COMMENTARY

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Non Sacchariferous Super Sweet Plant Species to Combat Sugar and Energy Crisis, Sugar Caused Health Disorders and Environmental Warming

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ABSTRACT

There are 15 super sweet plants spicies in India which are 100-10,000 times sweeter than sugarcane sucrose (saccharide) and accumulate non saccharide super sweet principles like proteins, terpenoids, flavonoids, coumerin etc and their 100 mg provide little or no calorie and sweetness equivalent to 1kg sucrose. Consequently these are becoming useful to diabetic, cardio vascular, kidney, obesity and dental caries patients and are reducing their disorders and mortality significantly. The ingrained higher microbial activities in such plants have been found to deplete CO2 fast through active carbonic anhydrase enzyme and thereby help in combating environmental warming. Similarly because of high potency for bio-fuel production and intense sweet principles accumulation, these plants species appears to be most suitable to solve energy and sucrose crisis and save about 4.5 million ha land of sugar cane for the use of agriculture, industry and housing in India.

Untamed burgeoning population and unplanned human activities pertaining to industrialization, agricultural practices, tourism, urbanization, food habit etc. are causing fast shrinkage in arable land, environmental degradation, soil sickness, and depletion of the natural resources including fossil fuel. Due to these provisos, arable land is declining @ 10 ha/min at global level (Buringh, 1987), 0.1 million ha/yr at national level (MOA2013), and that of N fertilizer response decline to a level of 60% of intensively cultivated Indian soil (Dwivedi and Dwivedi 2005). The addition of 2.1 billion tonnes of carbon /year in the atmosphere in India excluding that of per person carbon release in the environment at the rate of 17t in America, 16.6t in Australia, 7.4t in China etc have been recorded as pollutant (Annon.2015). All these factors are congruently resulting food, sugar and energy crisis, sugar caused health disorders and environmental warming. At this juncture, there is need to examine the potentiality of non saccharifirous super sweet (NSSS) plants which are reported to be 100-10000 times sweeter than sugarcane, efficient alcohol fuel producer (Dwivedi 2016) embedded with micro-organism possessing most efficient CO_2 depleting enzyme carbonic anhydrase, with a view to obviate aforesaid problems including environmental warming.

1. Sugar Requirement

Sugar is most favourite dietary gradient and its requirement is increasing day by day. Hence, it is most arduous task to meet 35-40 million tonnes of sweeteners (sucrose) requirement of India and 210 million tonnes globally by 2020 under aforesaid situations through sacchariferous sweet crops specially when the break though in the technology of sugar production is not offing and arable land is shrinking. This could be met through the sweeteners of non saccharifirous super sweet (NSSS) plants, which are 100-10,000 times sweeter than Sugar (Table-1). These sweeteners are non sugars with lower intrinsic energy and plants producing such sweeteners are called non sacchariferous super sweet plants (Dwivedi 1999). About 0.1-10 mg of NSS sweeteners would provide sweetness equivalent to 1000 mg sugars which in term would provide less than 30 cal and more than 4,000 cal energy respectively (Dwivedi 2016).

2. Sugar Mediated Health Disorders

The sweeteners are most tasty integral part of human's daily diet and consumed by human – being in an uncontrolled manner. Consequently, the health disorders like diabetes, cardiovascular diseases, dental carries, kidney disorder and diseases, hypertension etc. are caused which could only be mitigated by using very small amount of vegetal non – saccharide super (NSS) sweetener e. g. terpenoids, dihydrochalcones, dihydroisocoumerin, protein, steroidal saponine, (kinghorn & Seojarto 1986) which are 100-10,000 time sweeter than the sucrose (Table 2). The consumption

Table 1. Sugar and non saccharide super sweeteners (NSSS) "Stevioside" requirement of India.

Year	Area required for sugarcane cultivation (million ha)	Amount of sugar required.(million t)	NSSS requirement (t)		Area required for NSSS production (ha)	
			50% replacement of sugar	100% replacement of sugar	50% replacement of sugar	100% replacement of sugar
2015	5.01*	30*	37500	75000	9375	18750
2020	5.50*	40*	50000	100000	12500	25000

*Sugar requirement and sugarcane crop area (cooperative sugar 2016)

NSSS quantity and land area requirement calculated by authors.

of 0.1-10 mg of such sweeteners would provide sweetness equivalent to 1 g of sucrose and there by negligible calorie/ zero calorie (energy) to human body.

