

REVIEW ARTICLE**NUTRITIONAL AND THERAPEUTIC BENEFITS OF SUGARCANE AND ITS PRODUCTS****M. Nisha*, K. Chandran, R. Gopi, V. Krishnapriya and B. Mahendran****Abstract**

Sugarcane roots, stem and its products such as juice, sugar, and jaggery are well known for their nutritional and therapeutic effects in folk and traditional system of medicine. The sugarcane juice and jaggery have various bioactivities like anti-inflammatory, analgesic, anti hyperglycaemic, diuretic, antiseptic, antioxidant, antimicrobial, cardioprotective properties. The assumptions of traditional medicinal system have been supported by modern pharmacological studies especially the richness of phytochemicals including polyphenols, phytosterols, terpenoids, flavonoids and glycosides and its antioxidant and cytoprotective ability. The nutritional composition and medicinal properties of sugarcane stem, roots, juice, jaggery and sugar have been detailed in this review emphasising the need of more research to work out the feasibility of using sugarcane as cheap source of valuable bioactive molecules to cure various ailments.

Key words: Sugarcane, nutritional quality , medicinal property,

Introduction

Sugarcane is the most important commercial crop known to be under cultivation in India since time immemorial. The earliest mention of sugarcane cultivation is found in Indian writings of the period 1400 to 1000 BC (Barber 1931). Ample description of sugarcane and products derived from it are available in *Puranas* and various ancient literatures. ‘Noble cane’ belonging to the species *Saccharum officinarum* is being known to be cultivated in New Guinea about 8000 years ago for chewing purpose (Zakay Ronés et al. 1995; Zhao et al. 2015; Miraj 2016). Now, the crop is cultivated throughout the tropical and subtropical regions mainly for production of sugar, a natural sweetener. The genus *Saccharum*, to which sugarcane belongs even derived its name from the Greek word ‘*Sakcharon*,’ meaning sugar (James 2004). Though majority of sugarcane produced is used for sugar, it is also being processed into less refined and healthier form of sweeteners like

jaggery and Khandsari (Shahi 1999). In recent years, the crop has gained more attention as a bio energy crop for ethanol production and co generation of power. Apart from the economic and industrial use, sugarcane and products derived from it are known as key ingredient in the traditional medicine. In countries like China, Philippines, La Reunion Guiana and Brazil, *S. officinarum* was used medicinally (Kirtikar and Basu 1991). As the name *officinarum* (“of dispensaries”) implies it is used in traditional medicine internally and externally (Zakay Ronés et al. 1995; Miraj, 2016; Duarte et al. 2006). Sugarcane stem and roots has been used in the Ayurveda and Unani systems of medicine in India, since prehistoric times. Chewing raw sugarcane is recommended for sound and healthy body. In the ayurvedic system of medicine it is used either as single drug or in combination with some other plant materials to cure various diseases. The medicinal properties of sugarcane and its products are plausibly due

to presence of phyto-chemicals like polyphenols (Chen et al. 2008; Singh et al. 2015) at the range of 280-320mg/100g (Sahu and Saxena 1994). These phenolic compounds are mainly responsible for the antioxidant and cytoprotective ability (Duarte et al. 2006; Harish Nayaka et al. 2009). Other phyto constituents like phytosterols, terpenoides, flavonoids and glycosides are also present in considerable amount (Deshmane and Dev 1971; Mabry 1984; Smith and Paton 1985; McGhie 1993; deArmas et al.1999; Vila et al. 2008; Duarte et al. 2007; Colombo 2009; Singh et al. 2015).

Among the various species of *Saccharum*, stem and roots of *S. spontaneum* and *S. officinarum* have widely documented and utilized for its medicinal properties (Nadkarni 1976; Kirtikar and Basu, 1991; Kaushik and Dhiman 1999; Sammbamurthi 2006; Warriar et al. 2010; Karthikeyan and Samipillai 2010). The *S. spontaneum* is a wild species widely distributed in the tropics as well as in subtropics. It's a perennial grass growing upto three meters height with spreading rhizomatous roots and adaptable to various climatic conditions. Clones of *S. spontaneum* is highly variable from short bushy types with narrow leaves practically reduced to midrib to tall erect broad leaved forms with long internode types.

Saccharum officinarum were called original sugarcane varieties which is domesticated and selected for chewing by the indigenous people of Pacific Islands. This species is characterised by thick canes, high sugar, less fiber and soft rind. As on today these clones are not under commercial cultivation but are restricted to the native gardens in New Guinea and Indonesia growing for chewing purpose. In India also some of the clones are grown in kitchen gardens for religious offerings.

