Sugar Tech (Mar-Apr 2022) 24(2):387–396
https://doi.org/10.1007/s12355-021-01020-3

SCIENTIFIC CORRESPONDENCE

Value Addition and Fortification in Non-Centrifugal Sugar (Jaggery): A Potential Source of Functional and Nutraceutical Foods

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Received: 28 April 2021 / Accepted: 9 June 2021 / Published online: 27 July 2021

Abstract Nutraceutical, functional or fortified food not only supplements the diet but also assists in developing immunity and preventing diseases. Therefore, it also provides medical benefits apart from nutrition. Individual health and diet are receiving a lot of attention these days. Food products that are healthy, safe, and easy to use are in high demand. A lot of emphases has been directed toward food products with added health benefits. Jaggery (non-centrifugal sugar), made from sugarcane juice, is one of them. It is known to mankind for the last 3000 years and is an essential part of the diet in the rural part of many countries. Jaggery is recognized as a nutraceutical due to the presence of a variety of essential amino acids, antioxidants, phenolics, minerals like calcium, phosphorus, iron, and vitamins. Jaggery has a better natural source and nutrients for health benefits and could be used as a healthier dietary substitute to white sugar. The nutraceutical value of jaggery can be enhanced with value addition and fortification of medicinally important herbs and spices. This would not only enhance the quality of nutritive jaggery but will also offer value-added products with exciting flavors for daily use sweeteners with several nutritional health benefits.

Keywords Jaggery · Value-added products · Fortified · Nutraceutical · Ayurveda · Spices · Herbs

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Introduction

Balanced food is thought to be a healthier diet that will benefit human health in addition to the usual healthy diet requirements. It is also known as functional food, which is food that makes a clear claim of health benefits, as well as a claim of boosting the immune system. Besides, malnutrition and undernutrition are also of major concerns around the globe, especially in developing countries. Jaggery is a healthy non-centrifugal sugar (NCS) that is being used across many Asian/African countries and Colombia. Nowadays, different value-added food products made of jaggery are being used globally as part of daily cuisine, drinks, and desserts. 'Gur' is the Indian word for jaggery and is mentioned as a sweetener in Ayurvedic medicines for over 3000 years. However, the name jaggery is derived from the Portuguese word '*jagara*' that means coarse brown sugar. Indian Refined white sugar consists of sucrose, while jaggery consists of minerals and vitamins along with glucose, fructose (invert sugars), and sucrose (Ghosh et al. 1998). The jaggery consists of mineral content (calcium, phosphorous, magnesium, potassium, iron, zinc, copper, and vitamins (folic acid, B-complex, etc.)). Jaggery not only provides energy but also helps to avoid rheumatic diseases, bile disorders, weakness, muscle, nerve, and blood vessel relaxation, regulates blood pressure and decreases water accumulation, and raises hemoglobin levels to prevent anemia (Ghosh et al. 1998). According to Ayurveda, jaggery is found to be useful in the treatment of throat and lung infections.

The regular and high consumption of white sugar results in many health-related problems including dental, stomach problems, diabetes, obesity, etc. However, jaggery is supposed to be a source of more wholesome and healthy sugars due to its inherent richness in minerals, antioxidants,