Already, Indian is importing a huge amount of non saccharide super sweet principles worth about Rs. 650 millions mainly from Japan, china, USA and Australia (Dwivedi 2016) to meet the sweeteners requirements of 72 millions diabetic patients (kurup2007) and 240 million cardiovascular disease people and two hundred million high blood pressure patients (London, PT-2016) The human death due to diabetes alone is about 10 lakhs/ year, hence the use of non saccharide super sweet principles and cultivation fo super sweet plants are the only options left to meet the challenges. The potentiality of super sweet plants, their identification, habitat, cultivation practices and extraction of super sweet principles have not been given attention in India, so far. Consequently these plants are becoming extinct due to ignorance.

3. Super Sweet Plant Species in India

The following super sweet plant species and their super sweet principle were reported by Dwivedi (1999) (Table 3).These plant species are growing under natural habitat in different parts of India.

4. Environmental warming

This is a seriously growing problem throughout the world. The green house gases viz. CO2, Methane and nitrogen oxide and chlorofluro carbon, fine lead particles, water vapors etc are raising evironmental temperature. Annual addition of 2.1 billion tonnes of carbon at global level in the atmosphere is the main reason of warming. Super sweet plants are embedded with alcohol, methane and formic acid farming bacteria (Dwivedi 2016).These micro-organisms including micro-algae, *Bacillus subtilis and other Bacillus species, E.coli* etc which have carbonic anhydrase (CA) enzyme with very high turnover rate (Kcat) ranging between

Table 2. Some Indian non sacchariferous super sweet (NSSS) plants species, their sweet principles, sweetness and calorific values as compared to sacchariferous sugarcane sugar (Dwivedi 2005).

Sl No.	Sacchariferous Sweet (SS) sacchariferous super principles sweet (NSSS) sweet	Plant and Non Plant Species	Sweetness Compared to sucrose	Calorific Values (Cal/g)
NSSS Plants				
1	*Perilla frutescene L;* Ban Tulsi	Perillartin	1000 -2000	3600-3800
2	*Abrus precattorius L* Rati / Ghunghchi	Abrusoside	100-200	3800-3900
3	*Glycyrrhiz glabra L.;* Licorice	Glycyrrhizin	100-200	3850-3900
4	*Stevia rebaudiana Bertoni; L.;* Stevia	Stevioside	300-400	3800-3900
5	*Polypodium glycyrrhiza L.;* Sweet fern	Olsadin	800-1000	3600-3900
SS Plants				
6	*Saccharum officinarum L.;* Sugarcane	Sucrose	1	3950-4050

Table 3. Non-saccharide Super (NSS) Sweeteners and Non Sacchariferous Super Sweet (NSSS) Plants of India (Dwivedi 1999).

Non-saccharide super sweet sweeteners (100-10,000 times sweeter than Sucrose)	Non Sacchariferuos Super Sweet Plants
Mono terponoides : Perillartine	*Perilla frutescens L*
Sesque terpenoids : Harmadulcin	*Lippia dulcis Trev.*
Diterpenoids : Steviosides	*Stevia rebaudiana Bertoni*
Triterpenoids : Glycyrrhizin	*Glycyrrhiza glabra L.*
Abrusoside	*Abrus precatorius L.*
Osladin	*Polypodium glycyrrhiza L. And P. Vulgaris L.*
Phyllodulcin	*Hydrangia macrophylla Seringe*
Neohesparidin	*Citrus auruntium L.*
Glycyphillin	*Smilex glycyphylla Sm*
Naringin	*Citrus paradise Macl*
Hesperetin	*Citrus sinensis L.*
Trilobatin	*Symplococus paniculata Miq.*
Protein – Monellin	*Diascoreophyllum commuinsii Stapf*
Protein-Curculin	*Curculigo latefolia L.*

10^4 and 10^6 per second for catalyzing reversible conversion of CO2 to bicarbonate. (Faridi and Satyanarayanan 2015).

$$CO2 + H2O \rightleftharpoons HCO3 + H^+$$

Carbonic hydrase is an mtetallo-enzyme in which zinc is present at reaction site between enzyme and substrate (Dwivedi and Randhawa 1974, Dwivedi and Singh 1991, Faridi and Satyanarayan 2015 and Dwivedi 2016). This enzyme is being used in bioreactors for converting CO2 to bicarbonate and thereby cement and building material formation. Furthermore, HCO3 produced after CO2 capture can also be used to generate bio fuel by serving as carbon source for the cultivation of algae (Faridi and Satyanarayan 2015).