Nutritional composition and medicinal properties of sugarcane juice

Sugarcane juice is non alcoholic energy drink popular in India and many other sugarcane growing countries especially during the hottest periods of the year. The juice contains 75 to 85% water, 10 to 21% sucrose (non reducing sugar), 10-15% fiber, 0.3 to 3% reducing sugars (glucose and fructose) and other organic and inorganic compounds (Swaminathan 1995). The juice is extracted by crushing the cane through roller crusher and consumed with or without adding ice cubes. It is also consumed with addition of lime, ginger etc to improve the taste. The juice is mainly consumed fresh as the quality of the juice deteriorates on storage due to the presence of simple sugars. Fresh juice is marketed by street vendors, almost always without the appropriate hygiene/sanitary conditions required for the handling of food products and the juice is rarely available in packed form. Sugarcane juice and its unrefined products are the richest source of phenolic acids, flavonoids, and different glycosides. The sugarcane juice is the raw material for production of refined table sugar and unrefined forms like Jaggery and Khandsari. Sugarcane juice is well known for its medicinal properties in various systems of medicines viz., Ayurveda, Unanni and Sidha (Nadkarni 1976; Kirtikar and Basu 1991; Kaushik and Dhimank 1999; Sammbamurthi 2006; Warriar et al 2010). In Indian Ayurveda, sugarcane juice is considered as a nutritional drink. Native and traditional healers recommend it as diuretic (medications designed to increase the amount of water and salt expelled from the body as urine) (Caceres et al. 1987; Karthikeyan and Samipillai 2010). Regular use of juice is thought to keep the urinary flow clear and fast, which will further help the kidneys

to function properly (Nadkarni 1976; Kirtikar and Basu 1991; Ross 2005). It is used along with lime or ginger for better results. Sugarcane juice or jaggery with dry ginger is taken to relieve hiccup (Duke and Wain, 1981; Agarwal 1986). It is also used as aphrodisiac (stimulating sexual desire) (Chopra et al. 1956; Karthikeyan and Samipillai 2010), laxative (substances that increase bowel movements), coolant (useful in fatigue, thirst and burning sensations) (Chopra et al. 1956; Kaushik and Dhiman 1999; Karthikeyan and Samipillai 2010), demulcent (substance that relieves irritation or inflammation) (Kaushik and Dhiman 1999; Karthikeyan and Samipillai 2010), purifies the blood, antiseptic, and tonic (Chopra et al. 1956; Khare 2007; Karthikeyan and Samipillai 2010). It is also recommended for leprosy and intestinal troubles (Nadkarni 1976; Kirtikar and Basu 1991; Ross 2005, Karthikeyan and Samipillai 2010). It is highly recommended against tridosh (*Pitta, Kapha* and *Vata*) in Ayurveda (Kirtikar and Basu 1991).

Unani medicine, described it to be laxative, diuretic, fattening, aphrodisiac, blood purifier and good for lungs (Anis and Iqbal 1986; Caceres et al. 1987; vedavathy et al. 1991; Khare 2007; Koh et al. 2009; Karthikeyan and Samipillai 2010;) Juice is considered beneficial for the liver therefore large amount of sugarcane juice is recommended for immediate relief from jaundice (Khare 2007; Karthikeyan and Samipillai 2010). The sugarcane juice positively regulates host natural immunity against viral, bacterial and protozoan infections (Lo et al. 2005). It is also recommended for patients suffering from low blood pressure (Nadkarni 1976; Ross 2005). A decoction of stem is given for diarrhoea in child hood (Nadkarni 1976). It is an integral component of the medicines used in the treatment of ulcers of the skin and mucous

membrane particularly by Combodians (Nadkarni 1976; Kirikar and Basu 1991; Kaushik and Dhiman 1999; Ross 2005).

A large group of population relish sugarcane as chewing cane. High sugar, low fibre containing 'noble canes' of the *S. officinarum* group were largely being used for this purpose in tropical countries prior to the development of manmade hybrids. Chewing of sugarcane is known to provide strong teeth and recommended for oral health. The sugarcane juice from chewing of the cane is highly valuable for weak teeth due to lack of proper exercise resulting from excessive use of soft foods. It gives proper exercise to the teeth, cleans it and makes them strong (Karthikeyan and Samipillai 2010).

The traditional healers always suggested that the sugarcane juice had the healing properties only if it is extracted directly by chewing the cane as the sucked juice is coolest in nature compared to machine extracted the latter being hot and dark coloured on storage.

