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An Overview on Panela

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ABSTRACT: Sugarcane being a rich source of nutrients containing, phytocompounds, unique taste and aroma, where unrefined sugars (e.g. *Panela*) is produced from it. Panela is non-centrifugal cane sugar (NCS), a high carbohydrate-content food obtained by evaporation of water in sugarcane juice and is known by different name such as jaggery (South Asia), kokuto (Japan), Hakura (Srilanka), rapadura (Brazil), Gur/Desi (Pakistan) and Shekar sorkh/ Tabarzard (north of Iran). Despite the fact that panela has great properties and components, Panela is a relatively unknown product in Iran. According to the following literature review work and analysis provide and gain more information concerned with this product and its functional properties.

Keywords: *Food Composition, Health Benefit, Jaggary, Non-Centrifugal Sugarcane, Panela, Review.*

Introduction

Panela, a sugarcane product, has various names but Non-centrifugal cane sugar (NCS) is the technical term used by the Food and Agriculture Organization of the United Nations (Anon, 1994; Velásquez *et al.*, 2019). NCS is usually commercialized under local traditional names such as panela, jaggery, gur, muscovado, piloncillo, chancaca, kokuto, etc.

The NCS agroindustry is working on different strategies to respond to food consumption trends and to improve the competitiveness of this productive chain (Jaffe, 2015; Gutierrez *et al.*, 2018). NCS can be considered as a potential bioactive product, with antioxidant activity (AO) attributed mainly to the retention of a large amount of phenolic and flavonoids compounds of sugar cane juice (Asikin *et al.*, 2016; Nayaka *et al.*, 2009; Meerod *et al.*, 2019; Okabe *et al.*, 2008; Payet *et al.*, 2005; Seguí *et al.*, 2015) which in turn are responsible for the development of NCS aroma and color profiles (Lee *et al.*, 2018; Velásquez *et al.*, 2019). NCS is less processed compared to refined sugar, which helps preserving functional and nutraceutical components such as phytochemicals, vitamins, and minerals (Jaffé, 2015; Alarcón *et al.*, 2020) and is a valuable nutritional product from the sugarcane industry (Asikin, 2014).

- *Production of Panela*

Panela is the natural sugar obtained by intense dehydration and evaporation of sugarcane juice (*Saccharum Oficinarum*), without centrifuging, maintaining its constituent elements as sucrose, invert suger, fructose, glucose and minerals (Gomez-Narvaeza *et al.*, 2019; Anon, 2009; Galvis *et*

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al., 2019). The process to produce NCS begins with the milling of the sugarcane to obtain juice, as the main product, and bagasse as a by-product (residue), which constitutes the fuel for the concentration of the juices. Afterwards, the juice goes through a pre-cleaning system, where solid impurities are removed. Then, it goes to the clarification stage where the suspended solids are removed. After that, the juice goes to the concentration zone in open heat exchangers or "pan" where it is concentrated to 70^{o}Brix (Figure1). This concentration is obtained through the energy coming from the bagasse obtained in the grinding (Galvis *et al.*, 2019).

The NCS production requires a higher concentration of soluble solids between 92 to 95. Brix (García *et al.*, 2007). Finally, NCS goes through a process of beating, molding, cooling, demolding, packaging and commercialization (Galvis *et al.*, 2019).

The NCS making process started with cane juice with average values of pH 5.21, 1.42 g citric acid L-1, 8.6 g L-1 ash and 16.9 g L-1 of reducing sugars, obtaining NCS with average values of 5.53 pH, 0.85 g citric acid L-1, 26 g L-1 ash and 68.7 g L-1 reducing sugars (Galvis *et al.*, 2019).

- *Occurrence of acrylamide and other heat-induced compounds in panela*

- *Acrylamide*

Acrylamide has been detected in all the panela samples as described by Gomez-Narvaeza *et al.* (2019)'s studies regardless of the type of processing. The acrylamide content ranged from 60 to 3058 μg/kg. However, average acrylamide content was higher in granulated panela (812 μg/kg) as compared with block panela (540 μg/kg). Acrylamide is formed at temperatures higher than 120 °C from reducing sugars and asparagine (Capuano & Fogliano, 2011; Gomez-Narvaeza *et al.*, 2019). Agronomical factors and varieties of sugarcane have a significant influence on the final composition of the raw material, leading to variability in the level of these potential precursors of acrylamide (Duran- Castro, 2010; Gomez-Narvaeza *et al.*, 2019).

