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Review Article

A Review of Nutritional Facts, Production, Availability and Future Aspects of Coconut Palm Sugar

Muhammad Tuseef Asghar[1,2], Yus Aniza Yusof[1,3*], Mohd Noriznan Mokhtar[1], Mohammad Effendy Yaacob[1], Hasanah Mohd Ghazali[4] and Lee Sin Chang[4]

[1]Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, Serdang, 43400 UPM Selangor DE, Malaysia; [2]Department of Farm Machinery and Power, University of Agriculture, Faisalabad. 38000, Pakistan; [3]Laboratories of Halal Services, Halal Product Research Institute, Universiti Putra Malaysia, Serdang, 43400 UPM Selangor DE, Malaysia; [4]Department of Food Science, Faculty of Food Science and Technology, Universiti Putra Malaysia, Serdang, 43400 UPM Selangor DE, Malaysia

ABSTRACT

Coconut palm (Cocos Nucifera L.) sugar with its low GI value and micro and macro nutrition contents is focused in developed countries as a natural alternative to unhealthy cane sugar and more beneficial for farmers as compared with copra production and cane sugar production. Coconut palm sugar (CPS) is available in the forms of syrup, blocks and granular sugar. Granular CPS can be a better substitute for regular sugar as it would be convenient and healthy to use. CPS is important therapeutically as it is an antioxidant, antidiabetic, renal treatment, menstrual disorder treatment, and treatment for deficiencies of hemoglobin and vitamins. CPS production is less than demand due to lack of advanced production technologies. Coconut sap contains 12-15% sugar and very susceptible to spontaneous fermentation and converted to alcohol. It is necessary to utilize or process the sap as soon as possible. Traditional production is unhygienic, laborious and time-consuming keeps many coconut farmers away from CPS production even production of CPS can earn more economic benefits for local farmers. It can be produced traditionally by evaporation of coconut sap at 115oC to 120oC for 3 to 5 hours. Advanced techniques like vacuum drying, freeze drying, and spray drying etc. can also be used for hygienic but small in quantity and more costly production of CPS. Dry granulation may be a low-cost technique for mass production of granular CPS. It can be best stored at moisture content less than 2-4%.

Keywords: Coconut palm sugar processing, syrup, blocks, granular sugar, micro nutrients and minerals

INTRODUCTION

Today world is conscious about sweeteners due to increasing threats of diabetes, obesity, hypertension and heart diseases and many other related concerns. It is due to increased amounts of sugars in foods, soft drinks and sweets [1]. The natural and artificial sweeteners have become important ingredients of human diet and also carry prime importance for dieticians and in the food industry [2]. Coconut palm sugar serves as natural sweetener with distinctive taste and colour which cannot be easily substituted by any other kind of sugar and it is also a natural brown colour agent for large number of foods and beverage [3]. Kroger et al. [4] explained that low sugar, reduced-sugar or sugar-free food products are getting popularity in the US and all over the world, are made by ingredients those are common in food supply chain. Many sweeteners are available in markets right from sucrose (sugar cane, sugar) the widely-used sugar to low-calorie sugars like aspartame, neotame, saccharin, acesulfame-K and sucralose are of interest. Many polyols (alcoholic sugars) like mannitol, sorbitol xylitol and other bulk sweeteners are also acceptable for using in food products with their limited use to avoid gastrointestinal discomfort. These sugars are highly processed, very costly and of major concern for halal certifications. The availability of different sweet alternatives of sucrose is beneficial for consumers as it allows food manufacturers healthy, good taste, sweet foods and beverages which are low in calorie and safer for teeth as compares with regular sugar-sweetened foods. The artificial sweeteners are getting more popular and receiving much more attention. But their safety issue draws bad reputation to them and these rare sugars cannot meet the demand, application, commercial availabil-

Correspondence to: Yusof YA, Department of Process and Food Engineering, Faculty of Engineering, Universiti Putra Malaysia, Serdang, 43400 UPM Selangor DE, Malaysia. Tel.: +60-3-8946-4425; fax: +60-3-8946-4440; E-mail: yus.aniza@upm.edu.my