vitamins, and protein. Still, the wider societal acceptance and consumption of jaggery products are limited because of poor hygiene in manufacturing, the use of excessive chemicals to get attractive colors, and poor storability/shelf life of the produce. The per capita consumption of total sweeteners during the 1960 decade was 20.0 kg/annum, out of which 15.2 kg/annum consumption was of jaggery and khandsari products. However, the rate of consumption of these sweeteners came down slowly from 1960, and during 2018–19, per capita consumption of jaggery and khandsari is reported only to be 4.1 kg/annum (Table 1). This shows the societal tendency and more acceptances toward white sugar, without knowing the adverse effects of its consumption in recent times. People, especially the younger generation, prefer fast foods, desserts, and cold drinks made up of refined white sugar. Although, in this testing time of pandemic, jaggery products are gaining momentum because of health awareness and demerits of refined sugar consumption, however, there is still enormous scope to increase the consumption of this nutritious healthy sweetener (jaggery) by introducing and making different value-added products. Apart from making different shapes and forms of jaggery, powdered, granular, liquid formulations are now being manufactured for replacing the use of refined white sugar in bakery products, chocolates, confectionery, and beverages (Baboo et al. 1988). In the social sector, the usage of nutrient, mineral, and vitamin-rich jaggery value-added products is the need of the hour for substituting the white sugar products. Several powdered and liquid jaggery value-added products with a long shelf life and better quality are now available in the market which needs to be promoted. Production of chemical-free and organic jaggery is the recent developments in jaggery industry sector. Although jaggery itself is a nutritious sweetener, it can be blended and fortified with beneficial natural spices (turmeric, black pepper, fennel, caraway, etc.) and medicinally proven health-supportive herbs (holy basil, giloy, mint, triphala, amla, etc.) to produce even better antioxidant, detoxifier, digestive, and immunity booster products of potential functional and nutraceutical importance. Yang et al. (2020) developed a range of functional, nutraceutical, microcrystalline fortified brown sugar products with different beneficial herbs like P*hyllanthus emblica (Indian gooseberry)*, *Polygonatum* spp.(Solomon's Seal), *Dendrobium* spp.(Dendrobium orchid), *Pueraria montana* var. *Lobata* (Kudzu Vine), *Lepidium meyenii* (Pepper weed), *Panax notoginseng* (Chinese ginseng), *Citrus* x *limon* (Lemon*)*, *Vitis vinifera (*Grape vine*)*, *Zingiber officinale (*Ginger*)*, *Wolfiporia cocos* (Poria mushroom), *Hippophae rhamnoides* (Sea buckthorn), and *Angelica sinensis* (Dong Quai). These value-added products with improved nutritive value were found to be a rich source of bioactive compounds and they carry tremendous health benefits and are becoming quite popular in China. Several manufacturers have introduced a variety of value-added and fortified jaggery products like Dr Jaggery (www.drjaggery.com), Dhampur Green (www.dhampurgreen.com), Jugmug Thela (www.jugmugthela.com), etc. Recently, Dr. Jaggery has introduced a variety of value-added and fortified jaggery products namely jaggery with mint, turmeric, black pepper, triphala, giloy, cardamom, liquid jaggery with essential cardamom, nutmeg, and ginger oil, which can be highly nutritious and of health-supportive benefits (www.drjaggery.com). It has been discovered that combining value-added natural spices and herbs with jaggery not only provides health advantages but also improves the taste. The product range of value-added jaggery includes all three

Table 1 Per capita consumption of sugar, jaggery, and khandsari in India

Year	Population in Million (as on March 1)	Total Consumption of Sweetener (lakh tones)		Consumption Per Capita (kg per annum)		Total Per Capita Consumption of Sweeteners (Sugar, Jaggery and Khandsari) (kg per annum)
		Sugar	Jaggery and Khandsari	Sugar	Jaggery and Khandsari	
1960–61	439	21.13	66.87	4.8	15.2	20.0
1970–71	546	40.25	74.37	7.4	13.6	21.0
1980–81	684	49.80	85.22	7.3	12.5	19.8
1990–91	846	107.15	90.71	12.7	10.7	23.4
2000–01	1029	162.0	86.09	15.7	8.4	24.1
2010–11	1186	207.69	59.94	17.5	5.1	22.6
2017–18	1317	253.90	53.99	19.3	4.1	23.4
2018–19	1333	255.0	54.66	19.1	4.1	23.2

Source: Anonymous (2020a)

forms of jaggery-solid, powdered, and liquid, each having different types of additives. This dynamic range allows a wider selection choice for the consumer in society to replace or minimize the use of white sugar.

In this manuscript, we have discussed the importance and scope of value addition and fortification in jaggery that is known as an eco-friendly nutritive sweetener and potential alternative to sucrose. Jaggery is a traditional source of sweetener rich in minerals like calcium, phosphorus, and iron and is referred to as the most nutritious agent among all sweeteners (Madan et al. 2004) because it preserves most of the nutrients present in sugarcane juice as compared to white sugar. There is a huge potential scope for the existing jaggery market to develop interesting, innovative value-added products during the time of COVID-19 pandemic when there is an immediate focus on developing and sustaining immunity systems and adopting better food habits.