These results corroborate that temperature and moisture content are very important physical parameters, which affect the formation of acrylamide in the process of panela production, determining its accelerated formation at high temperatures. Recently, the Colombian National Institute of Drug and Foods Vigilance has stablished a mean value of 817 μg/kg of acrylamide in block panela collected from different Colombian producers (Anon, 2018; Gomez-Narvaeza *et al.*, 2019).

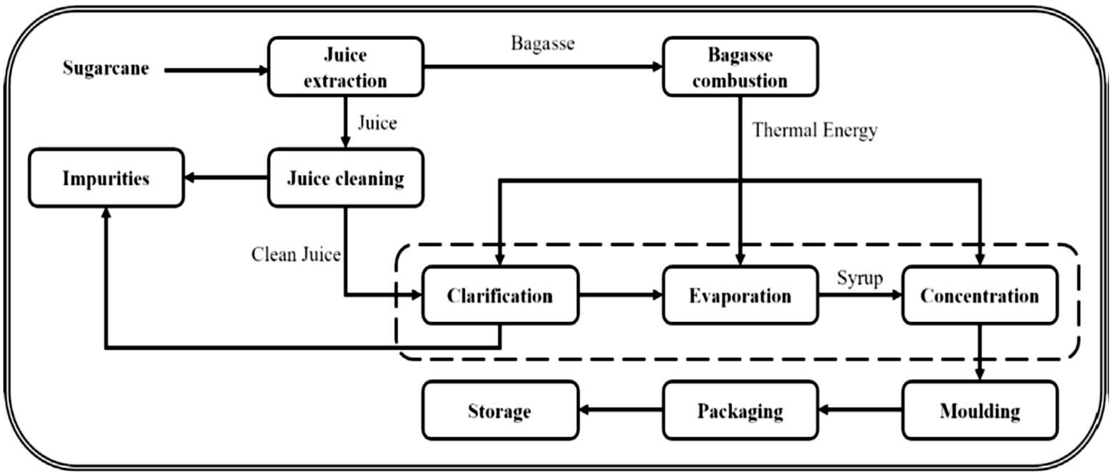

Fig. 1. Production diagram of a NCS (Velasquez *et al.*, 2019).

- *Hydroxy Methyl Furfural (HMF)*

The content of sugars and amino acids in non-centrifugal cane sugar (Asikin *et al*., 2017; Gomez-Narvaeza *et al.*, 2019), the low Aw and high temperatures applied during process justify the formation of furfurals in panela. HMF has two main pathways of formation:

i) as an intermediate during Maillard reaction

ii) a product of caramelisation by dehydration of sugar (Silva *et al*., 2018; Gomez-Narvaeza *et al.*, 2019).

Both routes are favoured at slight acid pH. However, the formation of HMF in the analysed panela samples was quite low compared to other food matrices such as coffee (100–1900 mg/kg), dried fruit (25–2900 mg/kg) or vinegar balsamic (316.4–35251.3 mg/kg) (Capuano & Fogliano, 2011; Gomez-Narvaeza *et al*., 2019). HMF ranged from lower than 0.6 (LOQ) to 14.8 mg/kg. Granulated panela showed significantly lower average levels (3.2 mg/kg) than block samples (5.9 mg/kg). There are no studies concerned with HMF content in panela.

- *Furfural*

Furfural in panela was not expected in large quantities since the major sugarcane juice are made of hexoses (glucose and fructose) together with some sucrose (Asikin *et al*., 2017; Gomez-Narvaeza *et al.*, 2019) and not pentoses. However, furfural was detected in granulated and block panela, ranging between 0.3 (LOQ) −4.5 mg/kg. It may be hypothesized that furfural was formed from the interconversion of HMF because of strong heating conditions (Wen *et al.*, 2016; Gomez-Narvaeza *et al*., 2019). Furfural exhibited the same behaviour as HMF, being the average content significantly lower in granulated samples (1.5 mg/kg) as compared to block panela (3.0 mg/kg). No significant correlations were found between acrylamide with HMF and furfural contents in panela.