5. Bio-Fuel

As mentioned in Table – 3, super sweet plants have protein, terpnoids, osladin etc. sweet principles. These can be converted into fuel with similar energy, density, freezing point and hydrocarbon molecule present in petroleum fuel utilized in jet, as has been done on other oil and protein rich plants (Wosken 2008).The plants as mentioned in Table 3, except *Citrus paradise* Macl. are neglected and growing in the forest, valleys, on mountain and under stress environment in a wild manner. Most of the non sacchariferous super sweet plants are found to grow under stress environment at their natural habitat. Field experiments conducted at IISR, Lucknow during the year 2002-2005 vouched that *Abrus Precatorius* and *Glycyrrhiza Glabra* could be cultivated on alkali soil at ESP 25-30 and ESP 20-25, respectively under sole and intercropping system and thereby blooming of waste alkali and improving farmers and national economy (Dwived 2005). If these two (*A.precatorius* L. and *G. glabra* L.) are preserved under wild condition the amount of bio-fuel production would be as follows : (Table 4)

Table 4. Estimated production of Bio-fuel by combined biomass of *Glycyrrhiza glabra L.* and *Abrus precatoriu L.* Under protected and natural conditions.

Sl. Nl.	Conditions	Bio-Fuel Production (million litres)			
		World		India	
		2007	2020	2007	2020
1	100% protection	110	210	22	20
2	Natural/50% protection	55	105	11	15

(Dwivedi 2005)

6. Saving of Land

The super sweet plants cultivation would help in two ways in saving /squeezing 5.0 million ha of land used for sugar cane cultivation, which in fact is not sufficient, to meet the sugar requirement of country even by 2030.

1. The recovery of super sweeteners ranges between 10- 14 % like that of sugarcane. Super sweeteners would be amalgamated with sugar to raise their sweetness by5 to 10 times. Thus 2-0 3.5 million ha land of sugar cane would be required to meet sugar requirement of country.super sweet plant would require only ten thousand ha land to produce super sweeteners for amalgamation.
2. If 100% and 50% requirement of sugar is met by super sweet principle then it will require 0.5- 1.0 million ha land respectively to feed sugar to nation. Consequetly saving of 4.0 to 4.5 million ha of land would be possible (Table 1).

7. Saving of Water

NSSS plants require less water as they are adapted to drought and salt stress conditions (Table 5). Hence as campared to sugarcane a great saving in water consumption is expected. However no detailed studies on water use efficiency in NSSS plants have been done like that of sugarcane where WUE (mole of water used/mole of CO_2 fixed) has been found to be 295 (Dwivedi, 2016a).

Table 5. Water requirement of Sugarcane and NSSS plants in tropical and subtropical areas.

Plants	(mm rainfall essential for good growth)	
	Tropical	subtropical
Sugarcane	2500-3000	1500-2000
NSSS Plants	1500-2000	1000-1500

NSSS – Non sacchariferous super sweet

Utilization of waste land

Most of the NSSS plants are growing under stress conditions on salt affected land, range and mountain in the forest and grassland and under waterlogged and dry conditions. It has been noted that *Abrus precatorious* and *Stevia rebaudiana* can grow on ESP 25-30 and ESP 20-25 respectively (Dwivedi 2005). Hence under planned conditions, the waste land could be utilized for for growing these plants; the good lands could be utilized for oilseeds and pulse crops as they are required most today.

Visualizing the ongoing facts, it may be mentioned that if the super sweet plants species are protected and nurtured under natural habitat, little good additional land would be required for their cultivation to meet sugar requirement of the people. All these would congruently help in rectifying sugar and energy crisis and improving sugar mediated human health disorder and mitigating environmental warming effect with little cost and efforts.

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