Different Forms of Jaggery

Jaggery is processed by boiling, concentrating, and clarifying sugarcane juice. There are basically three different forms of jaggery based on the processing viz. solid, liquid, and granular jaggery. The nutritional composition of all three types of jaggery is listed in Table 2. Solid jaggery is the most preferred type of jaggery, generally produced by clarification of raw cane juice and concentration of the clarified juice to attain the striking point of 118 °C–120° C. Then, the concentrated slurry is cooled and molded into different shapes based on the liking of the manufacturer and the marketing potential of value-added products (Anwar 2017). Structurally, it contains irregular-shaped anhedral microcrystals of sugar, enclosed with residues of molasses and other nutritious (vitamin and mineral) constituents of sugarcane juice. Studies have also standardized the process for making quality jaggery powder, for this, the juice is heated up to the temperature of 120–122 °C (striking point). The hot mass after removing from heat is allowed to cool. The mixture is then transferred from the pan to a solid metallic/wooden platform and left without stirring for crystal formation. After solidification of the lump, the powder jaggery is made manually by using wooden scrapers. The powder is then sieved and dried up to 1–2 percent moisture content before storage. This form has better storability due to low moisture content. For the preparation of liquid jaggery, the striking temperature of 105–106 °C is most suited and liquid jaggery thus produced has good quality with minimum microbial growth and crystallization (Singh et al. 2011; Sridevi 2008). Value addition and fortification of natural spices, herbs, vitamins, minerals, and other nutritionally important components/products in different forms of jaggery could be carried out simply by mixing (Anwar et al. 2011) or by co-crystallization technology (Yang et al. 2020).

Nutritional Components

Jaggery, made from sugarcane juice, has a pH of around 5.8–6.4 100 g of jaggery contains approximately 70–85 g of sucrose, 7–10 g of reducing sugars (glucose and fructose), 0.500–0.750 g fats, 0.35–0.45 g proteins, and 0.5–1.0 g ash contents. Jaggery is rich in important minerals like calcium, magnesium, potassium, phosphorus, sodium, iron, manganese, zinc, copper, and chloride, and vitamins like A, B1, B2, B5, B6, C, D2, E, nicotinic acid, and protein (Table 3) (Shrivastava and Singh 2020). Nakasone et al. (1996) has isolated around six antioxidants (Syringaresinol, Medioresinol, Coniferyl alcohol, sinapyl alcohol, and 3-hydroxy-1-(4-hydroxy-3,5 dimethoxy phenyl)-1 propanone, etc.) from *Kokuto* (Japanese jaggery). Jaffe (2015) reported that sugarcane jaggery also contains phenolics (280–320 mg/100 g jaggery). However, the

Table 2 Composition of different types of jaggery (per 100 g)

Particulars	Mineral content of different forms of jaggery		
	Solid	Liquid	Granular
Moisture (%)	3–10	30–35	1–2
Reducing sugars (%)	9–15	15–25	5–9
Non-reducing sugars (%)	65–85	40–60	80–90
Protein (%)	0.4	0.5	0.4
Fat (%)	0.1	0.1	0.1
Total minerals (%)	0.6–1	0.75	0.6–1
Calorific value (Kcal)	383	300	383

Source: Baboo and Solomon (1995); Singh (1998); Rao et al. (2007)

Table 3 Nutritional components of jaggery/100 g

Components	Range*
Calcium	40–100 mg
Magnesium	70–90 mg
Potassium	1056 mg
Phosphorus	20–90 mg
Sodium	19–30 mg
Iron	10–13 mg
Manganese	0.2–0.5 mg
Zinc	0.2–0.4 mg
Copper	0.1–0.9 mg
Chloride	5.3 mg
Vitamin A	3.8 mg
Vitamin B1	0.01 mg
Vitamin B2	0.06 mg
Vitamin B5	0.01 mg
Vitamin B6	0.01 mg
Vitamin C	7.00 mg
Vitamin D2	6.50 mg
Vitamin E	111.30 mg
Vitamin PP	7.00 mg
Protein	280 mg
Phenolics	280–320 mg

Source: Shrivastava and Singh (2020)

*The amount may vary depending upon the variety of sugarcane, soil, and method of processing

chemical composition of jaggery varies widely due to differences in the processed sugarcane varieties, climatic conditions, abiotic and biotic stresses, cultural practices adopted, use of different chemicals and vegetative clarificants, processing methodology of jaggery in different countries, etc. (Singh et al 2019).