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ity and usefulness being limited as they are unavailable in nature and expensive to prepare [1]. Extensive research is required to find suitable natural sweeteners like thaumatin and stevia. The tropical regions like Indonesia, Malaysia, Philippines, Sri Lanka, India and Thailand are rich in natural source of alternative sweeteners like Asian Palmyra Palm (Borassus flabellifer Linn.) commonly known as palm sugar and coconut palm (Cocos Nucifera L.) sugar or coco sugar with low glycemic index (GI) [5]and [6]. In the past, the palm sugars were found to be marketed as low glycemic index (GI) foods with no or little evidence of published literature. But recently the coconut palm sugar is reported to be a low GI sugar with GI of 35+4 to 42+4 [7] and [8]. Coconut palm sugar is a natural product made from freshly collected sap from unopened spadix of the coconut tree. It is widely grown in south Asia, Africa, South America, Australia and other tropical countries [9]. Ysidor et al. [10] and Kusumawaty et al. [8] mentioned that the coconut sap records great valorizations in south-eastern countries of Asia (Indonesia, Malaysia, India and Philippines etc.) which have largest farms of coconut in the world. The origin of coconut palm tree is Southeast Asia (Malaysia, Indonesia and Philippine) and islands between Pacific and Indian Oceans. The fruit of coconut is believed to be brought to India from the Pacific region and then introduced to East Africa. This plant was then introduced to West Africa after the discovery of Cape of Good Hope, from where it dispersed to other tropical and American continent [11].

HISTORIC USE OF SUGAR IN DIFFERENT REGIONS

Redhead and Boelen [12] in their studies took palm sugar as a very first source of sugar. Greek historian Megasthenes reported the use of Palmyra palm (Borassus flabillfer) sugar in 4th century BC. [13]. The evidence of sugar extraction in India is even more than 4000 years old [14]. The sap from fishtail palm (Caryota urens) had been used for making of solid sugar blocks (jaggery) and liquid sugar syrup (treacle) in Sri Lanka [15]. The main traditional use of palm in Africa is wine production, similar use has been reported in Egypt long before the birth of Christ by [16] and on the coast of Guinea by early navigators during the 15th century [17]. Different palm species have been tapped for several years to produce fresh juice (sweet toddy), fermented wine drink (toddy, arak, wine), syrup (honey), and block sugar (jaggery). Coconut palm (Cocos Nucifera L.) sugar is known as “Gula Melaka” in Malay “Gula Kelapa” in Indonesia, “Pakaskas” in the Philippines and “nam tan puek” in Thailand. The sap derived from incision of the inflorescence of the coconut is called as” Kallu “(Tamil vernacular) or as “toddy” (English), a fermented native beverage (Tamil nadu) or tuba (Philippines), tuak (Indonesia) and neera air (Malaysia) [18]. Coconut palm sugar is directly consumed as an ingredient for making of cakes, desserts, drinks and food coatings [19]. Coconut plant with its fruits opened and unopened flowers are shown in .

ENVIRONMENTAL AND SOCIAL IMPACT

Palm tree benefits the environmental ecology by restoring the damaged soil using a very little amount of water during the restoring process [20]. In South and Southeast Asia, many species of palms are tapped to produce fresh juice, fermented drink, syrup, blocks and granular sugar. Main palm species (see) like sugar palm (Borassus flabellifer) “Enau” in Malay, coconut palm (Cocos Nucifera L.) “Kelapa” in Malay and mangrove or nipa palm (Nypa fruticans) “Buah nipah” in Malay if tapped under proper management can produce more sugar as compared with sugar cane. Most of these tapped palms not only produce sap drink and sugar but also critically affect the socio-economic status of rural poor by producing edible fruits, fibers, polymers and building materials [20] and [21]. Sap, if compared with coconut water, is richer in phytochemicals and nutrients. Physiologically, tapping when compared with production of nuts and water is more energy efficient and produce more economic returns [22].

This randomized, single-blinded, parallel-group comparison study was conducted according to the principles stipulated in the Declaration of Helsinki. Written informed consent was obtained from all participants prior to their participation in the study, which was conducted from February to April 2017. This study was approved by the Institutional Review Board of Shinkokai and the Meiji Institutional Review Board (UMIN000025966).

