Sugarcane bagasse, a byproduct of sugarcane juice extraction that is underutilized, could be turned into value-added goods. Dietary fiber-rich biscuits can be made by replacing 10% of the wheat flour with steamed bagasse flour, making them excellent for persons suffering from constipation, obesity, color cancer, and a variety of other diseases/disorders (Sangeetha et al., 2011).

CONCLUSION AND FUTURE SCOPE

Getting enough fruit into your diet can be accomplished by consuming fresh fruit juices. Sugarcane juice is a healthy, cheap, and refreshing drink that helps keep the body in good health**.** The production of sugarcane is high but the utilization of sugarcane juice is still rare due to its perishable nature offers obstacles in terms of stability, marketing, shelf life, and processing. This is owing to its high sugar content, which makes it an attractive source of energy for pathogenic microorganisms. This review covers the preservation of sugarcane juice using different technique (hurdle technology, chemical preservative and natural preservative) so that the obtained juice can be easily utilized or added in product formulation as a natural sweetener. The future scope of this study is to production of fresh, high energy sugarcane juice in the form of bottled packed by replacing carbonated drink. Utilizing sugarcane juice as a refreshing beverage has various health advantages in addition to increasing its economic value. Including strengthens the stomach, kidneys, heart, eyes, brain, and sex organs. The juice of sugarcane is used as a remedy for jaundice, and is regularly consumed along with lemon juice by hepatitis patients. Sugarcane juice has a wide range of therapeutic characteristics, and it is frequently used in traditional medicine to treat jaundice.

REFERENCES

1. Aguilar-Rivera, N., Rodríguez L., D. A., Enríquez R., V., Castillo M., A., & Herrera S., A. The Mexican Sugarcane Industry: Overview, Constraints, Current Status and Long-Term Trends. *Sugar Tech*, 2012; *14*(3): 207–222. https://doi.org/10.1007/s12355-012-0151-3.
2. Ali, J., Hussain, A., Paracha, G. M., Afridi, M. S., Rahman, I. U., & Hassan, S. *Microbiological Quality Evaluation, Preservation and Shelf Life Studies of Sugar Cane Juices Sold in Peshawar City, Khyber Pakhtunkhwa-Pakistan Pakistan Council Scientific and Industrial Research Laboratories Complex*, 2015; *15*(4): 485–489. https://doi.org/10.5829/idosi.aejaes.2015.15.4.92216
3. Arif, S., Batool, A., Nazir, W., Khan, R.S. and Khalid, N. *Physiochemical characteristics nutritional properties and health benefits of sugarcane juice*. Elsevier Inc. Available at: https://doi.org/10.1016/B978-0-12-815270-6.00008-6, 2019.
4. Bucheli, C. S., & Robinson, S. P. Contribution of Enzymic Browning to Color in Sugarcane Juice. *Journal of Agricultural and Food Chemistry*, 1994; *42*(2): 257–261. https://doi.org/10.1021/jf00038a006.
5. Chauhan, O.P., Singh, D., Tyagi, S.M. and Balyan, D.K. Studies on preservation of sugarcane juice. *Int. J. Food Prop.*, 2002; 5: 217–229.
6. De Matos, M., Santos, F., & Eichler, P. Sugarcane world scenario. In *Sugarcane Biorefinery, Technology and Perspectives*. Elsevier Inc. https://doi.org/10.1016/B978-0- 12-814236-3.00001-9, 2019.
7. Hari, K., Jebitta, S.R. and Sivaraman, K. Production and characterization of sugarcane juice powder. *J. Sugarcane Res.*, 2013; 3: 20–34.
8. Mohan, N. and Agrawal, A. New ventures of value-addition in jaggery processing for a dynamic sugar industry. Int. J. Eng. Res. Technol., 2020; 9.
9. Huang, H. W., Chang, Y. H., & Wang, C. Y. High Pressure Pasteurization of Sugarcane Juice: Evaluation of Microbiological Shelf Life and Quality Evolution During Refrigerated Storage. *Food and Bioprocess Technology*, 2015; *8*(12): 2483–2494. https://doi.org/10.1007/s11947-015-1600-2.
10. Kaavya, R., Pandiselvam, R., Kothakota, A., Banuu Priya, E. P., & Arun Prasath, V. Sugarcane Juice Preservation: A Critical Review of the State of the Art and Way Forward. *Sugar Tech*, 2019; *21*(1): 9–19. https://doi.org/10.1007/s12355-018-0622-2.
11. Tarafdar, A., Kumar, Y., Kaur, B. P., & Badgujar, P. C. High-pressure microfluidization of sugarcane juice: Effect on total phenols, total flavonoids, antioxidant activity, and microbiological quality. *Journal of Food Processing and Preservation*, 2021; *45*(5): 1–10. https://doi.org/10.1111/jfpp.15428.
12. Kaavya, R., Pandiselvam, R., Kothakota, A., Banuu Priya, E.P. and Arun Prasath, V. Sugarcane juice preservation: a critical review of the state of the art and way forward. *Sugar Tech*. Available at: https://doi.org/10.1007/s12355-018-0622-2, 2018.
13. Karmakar, R., Ghosh, A. K., & Gangopadhyay, H. Effect of Pretreatments on Physico-Chemical Characteristics of Sugarcane Juice. *Sugar Tech*, 2011; *13*(1): 47–50. https://doi.org/10.1007/s12355-011-0064-6.
14. Khare, A., Behari Lal, A., Singh, A. and Pratap Singh, A. Shelf enhancement of sugarcane juice. *Croat. J. Food Technol. Biotechnol.*, 2012; **7**: 179–183.
15. Kaur, G., Kumar, V., Goyal, A., Tanwar, B., and Kaur. J. Optimization of nutritional beverage developed from radish, sugarcane and herbal extract using response surface methodology. Nutrition and Food Science, 2018; 48: 733-743. DOI: 10.1108/NFS-11-2017-0247.
16. Kohli, G., Jain, G., Bisht, A., Upadhyay, A., Kumar, A. and Dabir, S. Effect of non-thermal hurdles in shelf life enhancement of sugarcane juice. *Food Sci. Technol.*, 2019; 112.
17. Krishnakumar, T. & Chellamuthu, T. & D. Effect of delayed extraction and storage on quality of sugarcane juice. *African Journal of Agricultural Research*, 2013; *8*(10): 930–935. https://doi.org/10.5897/AJAR12.1807.
18. Kumar, R. and Kumar, M. Upgradation of jaggery production and preservation, 2018.
19. Laksameethanasan, P., Somla, N., Janprem, S. and Phochuen, N. Clarification of sugarcane juice for syrup production. *Procedia Eng.*, 2012; 32: 141–147.
20. Ma, S., Karkee, M., Scharf, P. A., & Zhang, Q. Sugarcane harvester technology: Acritical overview. *Applied Engineering in Agriculture*, 2014; *30*(5): 727–739. https://doi.org/10.13031/aea.30.10696.
21. Mohan, C. Sugarcane biotechnology: Challenges and prospects. *Sugarcane Biotechnology: Challenges and Prospects*, 2017; 1–176. https://doi.org/10.1007/978-3-319- 58946-6.
22. Muhammad Asghar Qureshi, S. A. Sugarcane cultivation in Pakistan. *Pakistan Sugar Book, August*, 2005; *2005*.
23. Na, T., Nadu, T., Agricultur, N., & Technology, P. *Qua Ality Cha Anges of F Sugarc Cane Juic Ce Store Ed in Diffe Erent Pa Ackagin*, 2013.
24. Panigrahi, C., Shaikh, A. E. Y., Bag, B. B., Mishra, H. N., & De, S. A technological review on processing of sugarcane juice: Spoilage, preservation, storage, and packaging aspects. *Journal of Food Process Engineering*, 2021; *44*(6): 1–19. https://doi.org/10.1111/jfpe.13706.
25. Pongpat, P., Gheewala, S. H., & Silalertruksa, T. An assessment of harvesting practices of sugarcane in the central region of Thailand. *Journal of Cleaner Production*, 2017; *142*: 1138–1147. https://doi.org/10.1016/j.jclepro. 2016.07.178.
26. Ramachandran, C., Sudha Rani, R., Lavanya, K., Nivetha, S., & Usha, A. Optimization of Shelf