Health-Supportive Value of Jaggery

Jaggery is considered as a medicinal natural sugar product because of its various biological properties and uses in Ayurvedic formulations. Indian scripts have narrated the nutritive importance and principal mechanism of jaggery in blood purification, rheumatic afflictions prevention, bile-related disorders (Sushruta Samhita, Chapter 45, Sloka 146). Shahi (1999) reported that because of the medicinal and nutritional properties, jaggery has attained huge scope for application in diversified food products. Jaggery is also referred to as nutraceutical because of the presence of a variety of essential amino acids, minerals, and vitamins. The bioactivity of jaggery is attributed due to the presence of micronutrients and polyphenols. Jaggery is a rich source of calcium that is essential for bone strength. Jaggery contains iron that helps in the prevention of anemia and also has anti-allergy properties, which helps to reduce stress and manage asthma-related problems (Singh et al. 2008). Magnesium present in jaggery (approximately 70–90 mg per 100 g of jaggery) helps to reinforce our nervous system, relax our muscles, relieve stress, and protect our blood vessels. The presence of potassium in jaggery helps in regulating blood pressure and heart functions. Calcium, phosphorous, and zinc are present in moderate amounts in jaggery that help to boost immunity and promote good health. It also helps to treat jaundice by purifying the blood, preventing rheumatic diseases. Jaggery also functions as an antioxidant because of the presence of selenium and it has the ability to detoxify free radicals from our bodies. It has been used for different health-related issues like cooling, diuretic, mental refreshment, besides improving throat conditions. It is also known to increase sperm count and is lactogenic (Anonymous, 2018). Jaggery is used as a remedy for cough and stomach ache, indigestion, gastric acidity, and constipation. It was reported that jaggery was found to be a remedy for the normal functioning of the lungs (Sahu and Paul 1998).

A refined sugar undergoes huge nutritive losses due to multiple chemical processing, whereas jaggery is prepared in a natural way and is a relatively unrefined sugar, hence retains more natural nutrients and other bioactive components required for human health. In the ancient Indian Ayurvedic system, sugarcane jaggery is mentioned to cure most of the ailments affecting the human body. It is also quoted that old jaggery is comparatively more beneficial in medicinal therapies (Pandey 2010). Jaggery is a digestive stimulant that aids in the improvement of digestion and appetite. Many naturopaths and alternative therapies advise eating jaggery after a meal to aid digestion. However, it is a common practice among people in India and Mediterranean countries experience abdominal heaviness after consuming a meal. The conversion of jaggery to acetic acid in the stomach improves the enzymatic activity of the abdomen, which increases digestion and appetite. Ayurveda also recommends jaggery for migraines and for cleaning the clotted blood from the body during pregnancy. The capacity of jaggery to prevent smoke-induced lung lesions in smoking populations suggests that it could be used as a safe food for employees in dusty and smoky environments. Jaggery is capable of combating the genotoxic effects of arsenic, as a result, it makes it easier to breathe and naturally combats pollution (Singh et al. 2008). The dust clogged in the food pipe of workers in these industries could be removed by consuming jaggery (Sahu and Paul 1998). The majority of the rural population utilizes jaggery as the most suitable natural functional food.

Fig. 1 Different value-added and fortified jaggery products newly made available in the market that are selling jaggery with value additions for enhancing the nutritional properties. (i) Giloy (*Tinospora cordifolia)* jaggery (ii) Ginger (*Zingiber officinale)* jaggery (iii) Split gram jaggery cookies (iv) Jaggery yogurt (v) Mint (*Mentha)* jaggery (vi) jaggery with clarified butter and chestnut (vii) Jaggery fortified with spices and herbs (viii) Jaggery-coated split chickpea (ix) Cardamom oil (*Elettaria cardamomum)* fortified liquid jaggery

Value Addition and Fortification in Jaggery

Jaggery is a health-supportive superfood that can be used alone or in combination with other beneficial products. This natural healthy sweetener has the tremendous potential to combine with a range of other natural health-supportive products like spices, herbs, lentils, etc., that further enhances its nutritious value. Different groups and manufacturers have now been producing diverse jaggery-based value-added and fortified products (Fig. 1) which are available in the market for consumption and mostly liked by the majority of the population in their daily diets.