QUALITY OF SAP AFTER COLLECTION

The pH of coconut sap keeps on decreasing during collection due to increasing microbial loads that leads to increasing total acidity of the sap[23]. The decrease in pH cause sucrose inversion and lower the quality of sap. Thus the long collection time causes low pH, high amounts of total acidity and reducing sugar resulting in the low recovery of sugar from sap [24]. Loetkitsomboon [25] also, found the comparable results by increasing the reducing sugar (from 0% to 0.78%) significantly decrease the amount of recoverable sugar. Ysidor et al. [10] reported that the quality of coconut sap deteriorated during storage, especially the sugar contents dropped significantly, pH also dropped, and phenol contents were increased to more than double. Reducing sugars and proteins also increased concluding that the processing should be as soon as possible to recover more and more sugar. Odunfa [26] found that the major sources of fermenting organisms are tapping implements, gourds and air. Okafor [27] and Sanni [28] reported that yeasts particularly Saccharomyces cerevisiae is dominating among fermentation organisms. However, the shelf life of coconut sap is always a limiting factor for its valorization. Undeniably, the fast spoilage of coconut palm sap due to its rich nutritional composition and it is deteriorated by microorganisms associated with unhygienic production conditions and environment [29]. The glaucids of the sap undergo prompt deterioration after harvesting producing many volatile compounds like acids, alcohols, ketones, aldehydes and esters resulting in the instability of the product [29] and [30]. Borse et al. [29] reported that compounds like isoamyl alcohol along with other compounds such as ethyl caprate, ethyl lactate, ethyl caprylate, phenyl ethyl alcohol, palmitoleic acid and dodecanoic acid are responsible odor of fermented coconut sap further ethyl alcohol contents of fresh, clarified and fermented sap were found to be 0.07%, 0.06% and 2.56% respectively.

CHANGES IN PH AND SUGAR CONTENT OF FRESH SAP

Hebbar et al. [22] studied the behavior of pH of freshly harvested coconut sap and explained that fresh sap is slightly alkaline in nature with pH of 7.5-8 that varies from tree to tree. Its fermentation begins within 2 to 3 hours of collection under ambient conditions with decreasing pH trend and results into completely fermented sap with pH 3.5. No change in pH was observed when the sap was stored in a deep freezer at -2°C to -1°C. Fresh sap with pH around 7.5 has about 15% sugar that reduces to 6% at pH 4. During the same period, the level of reducing sugar increased to 5%. When

the fresh sap is exposed to atmosphere undergoes initially lactic fermentation and finally alcoholic fermentation due to the actions of microorganism [29]. Spontaneous deterioration of sap due to the highly fermentable nature of sap has prompted developments in sap processing to improve its shelf life as clarified and processed sap is suitable for longer storage [31].

PRODUCTS FROM COCONUT SAP

Barh and Mazumdar [32] and Steinkraus [33] mentioned that the fresh sap can be converted into coconut palm sugar (Tamil Nadu and Kerala) and palm blocks known as "jaggary" in West Bengal by evaporation of sap on heating and to alcohol and vinegar by fermentation.

PROCESSING OF COCONUT SUGAR FROM SAP

Hebbar et al. [22] reported that coconut sap is rich in sugar contents (about 15%) and considerable amounts of many other nutrients that can be easily used to produce various value-added products. Coconut sugar syrup (honey), coconut sugar blocks (jaggery) or coconut granular sugar can be produced by evaporation with continuous stirring of unfermented coconut sap at 115-124°C.

COCONUT SYRUP OR HONEY

Srikaeo and Thongta [34] explained that the coconut syrup is produced by pouring the fresh coconut sap into a big wok from bamboo tubes or other collection utensils, samples for alkalinity, sugar contents and solid contents were taken and remaining large quantity was heated at around 97°C up to 120 + 2°C continuously for about 3.5 hours. It was occasionally stirred during the heating process. After realizing the viscous and fairly thick hot syrup with Brix level of 75°-80°, the heating was stopped, and the wok was cooled to get coconut sugar syrup (honey).