Importance of Jaggery

Jaggery is traditional sweetener prepared by concentrating the sugarcane juice. This natural unrefined non centrifugal sugar is consumed in Asia, Africa Latin America and Caribbean Islands. India is the largest producer and consumer of jaggery, contributing to more than 70% of the world production (Rao et al. 2007). It is consumed by all sections of society as a sweetener cum source of energy as it the healthiest form of sugar containing minerals and vitamins (Madan et al. 2004). Worldwide non centrifugal sugar prepared by concentrating the sugarcane juice is known in different names, the most common being 'unrefined muscovado', whole cane sugar, panela

(Latin America), Jaggery (South Asia) and Kokoto (Japan). The jaggery is called by different names such as Gur/Desi in Pakistan, Rapadura in Brazil, Gur/Gud/Vellam in India, Hakura in Srilanka and so on (Anonymous 2014; Vinutha et al. 2014).

The history of juice extraction and boiling to concentrate it dates back to 2000 years in our country. Around 20-30% of the sugarcane produced in the country is processed in to jaggery (Thakur 1999). The major jaggery producing states are Uttar Pradesh, Tamil Nadu, Maharashtra, Andhra Pradesh and Karnataka. Jaggery production is one of the major agro processing industries. It provides employment to about 2.3 million people in cooperative sector of rural area (Nerkar 2004). Jaggery is an important raw material for various cottage industries, producing sweets like reori, gazak, chikki, patti, ramdana etc. It is also used in animal feed mixtures. In the recent years, the demand is steadily increasing among the health conscious urban population to use jaggery as health supplement rather than sweetener.

Jaggery is produced in to three forms viz., solid, liquid and granular. In the preparation of the solid form, the sugarcane juice is clarified with herbal clarificant to make light coloured jaggery by removing the impurities and colouring compounds in the juice. The juice is then boiled in triple pan furnace and concentrated to desired size and shape (Singh et al. 2011). A good quality jaggery contains more than 70% sucrose < 10% glucose and fructose < 5 % minerals and <

3% moisture (Pattnayak and Misra 2004). The detailed composition of 100g jaggery is given in Table 1. The liquid jaggery or semi liquid syrup is obtained during concentrating purified sugarcane juice for solid jaggery making. It contains 30-36% water, 40-60% sucrose, 15-25% invert sugar, calcium 0.3%, iron 8.5-10mg/100mg, phosphorous 0.5/100mg, protein 0.1/100mg and vitamin B 14/100mg (Singh 2008; Singh et al. 2013). Granular jaggery preparation is same as solid jaggery up to the concentration of juice. The concentrating slurry is rubbed with wooden scrapper for formation of granules. It is then cooled, sieved to get < 3mm sized granules and dried to reduce the moisture content to less than 2%. The composition per 100g granular jaggery is 80-90g sucrose, 5-9g reducing sugar, 0.4 g protein, 0.1g fat, 9mg calcium, 4mg phosphorous and 12 mg iron (Singh et al. 1978). In the ayurvedic medicinal system, jaggery is being used as a medicine, blood purifier and base material for syrup.

The jaggery obtained from juice by concentrating it is considered as a wholesome food due to the presence of minerals and vitamins along with the major component sucrose; a source of energy. It is made up of long chains of sucrose which is digested slowly, provides energy for a longer time and is not harmful for our body. It is known to produce heat and instant energy to human body. Jaggery during its preparation gathers considerable amount of iron from the pans and hence is good for health especially to

Table 1. Nutritional composition of jaggery 100g (Singh et al. 2013)

Minerals (in mg)		Vitamins (in mg)	
Calcium	40-100	A	3.8
Magnesium	70-90	B1	0.01
Potassium	1056	B2	0.06
Phosphorous	20-90	B5	0.01
Sodium	19-30	B6	0.01
Iron	10-13	C	7.0
Manganese	0.2-0.5	D2	6.5
Zinc	0.2-0.4	E	111.3
Copper	0.1-0.9	PP	7
Chloride	5.3		
Carbohydrates (in g)		Prote	280
Sucrose	72-78	Water	1.5-
Fructose	1.5-7	Calori	312
Glucose	1.5-7		

anaemic patients (Shrivastav et al. 2016). Jaggery is a good cleansing agent known to clean lungs, stomach, intestines eosophagous and respiratory tract (Sahu and Paul 1998). Daily intake of jaggery is recommended for workers exposed to smoky and dusty atmosphere, to protect them from dust allergy, asthma, cough and cold and congestion in chest. Thus, jaggery helps to breathe easier and counters the pollution problems naturally (Singh et al. 2013; Shrivastav et al. 2016). Jaggery contains considerable amount of magnesium, it strengthens nervous system, helps to relax muscles, gives relief from fatigue and takes care of our blood vessels. It along with selenium, acts as an antioxidant and has property to scavenge free radicals from body. The potassium and low amount of sodium present in jaggery maintain the acid