Value Addition with Nutritionally Important Herbs and Spices

The ancient Ayurvedic system of medication has mentioned a range of medicines that are derived from sugarcane juice and jaggery and their use in the treatment of different diseases (Table 4). Sugarcane juice ranging from 0.6 to 13.5 percent, Sharkara (sugar or khand) to the tune of 2–74 percent, and sugarcane jaggery ranging from 10 to 87 percent have been utilized in the manufacturing of various Ayurvedic tablets, *Choornam*, and other products listed in Table 4 (Anonymous 2012c). While Yang et al. (2018) utilized 3–6 percent of various herbs for value addition in the jaggery, commercial brands such as Dr. Jaggery have employed herbs and spices ranging from 2 to 11 percent in their value-added/fortified jaggery products (Rao et al. 2021). The administration of jaggery used in Ayurvedic preparations has been found to improve memory and intellect (Ayurved -prakaran of the Aachar Khand, Chapter 192) (Anonymous 2000). These benefits of jaggery are due to the presence of iron, calcium, phenolics, and other antioxidants (Jaffe 2013). Besides, jaggery has also been extensively mentioned in Indian *Purans* and *Samhita* (Harita Samhita, Sharangdhar Samhita, Bhavprakash Nighantu, etc.) for the preparation of Ayurvedic medicine formulation like decoction, paste, pills, and powder (Shrivastava 2017; Shrivastava and Singh 2020). These ancient literature works claim that consuming jaggery in the right medicinal combination can cure almost all the diseases of the human body.

Traditional recommended spices and herbs like dry ginger, turmeric (0.03–0.11 mg/100 g antioxidant), black pepper, holy basil (39.67 mmol/100 g antioxidant),

Table 4 Value-added and fortified jaggery products and its benefits

S.No	Value-added product	Benefits	References
1	*Trifla (Haritaki (Terminalia chebula), Aonla (Phyllanthus emblica), Bahera (Terminalia bellirica)* and jaggery (Dr. Jaggery Gur-Ambika)	Removes fatigue/laziness/inertia, freedom from common diseases, improvement in eyesight. Enhances body strength, hair will start turning dark, signs of aging start disappearing, voice and speech will improve, beneficial in muscular skeletal disorders	Ayurved -prakaran of the Aachar Khand (Chapter 167). (Chapter 172). *Agnipurana* (Chapter 285). *Mritasanjivan karaka siddh yogon ka kathan, Aarogya Ank*, 9th Edition, 14th Reprint; Gita Press, Gorakhpur, Jeena and Ramadasan 2000, Rao et al. 2021
2	*Ghrit* (clarified butter) and jaggery	Cures almost all diseases of human body	*Ayurved -prakaran* of the *Aachar Khand* (Chapter 167)
3	Sugar, honey, and jaggery	Manages most of the human diseases	*Agnipurana* (Chapter 280). *Sarva roghar aushidhiyon ka varnan*
4	Yoghurt (curd) and jaggery	Destroys muscular skeletal disorders	*Ayurved -prakaran* of the *Aachar Khand* (Chapter 169)
5	Ghrit (clarified butter), honey, sugar, jaggery, salt, dried ginger, with black pepper (*Piper nigrum*) or *pippali*, *Piper longum*)	Beneficial in most of the human diseases (*sarv-rogvinashak*)	*Ayurved -prakaran* of the *Aachar Khand* (Chapter 174)
6	*Ananta* or *Dhamasa (Fagonia arabica)* and *Shringvera* (*Zingiber officinale*) in equal quantity and mixing equal quantity of Guggul (*Commiphora wightii*) and jaggery	Cures flatulence and indigestion	*Ayurved -prakaran* of the *Aachar Khand* (Chapter 183)
7	Ash of the leaves of *Ketki* (Screwpine), screw pine or *kewda* (*Pandanus fascicularis*) with *jaggery*	Remedy for spleen disease	*Ayurved -prakaran* of the *Aachar Khand* (Chapter 184)
8	Gum of lemon (*Citrus*) (having seeds) with jaggery and *ghrit* (clarified butter)	Improves digestion and metabolism, lowers cholesterol, prevents scurvy, kidney stones, and cardiovascular arteriosclerosis, anti-inflammatory, reduce blood pressure and blood lipids, inhibits tumor growth, an antioxidant, can regulate neuronal injury and pain response	*Ayurved -prakaran* of the *Aachar Khand* (Chapter 184), Anonymous 2002, Miyake et al. 2006, Gattuso et al. 2007, Pradeep and Kuttan 2002, Shi 2006
9	Dried ginger (*Zingiber officinale)* mixed with *Yavkshaar* (Nitre) with equal quantity of jaggery in the morning	Cures indigestion	*Ayurved -prakaran* of the *Aachar Khand* (Chapter 186)
10	Banana (*Musa spp.*) roots and *jaggery* cooked in *ghrit* (clarified butter)	Kills stomach borne worms	*Ayurved -prakaran* of the *Aachar Khand* (Chapter 190)
11	Pumpkin (*Cucurbita pepo*) juice mixed with jaggery, sugar, and milk	Management of snake poison	*Ayurved -prakaran* of the *Aachar Khand* Chapter 191) (Anonymous 2000)
12	Barley (*Hordeum vulgare*), sesame (Sesamum indicum), Ashvgandha (*Withania somnifera*), musli (*Chlorophytum borivilianum*), *Sarla* (black Basil) and jiggery	Works as anti-aging and gives strength to the body	*Ayurved -prakaran* of the *Aachar Khand* (Chapter 182)
13	*Ashvagandha* (*Withania somnifera*), *Naagbala* (*Sida Veronicaefolia*), jaggery and *urd* (*Vigna mungo*)	Works as anti-aging and gives strength	*Ayurved -prakaran* of the *Aachar Khand* (Chapter 172 & 185)
14	Haritika(*Terminalia chebula*), *Chitrak* (*Plumbago zeylanica*), dried ginger, *Giloy* (*Tinospora cordifolia*), *Musli* (*Chlorophytum borivilianum*) and jaggery	For longevity, cures most of the diseases	*Agnipurana* (Chapter 283). Chapter 283- *Nana rognashaka aushadhion ka varnana*
15	Decoction of jaggery, drumstick (*Moringa oleifera*), *Nishoth* (*Operculina turpethum*) and rock salt	Overcomes inflammation and timidity,	*Agnipurana* (Chapter 283). Chapter 283- *Nana rognashaka aushadhion ka varnana*
16	*Haritika (Terminalia chebula)*, *Bhilavaan* (*Semecarpus aanacardium*), oil, *jaggery* and dates or *Khajur* (*Phoenix dactylifera)*	Useful in curing leprosy	*Agnipurana* Chapter 283- *Nana rognashaka aushadhion ka varnana*