COCONUT SUGAR BLOCKS

Coconut sugar blocks are obtained by heating large quantity of fresh sap from bamboo tubes or other collection utensils poured into a big wok, at around 97°C up to 124 + 2°C continuously for about 4.0-4.5 hours. It was occasionally stirred during the heating process, achieving the viscous and fairly thick hot sap with 85° Brix, heating was stopped and syrup was cooled for 10 minutes while continuously stirred and finally poured into molds for solidification in the form of coconut sugar blocks, this process is similar to that of arrenga palm sugar as described by [35] the block is shown in .

COCONUT GRANULAR SUGAR

The process used for production of granular coconut palm sugar similar to the production of coconut sugar blocks but in this case the heating process is continued to achieve more than 85° Brix as explained by [35] who reported that the heating was stopped when the viscous and fairly thick hot syprup with 85° to 90° Brix was realized, it was then cooled while stirring continuously, sheared and pressed. The stirring speed was enhanced when the sugar started forming granules, finally converted granular coconut palm sugar, the sugar was then passed through a sieve to obtain uniform particle sized, superior quality sugar as shown in Figure 5.

PRODUCTION METHODS OF COCONUT PALM SUGAR

Ho et al. [36] explained the process for palm sugar production. In this process, a large volume of filtered sap is taken in a big wok and heated on wood or gas fired stove for 3 to 5 hours at 100°C until it is concentrated with a specific typical aroma. In this process, mainly two major reactions took place, Maillard reaction and caramelization. After heating, the concentrated sap is poured into steel or bamboo molds to form its ready to pure solid sugar [19]. Many other researchers like, [22]; [35]; [24]; [37]; [5]; [38] also reported the same process for palm sugar and coconut palm sugar production.

TRADITIONAL PRODUCTION

Palm sugar or palm syrup is produced traditionally by heating filtered sap in an open pan on the wood stove at 100°C for 3 to 5 hours until it is concentrated. Throughout the process quality of final product is determined by measuring its Brix level, colour intensity, thickness, viscosity and aroma. This process requires continuous heating of 3 to 4 hours and a huge amount of energy to produce concentrated product by evaporation of excess water from coconut palm sap. The process is continued until the total solid level of 65° Brix or above is realized. The process of production especially heat at an elevated temperature and heating time accelerates inversion and non-enzymatic browning reactions. Overheating change the properties (unique flavor and colour) of syrup and sugar. Vacuum drying was preferred for the production of coconut palm sugar syrup to avoid darker colour of coconut palm sugar syrup [37] and [24].

VACUUM DRYING

Vacuum drying can be used to produce dried palm sugar. Increasing temperature and time altered the physicochemical properties of the vacuum-dried powders. Based on the results of these studies, the drying condition of palm sugar at 40o C for 3 h delivered the highest total phenolic content and antioxidant activities of dried palm sugar. Vacuum drying can minimize the loss of phenolic compounds and antioxidant properties [39]. Naknean et al. [5] concentrated palm sap using vacuum dryer at 70oC and 80oC sugar to produce palm syrup with Brix level 70o and found that the vacuum drying improved the quality of palm sugar syrup as compared to open pan method. To date, there is still no such process was applied to prepare granular coconut palm sugar.

DRY GRANULATION METHOD

Iskandar et al. [35] studied the transformation of arenga palm sugar blocks into arenga palm sugar granules using 2-3mm slices by drying them on 70oC, 80oC and 90oC recommending 80oC the best temperature for dry granulation process and found that process time and temperature affect the quality and crystallinity of granular palm sugar significantly and explained that microstructure and morphology of granular palm sugar were not dramatically different whether the granular sugars were produced by wet granulation or dry granulation but crystallinity was found to different in both processing techniques.

SPRAY DRYING

Jayasundera and Kulatunga [40] investigated the drying process and produced coconut treacle (made by boiling the coconut sap) powder by spray-drying using different formulations of coconut treacle: maltodextrin: water using inlet and outlet temperature of 165°C and 65°C respectively finding the best recovery at 35%:15%:50% and determined particle analysis, physiochemical

properties, storage properties and sugar profile.