Stability of Sugarcane Juice with Natural Preservatives. *Journal of Food Processing and Preservation*, 2017; *41*(1): 1–11. https://doi.org/10.1111/jfpp.12868.

27. Sangeetha, A. V., Mahadevamma, S., Begum, K. and Sudha, M.L. Influence of processed sugarcane bagasse on the microbial, nutritional, rheological and quality characteristics of biscuits. *Int. J. Food Sci. Nutr.*, 2011; 62: 457–464.
28. Sankhla, S., Chaturvedi, A., Kuna, A., & Dhanlakshmi, K. Preservation of Sugarcane Juice Using Hurdle Technology. *Sugar Tech*, 2012; *14*(1): 26–39. https://doi.org/10.1007/s12355-011-0127-8.
29. Singh, A., Lal, U. R., Mukhtar, H. M., Singh, P. S., Shah, G., & Dhawan, R. K. Phytochemical profile of sugarcane and its potential health aspects. *Pharmacognosy Reviews*, 2015; *9*(17): 45–54. https://doi.org/10.4103/0973-7847.156340.
30. Singh, R. K., Jha, A., Singh, C. K., & Singh, K. Optimization of Process and Physico-Chemical Properties of Ready-to-Serve (RTS) Beverage of Cane Juice with Curd.*Sugar Tech*, 2012; *14*(4): 405–411. https://doi.org/10.1007/s12355-012-0171-z.
31. Singh, S., Gaikwad, K. and Omre, P.K. Spoilage of sugarcane juice a problem in sugarcane industry. *Int. J. Agric. Eng.*, 2014; **7**: 259–263. Available at: http://www.researchjournal.co.in/online/IJAE.htm.