Table 4 continued

S.No	Value-added product	Benefits	References
17	Jaggery, dried ginger (*Zingiber officinale)* and the three salts (Rock salt, *Vidang* salt and Black salt)	Remedy for hiccups	*Agnipurana* (Chapter 283). Chapter 283-*Nana rognashaka aushadhion ka varnana*
18	A medicinal preparation, '*Karavyadivati*' which contains jaggery	Heal anorexia/distaste	*Agnipurana* (Chapter 285) *Mritasanjivan karaka siddh yogon ka kathan* (Anonymous 1947), Shrivastava & Singh 2020
19	Dry pulp of unripe wood apple (*Aegle marmelos*), bark of mango, *Dhay* (*Woodfordia fruticosa*) flower, *Paatha* (*Allo vera*), dried ginger (*Zingiber officinale)* and *Svarasa* (juice) of banana (*Musa* spp.) roots, butter milk, and jaggery	Treat bad or chronic dysentery	*Agnipurana* (Chapter 285) *Mritasanjivan karaka siddh yogon ka kathan* (Anonymous 1947)
20	Giloy (*Tinospora cordifolia)* and jaggery (Dr. Jaggery Gur-Amrita)	Antioxidant, detoxifier, anti-inflammatory, anti-pyretic, antibacterial, antiseptic, and antiviral	Rao et al. 2021
21	Turmeric (*Curcuma longa)*, black pepper (*Piper nigrum),* and jaggery (Dr. Jaggery Gur-Rakshahar)	Antioxidant, detoxifier, anti-inflammatory, antibacterial, antiseptic and antiviral, help with digestive problems, and treat cough flu and infections naturally	Rao et al. 2021
22	Emblic or Indian Gooseberry (amla) (*Phyllanthus emblica* L.)and jaggery	Protects the body against oxidative stress, gives strength, coolant, and laxative, used in hemorrhage, diarrhea and dysentery, antibacterial, treats leucorrhea and atherosclerosis	Anwar et al. 2011, Chatterjee et al. 2011
23	*Whorled Solomon's Seal* or Mahameda *(Polygonatum) and* jaggery	Lower blood glucose, anti-inflammatory, antibacterial, and anti-tumor, antiviral, enhances memory, anti-aging, anti-osteoporosis	Wang et al. 2011, Yan et al. 2000, Bodnar et al.1998, Zen et al. 2012
24	Pseudoginseng or Himalayan ginseng (*Panax pseudoginseng)* and jaggery	Promotes hemostasis, improve cardiovascular and cerebro vascular systems, regulate immunity, anti-inflammatory and anti-tumor has an anti-atherosclerosis effect	Gao et al. 2014, Wong et al. 2017, Yang et al. 2018, Li et al. 2011
25	May-tree or whitethorn, or, thorn apple (*Crataegus*) and jaggery	Alternative treatment for hypertension, prevent and treat cardiovascular diseases, hyperlipidemia, coronary arteriosclerosis, and coronary heart disease, improve digestive disorders,anti-tumor, anti-inflammatory,lipid-lowering, and antioxidant	Rigelsky and Sweet 2002, Wang et al. 2011, Willer et al. 2012, Rodrigues et al. 2012, Salam et al. 2012, Ozturk and Tuncel 2011
26	Essential oil of ginger (*Zingiber officinale*), nutmeg (*Myristica fragrans*), and liquid jaggery (Dr. Jaggery Gur-Hitakara)	Blood purifier, controls acidity, gives strength and increases hemoglobin level in blood. It can be used as a dietary supplement to recover the lost energy during diseases, helpful to act as antioxidant, detoxifier, anti-inflammatory, and antibacterial	Rao et al. 2021, Mahboubi 2019
27	Dry ginger *(Z. officinale)*, turmeric *(C.longa)*, black pepper *(P. nigrum)*, holy basil *(Ocimum tenuiflorum)*, cinnamon *(Cinnamomum verum)*, licorice (*Glycyrrhiza glabra)*, long pepper, clove (*Syzygium aromaticum)* and black cardamom (*Amomum subulatum*) and jaggery (Dr. Jaggery Gur-Ojasvita)	Antioxidant, detoxifier, anti-inflammatory, antibacterial, antiseptic and antiviral; help with digestive problems, and treat natural infections like cough and flu, perfect in building resistance in the body against viral and bacterial infections	Rao et al 2021, Anonymous 2012a