OTHER PROCESSING METHODS

Uttraporn [41] explained the effect of evaporation method on the quality of coconut palm sugar cake applying fast evaporation method using an electric pan and slow method using double-jacket kettle and studied the effect of evaporation on physical (L*, BI and hardness) and chemical quality (sucrose, glucose and fructose content) of coconut palm sugar cake. Higher L*, lower BI and higher hardness were observed in coconut sugar cake produced by fast evaporation method as compared with slow evaporation method. Naknean et al. [42] also, reported that the processing methods greatly influence the quality of palm sugar that was observed due to Maillard reactions caramelization which increased exponentially when heating time and temperature were increased [43].

COMPARISON WITH CANE SUGAR

Coconut palm sugar (CPS) also known as coconut sugar, coco sap sugar or just coco sugar. Coconut sugar is found to be better as compared to cane sugar as cane sugar only supplies calories, but coconut sugar also supplies nutrients in addition to calories. The mineral content of coconut palm sugar is higher as compared with refined and unrefined cane sugar and it is a rich source of magnesium, potassium, iron and zinc (Table 2). If compared with refined or unrefined cane sugar, coconut sugar is found to be two, four and ten times rich in iron, magnesium, and zinc respectively. In addition, coconut palm sugar also contains essential amino acids which are required for synthesis of protein, and it is also a rich source of vitamins B1, B2, B3 and B6 [22].

COMPARISON WITH STEVIA SUGAR

Stevia (Stevia rebaudiana Bertoni, Asteraceae) a "wonder" herb of Paraguay, is a gift of nature and used as non-caloric sweetener due sweetening property of its leaf. Stevia leaf is 30 times sweeter than sugar on dry weight basis and sweetness is due to steviol glycoside. The sweet compound pass through the digestive process without chemically breaking down, making stevia safe for diabetic and obese people [44]. Table 3 is a comparison of both stevia and coconut sugar in terms of production technology, cost, acceptability etc.

WORLD PRODUCTION AND DEMAND

There is a huge demand for coconut sugar, however, production and supply are limited. The recent revelations on the health benefits of coconut sugar in comparison with cane sugar have led to a sudden surge in the demand for coconut sugar in the international market. Indonesia, the Philippines and Thailand are the major producers and suppliers of coconut sugar to the global market [22]. PCA [45] reported that the Philippines has the greatest production share of 52%, Indonesia comes 2nd with a production share of 24%, Thailand holds the 3rd position with the production of 13% and rest produce only 11% of world coconut sugar production.

FUTURE PROSPECTIVE

Tarigans [46] reported that coconut sugar production can provide a better opportunity for small-scale coconut farmers as they can get relatively better income than that of copra-based products. Kusumawaty et al. [8] indicated a major problem in coconut sugar production, that is its quality as most of the producers make ordinary brown sugar while worldwide markets demand crystallized sugar and this problem is also associated with addition of chemical preservatives and whitening chemicals like sodium bisulphite which ultimately affect coco sugar attributes such as taste, colour and shelf life. Recently the advancements in coconut sap collection techniques and value addition of sap and associated health benefits have suddenly improved the local and international markets for coconut sugar and coconut sap as drink "Kalaparasa" Indian local name. Apart from improving local coconut farmer income switching to coconut sugar and coconut sap drink the coconut sap tapping exhibited huge advantages to the environment, local economy, customers and other crops farmers [22].

POTENTIAL

Shaw et al. [6] in his publication claimed that world prevalence of diabetes affected 285 million (6.4%) adults (aged 20-70 year) and will increase to 439 million (7.7%) adults by the year 2030. Furthermore, he mentioned that there will be 69% increase in diabetic adults in developing countries and 20% in developed countries. Masa [47] reported that the demand for coconut palm sugar is increasing due to increasing demand of low calories, reduced sugar and sugar free products, health awareness in food markets, due to increasing number of people with dental caries, obesity and diabetes, global market for low G.I., low calorie and non-sugar sweetener was about US$ 9.2B in 2010. PCA [48] reported that production of coconut palm sugar is a source of income for growing communities in different regions of the country. International markets for coconut palm sugar are Norway, France, Middle East, Japan, South Korea, Asia, USA, UK, Germany, New Zealand, Australia, Canada and France [45].