balance in the body and control blood pressure (Singh et al. 2013). The moderate amount of calcium, phosphorous and zinc helps to maintain optimum health (Singh et al. 2013). It also purifies the blood, prevents rheumatic afflictions and bile disorders, and thus helps to cure jaundice (Khare 2007). Ayurveda also prescribes jaggery for migraine, and at the time of post pregnancy, for removing all clotted blood from the body, within 40 days after the birth of a baby (Singh 2008). Jaggery is melted and applied hot to the body parts pricked with thorn, glass or stone and on parts bitten by poisonous insects for faster healing.

Sugar

It is the most important product of sugarcane that drives sugar industry. Around two third of the table sugar is produced from sugarcane, the rest being from other sources like sugar

beet. Technically, centrifugal sugar is obtained from sugarcane juice after concentrating, filtering and centrifuging it, hence is primarily composed of sucrose. As per Hindu religion great value is given for sugar and considered it as nutritious, pectoral and antihelminthic (given to children as a remedy for worms) (Kirtikar and Basu 1991). In places like Punjab, sugar is considered a heavy tonic and aperient (a drug used to relieve constipation), useful in heat delirium and disorders of the bile (*pitta*) and wind (*vata*) (Kirtikar and Basu 1991). Drinking of sugarcane candy dissolved in water stops purgation (evacuation of the bowels brought about by taking laxative) (Nadkarni 1976). In Arabian literature, it is described as detergent and emollient (having the quality of softening or soothing the skin). Many have said it as attenuant (a medicine or agent that thins the blood), pectoral and useful in calculus complaints Kirtikar and Basu 1991; Girach 1992; Bhandari 1993).

Consumption of sugar or jaggery mixed with hot milk relieves pain during dysuria (pain or discomfort when urinating). As a detergent or antiseptic it is sprinkled around the sick bed for disinfecting the room. Burning of sugar produce formic acid, which is a good antiseptic. It is a practical and very excellent way of cleansing a patient's room. Sugar is employed as an antidote in case of poisoning by copper arsenic or corrosive sublimate. Finely powdered sugar is sprinkled upon ulcers with unhealthy granulations (Kirtikar and Basu 1991).

Therapeutic application of stem and roots

The roots of the *S. spontaneum* and *S. officinarum* are known as diuretic and demulcent. Both roots and stem are used for the treatment of skin, eye diseases, bronchitis, loss of milk production, cough anaemia, constipation as well as general debility (Kadam et al. 2008). The young growing part can be eaten by patients ailing from fistula in anus, when there is no fever (Nadkarni 1976). In folklore treatments roots is burned near women after delivery and near burns and scalds as its smoke is considered beneficial when it comes in contact (Kirtikar and basu 1991; Kaushik and Dhiman 1999). Oil prepared from the roots is used for treating joint pain. Special oil is prepared from fresh roots, dried ginger and sesame oil for external application as this is highly useful for treatment of skin problems of the feet due to constant contact with moisture (Karthikeyan and Samipillai 2010) In Malaysia, decoction from roots of the sugarcane is used for whooping cough. The dew which collects on the long leaves of sugarcane is useful for several eye disorders like defective vision, cataract and conjunctivitis, burning of eyes and eye strain after excessive reading.

Sugarcane based Ayurvedic and Folklore medicines

Sugarcane is well documented in the folklore medicines of several countries including India. Sugar candy mixed with curd is used as drink to relieve from heat sensation in the body locally. A mixture of 10g jaggery, 5 g ghee and gingelly seeds is fermented with

milk and applied to temple and forehead in case of headache. Sugarcane juice fermented to vinegar, mixed with water is a digestive drink after meals. Paste made of equal parts of sugar and yellow soap is used against boils. Sugarcane vinegar (prepared by fermenting juice) and water mixed in the ratio 1:2 is given in case of extreme urticaria (kind of skin rash with red, raised, itchy bumps). Sugarcane vinegar is applied as lotion for headache A decoction of sugarcane root with Gokshru remove urinary bladder calculi (Nadkarni 1976; Kaushik and Dhiman 1999)

Conclusion

Sugarcane is cultivated throughout the world for its economical value as table sugar. Many by-products in the industry elevated its status to a energy crop. Still the income to the farmers from this crop is relatively less compared to other cash crops and vulnerable due to boom bust cycle coupled with climactic vagaries. Hence further diversification of the product is in the anvil and its therapeutic and nutritional value can contribute to the product diversification and value addition and thereby contribute to the doubling of farmer's income.

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