Table 4 continued

S.No	Value-added product	Benefits	References
28	Essential oil of cardamom (*Elettaria cardamomum*) and liquid jaggery or '*kakavi*' (Dr. Jaggery Gur-Ananta)	Antioxidant, detoxifier, diuretic in nature, used to treat cardiovascular, blood purifier, cures stomach and kidney-related diseases, anti-inflammatory, antibacterial, helps with digestive problems, and treats bad breath and infections, improves digestion/appetite and fight against pollutants	Rao et al 2021, Ashokkumar et al. 2020
29	Mint oil *(Mentha)* and jaggery (Dr. Jaggery Gur-Siatalah)	Natural coolant, builds resistance against viral and bacterial infections, improves digestion/appetite and fights with natural pollutants, work as antioxidant, detoxifier, anti-inflammatory, and antibacterial	Rao et al 2021, Anonymous 2012b
30	Dry ginger (*Zingiber officinale*), cardamom, fennel (*Foeniculum vulgare*) and star anise (*Illicium verum*) and jaggery (Dr. Jaggery Gur-Ananda)	Antioxidant, anti-inflammatory, detoxifier, antibacterial, help with digestive problems, anti-diarrheal, and strong antiviral	Rao et al 2021

Source: Shrivastava and Singh 2020, Yang et al. 2020, Rao et al. 2021

cinnamon (120.18 mmol/100 g antioxidant), triphala (706.25 mmol/100 g antioxidant), brahmi (10.40 mmol/100 g antioxidant), licorice, long pepper, cardamom, giloy (250 µg/mL, flavanoids), gooseberry (301.14 mmol/100 g antioxidant) are important not only for boosting immunity but also for preserving good well-being in today's stressful lifestyle, as well as for treating or providing relief from a variety of maladies. These spices and herbs contain natural ascorbic acid, lycopene alkaloids, terpenoids, lignans and carotene, bioactive components, polyphenols, phytochemicals, flavonoids camphene, geranial, zingiberene, curcumene, and some unique chemicals. These beneficial spices and herbs, when combined with a non-centrifugal sweetener like jaggery in the right proportions, not only make the product delicious to consume, but they also act as an antioxidant, detoxifier, anti-inflammatory, antibacterial, antiseptic, and antiviral, aiding digestion and treating cough, flu, and infections (Rao et al. 2021).