The development of new indigenous and local technologies for coconut sap drink, coconut honey, sugar blocks, granular sugar and the value-added products like toffees, chocolates, jam, syrup, ice cream, cakes and snacks etc. will enhance local economy by opening new horizons for poor farmers. One hectare of coconut trees can produce almost 19 tons sugar/year which more than sugar cane that can produce only 5-10 tons of sugar/year. Tropical countries like Malaysia, Thailand, Philippines, Indonesia, Sri Lanka and India are largest producers of coconut so they have a high potential for production of coconut palm sugar. Experiences from coconut-producing countries like Philippines and Indonesia show that CPS production is 8-10 times more profitable than producing nuts. A tapper as compared to another farm worker can earn twice per day with a huge advantage of being paid throughout the year. Many farmers are cultivating coconut trees thus they can produce organic coconut palm sap and sugar to earn more profit from local as well as international markets [22].

NUTRITIONAL VALUE

Barh and Mazumdar [32] studied sugar palm sap both (male and female), date palm and coconut palm sap to find available nutrients in sap and effect of fermentation on the quality and quantity of nutrients. The nutrients and their quantities in coconut palm sap before and after fermentation are given in . The comparison shows that coconut sap was found to be rich in nutrients as compared to all other saps. Steinkraus [33] considered coconut and palm sap nutritionally important as fresh and fermented but he was unable to describe the nutrients quantitatively.

BIOCHEMICAL AND MINERAL COMPOSITION

Hebbar et al. [22] reported that fresh coconut palm sap is rich in sugars, proteins and minerals, a rich source of ascorbic and phenolic acids also essential elements like N, P, K and Mg. Micronutrients like Fe, Zn and Cu are also found in coconut sap. But he did not explain the effect of processing on nutrients.

SUGAR CONTENTS

Kalaiyarasi et al. [49], Hebbar et al. [22] and many other researchers reported that fresh coconut sap collected from unopened inflorescences of the coconut tree is a rich source of sugar (12-15%) and also carry traces amounts of fructose, maltose and glucose etc.

THERAPEUTIC PROPERTIES

Antioxidant and antidiabetic properties: Renjith et al. [50] suggested that the extract of Cocos nucifera inflorescence in methanol possessed very good antioxidant properties and potential for scavenging of free radicals and this extract also found to be more active in controlling hyperglycemia induced by streptozotocin (STZ) that could be due to the existence of dietary fibers, polyphenols and partly due to the presence of amino acids like leucine, arginine and isoleucine which have antidiabetic properties as stated by [51] and [52]. This study also demonstrated the nontoxic nature and the cryoprotective properties, so a natural antidiabetic medicine from coconut inflorescence extract can be developed.

Treatment for type II diabetes: Devi et al. [53] reported that coconut palm sugar can be an excellent alternative to regular cane sugar due to its low GI and it can be used as therapeutic agents for the treatment of type II diabetes as it contains α-amylase.

TREATMENT FOR KIDNEY OR RENAL DISEASES

Coconut sap prevents kidney stones and flush the already built up stones and it contains phosphorus which is needed for revitalization and proper functioning of kidney [54]. [55] reported the use of coconut inflorescence water for treatment of kidney or renal diseases.

TREATMENT FOR MENSTRUAL CYCLE DISORDERS

Bhandary et al. [56]reported the use of coconut inflorescence water for treatment of menstrual cycle disorders. The infusion of the tender inflorescence is taken orally in the morning for continuous three days coinciding with the menstrual period for leucorrhoea and all other problems related to menstrual cycle.

TREATMENT FOR HEMOGLOBIN AND VITAMINS DEFICIENCIES

Barh and Mazumdar [32] studied the effect of date sap on hemoglobin deficient animatic and vitamins deficient patients and found it to be improvised treatment but in the same study the other finding was that coconut sap is even richer in many nutrients than date palm sap, but it was not studied as a treatment for anemic and vitamins deficient patients. So, the effect of coconut sap as treatment could have more potential and research is required.

Low GI coconut sap sugars

Foster-Powell et al. [57] and FAO and WHO [58] defined GI as incremental area under blood glucose response curve of 50 gram carbohydrate portion test diet expressed as the percentage of response to the same amounts of standard food carbohydrates taken by the same subject, endorsed the use of GI for carbohydrate-rich food classification and recommended the use of GI in conjunction with food composition tables to guide food choices. Trinidad et al. [7] found the glycemic index (GI) of local foods consumed in the Philippines and reported that coconut sugar and syrup being low in GI (35+4 to 42+4) are fit for diabetic people and are a better replacement for synthetic sugar due to their natural and conventional occurrence [59]. Standards expressed the GI of coconut palm sugar as 35. Low GI foods have shown the reduction in postprandial glucose and insulin and improvement in overall blood glucose and lipid concentrations in diabetes mellitus and normal subjects [60-64].

STORAGE

Since quality is supremely important in food, deterioration must be controlled during storage. Non-enzymatic browning may cause unacceptable nutritional and sensory effects in some stored food products and may be a limiting factor in the shelf life of products [38]. Thus, the study of the processing methods that influence non-enzymatic browning reactions is very important for coconut palm sugar syrup properties during production and storage. The information obtained from this study could be used as a guideline for optimizing or designing thermal processes to reduce the quality loss of this product. In addition, more detailed knowledge of coconut sugar syrup during processing and storage will be of benefit for producers and consumers [5]. Farooque [65] reported that the microorganisms responsible for deterioration of blocked sugar (jaggery) show maximum growth at moisture content of 10% and at a temperature of 30°C but Wig [66] observed that the freshly prepared block sugar contains 4% to 11% of moisture content while the optimum conditions for storage were found to be 7% to 8%. [67] recommended that the blocked sugar can be best stored at a relative humidity of 40% to 45%. Javalekar et al. [68] studied physical and chemical properties of stored sugar blocks. Uppal and Sharma [69] and Uppal and Sharm [70] suggested that some physiochemical properties like sweetness, colour and crystallinity of blocked sugar remained unchanged by keeping it in air tight storage container during the rainy season. Shreedevi [71] explained storage conditions for blocked sugar and mentioned that sugar blocks with higher moisture contents and open storage deteriorate fast and become unfit for human use. The blocked sugar wrapped in alkathene film, covered in a plastic pouch and then packed in the paper box could have superior quality. So, dry and harder sugar blocks stored in air tight and hygienic containers could have even better quality for a long time.

REVIEW OF PROCESSING

Research about palm sugar and coconut palm sugar has been conducted by many researchers such as Prakobsil et al. [72] reported that coconut palm sugar or coco sugar is produced from the sap freshly tapped from coconut flower stalks by boiling it, Hebbar et al. [22] explained that the coconut palm sugar can be prepared by evaporation of fresh coconut sap processing of coconut sap sugar at 115°C with continuous stirring for three-four hours and coconut palm syrup is obtained at 65° Brix level, sugar blocks at 85° Brix level and granular coconut palm sugar by cooling, pressing shearing and stirring the concentrate when the Brix level of more than 85° is reached, Naknean et al. [37] who characterized palm

sap during heating into syrup, Suwansri et al. [73] who conducted the crystallization of palm sugar syrup by adding can sugar, Amin et al. [74] examined the antioxidant activity of a palm sugar, like flavor on Maillard reaction of sucrose and amino acids (arginine, asparagine and glutamine) and Naknean et al. [42] examined factors that cause browning and crystallization of sugar syrup and sugar blocks from palm sap. These authors are less focusing on dry granulation using coconut palm sugar blocks. The purpose of the study was to determine the physio-chemical properties of the arenga palm sugar blocks and granules, to analyze process phenomenon of arenga palm sugar granules by dry granulation and to obtain the structure and morphology of arenga palm sugar granules [35]. Jagannadha Rao et al. [75] studied the effect of moisture content on the glass transition temperature (Tg) and sticky point temperature (Tsc) on sugar cane, palm sugar and palm sugar granules. Following describes the publishing year, title of research and focus of research conducted regarding coconut sap and coconut palm sugar.

CONCLUSION

The number of patients suffering from diabetes, obesity and heart diseases is increasing due increasing use of unhealthy cane sugar or other unsafe artificial sweeteners. CPS as natural, sweet and nutritional alternative is getting more popular among health-conscious people. It is also beneficial for coconut farmers as it can earn more money as compared with copra production. Tradition production is unhygienic, laborious and costly so some advanced, low cost and hygienic techniques should be introduced. A comprehensive research is required to find innovative ways for healthy, low cost and mass production of CPS to meet the world requirements.

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