Value Addition with Other Nutritious Product

It has been suggested that drinking warm water with jaggery first thing in the morning on an empty stomach helps to regulate our body temperature and can also help to balance our metabolism. It boosts the natural digestive enzymes, speeds up digestion, and is also helpful in dealing with any kidney-related ailments. Jaggery and warm water also help to detoxify the body. This combo also catalyzes bile movement, controls acidity, and results in the optimum secretion of gastric acid, helping in body weight control (Anonymous 2020b). Roasted gram or split chickpea, a naturally rich source of vitamins, fiber, and proteins, complements a bite of the jaggery-based product perfectly. The potassium magnesium, vitamins B1, B6, and C, and high fiber in jaggery and proteins in roasted chickpea help to strengthen muscles, remove toxins, and helps in cleaning the digestive system. The potassium content in jaggery helps in balancing the electrolyte and mineral level in the body, boosts metabolism, gives energy with a low-calorie count. Jaggery and split chickpea also contain phosphorus that is required for strengthening the bones and beneficial for the teeth. The potassium component present in jaggery and chickpea and zero fat contents in chickpea lower cholesterol levels in the blood and reduce the risk of heart attacks. It also plays a pivotal role in managing acid levels of the body. Besides, jaggery has anti-aging properties because of the presence of glycolic acid (alpha-hydroxyl acids, AHA) and chickpea contains magnesium that is found to be beneficial in getting rid of facial wrinkles. Thus, consuming jaggery and chickpea together provides multiple benefits to the skin such as reducing fine lines, wrinkles, age spots, acne, and uneven skin color and brings a healthy glow to our skin (Anonymous 2020b). This superfood combination enriched with vitamin B6 is also helpful in improving our brain functions and coping with stress. A combination of turmeric and jaggery is effective in eliminating toxins from the body. The mixture of clarified butter and jaggery acts as an excellent detoxifying element. This combination when consumed aids in the elimination of toxins and reduction in body acidity. When clarified butter and jaggery are combined, it can help to relieve constipation also (Anonymous 2020b). They can also help in detoxifying our body, improve mood swings, and maintain the health of our skin, hair, and nails. Many health nutritionists have recommended consuming jaggery mixed with a tablespoon of clarified butter post-meal for optimum health benefits. Nutritive palatable value-added products could be made by inclusion of solid jaggery to puffed rice, sesame, and various kinds of nuts like peanut, cashew, almond, and taste enhancers like chocolate

powder, etc., in different proportions. The jaggery product made with cocoa powder (10 percent) is found to be very much accepted as a replacement for usual chocolate (Said et al. 2013). Peanut and jaggery combinations also produced a variety of high-energy nutritive food products composed of many bioactive molecules, vitamins, and minerals. Similarly, different kinds of seeds like sesame, flaxseed, chia, sunflower, melon seeds that are rich sources of antioxidants can be used in combination with jaggery to produce fortified value-added energy food products.

Jaggery candies and jaggery cake prepared with different seeds, nuts, lentils, and spices are examples of other commercial products. Jaggery can also be used to make flavored alcoholic drinks. For the weak and malnourished people, value-added jaggery would be a cheap source of nutrition (Said et al. 2013). Solid and liquid jaggery can also be enhanced with natural flavors like lemon, strawberry, chocolate, and pineapple, or nutritious supplements such as protein, vitamins, and minerals, or texture with various additives, and taste with the addition of nuts, spices, cereal, and pulses. Furthermore, numerous jaggery value-added products, such as locally created Indian sweets like rosagolla, peda, curd, and laddu (containing puffed grains, almonds, and sesame, among other things), have increased in popularity and consumption in the society (Nath et al. 2015).

Conclusion

Jaggery is nutritionally beneficial and contains useful nutritive and nutraceutical elements needed for a healthy human life. The value-added jaggery products increase the nutritional and functional value of the product, enhancing dietary and health advantages. The addition of several herbal elements to jaggery amplifies its medicinal value and can be recommended for daily use. The awareness of health-boosting, diverse benefits of jaggery, and its value-added products should be publicized and popularized in society for better healthier and happier living.

Declarations

Conflict of interest The mention of trade names or commercial goods in this article is purely for the purpose of providing specific details and does not mean that the authors recommend or endorse them.

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