According to this finding, Granulated panela showed the highest acrylamide content as compared to the block panela, in line with the intense dehydration and lower moisture content in the final product. HMF and furfural contents exhibited the same behaviour, being the average content lower in granulated samples as compared to block panela (Gomez-Narvaeza *et al*., 2019).

- ***New Technologies***

- *Freeze pre-concentration of sugarcane juice*

Conventional jaggery making process consumes large quantity of bagasse due to low furnace heat utilization. Boiling of juice at high temperature causes hot spots, it leads to caramelization of sugar. It gives dark brown colour to jaggery. Hence, jaggery makers uses chemicals to improve clarification of juice. These issues are addressed by improved Freeze Pre-Concentration System (FPCS). In this process, water is selectively freezed and separated from juice to form ice and concentrated juice. Freezing point of juice changes from -1.5 to -4.6ºC for 20 to 40ºBrix. During this initial 63% water removal, bagasse is saved and that can be recycled in field for composting. Concentrated juice is obtained at low temperature. This juice is further concentrated using steam jacketed pan with vegetative clarificants. Altogether, it improves colour of jaggery from dark brown to golden yellow which has higher market value.

Advantages of FPCS are as follows,

- Saving of bagasse upto 77% of produced bagasse. It gives additional revenue to farmers
- Reduction in area required for jaggery making unit by 60%
- Quality of jaggery gets improved. Colour of jaggery gets improved without using chemicals

- Automated operation reduces number of workers required to handle boiling process
- Despite all of this advantages, This operation is not economical (Ranea & Uphadea, 2016).

- *Non-centrifugal cane sugar derived from membrane clarified juice*

Sugarcane juice clarification procedures (Meerod *et al.*, 2019; Zhu *et al.*, 2020) and drying-solidification methods (Asikin *et al.*, 2016; Zhu *et al.*, 2020) have been reported to affect the NCS product's nutritional and antioxidant properties. In many of these clarification processes, milk of lime and polymer flocculant are added to remove impurities. In doing so, some of the bioactive compounds such as polyphenolics and long chain alcohols are removed from the juice by the precipitates formed between free calcium ions and inorganic phosphate present in the juice. An alternative approach in juice clarification is the use of membranes where the high temperature is not required, reducing the formation of degradation products. Another advantage of membrane clarification over the traditional clarification process is no flocculant contamination in the product enabling an "organic" NCS to be produced, if the sugarcane is organically sourced (Zhu *et al.*, 2020).

Zhu *et al.* (2020)'s study compared the membrane clarification derived M-NCS to NCS products derived by the traditional clarification process. The M-NCS product turbidity and color was at least 5 times and 2 times respectively lower than NCS products. This is expected because of the small pore size of the membrane used in the clarification process. The moisture content, aw, pH and the size of the aggregates of M-NCS and the NCS samples are similar, implying that they would have similar stability and shelf-life. The difference in pH may play a role in difference in stability between M-NCS and the NCS samples. It should be noted that the starch content of M-NCS was the lowest, and therefore will cause a reduction rate of moisture up-take which will influence the stability of M-NCS (Zhu *et al.*, 2020).

From these studies, The NCS produced via membrane processing of juice could be a better choice than the traditional derived NCS for the beverage industry as it has a lower turbidity, starch and amino acids content that cause posthaze in beverages (Zhu *et al.*, 2020).

- ***Consumption & Usage***

Sugarcane is the third most important commodity in the world, with a larger production in the America (54.1%), followed by Asia (39.1%), Africa (5.1%) and Oceania (1.7%. Colombia ranks seventh among the countries with the highest production in the world with 34.535.753 MT (Anon, 2016; Galvis *et al.*, 2019). According to recent reports, world NCS production is approximately 12 million tons per year, and it is mainly produced in India (~60%), Colombia (~15%) and Pakistan (~5%) (Anon, 2018; Anon, 2018; Alarcóna *et al.*, 2020).

The presence of minor components makes NCS a healthier alternative than other sweeteners, turning it into a whole nutritional and functional food. Additionally, its low cost makes NCS a suitable energy and nutrients source mainly for low-income population in the rural areas where it is produced (Hussain *et al.*, 2012; Alarcóna *et al.*, 2020). NCS can be stored for 1–2 years and is used either as table sugar and a snack or as raw material for the production of confectionery, beverage, and bakery products as a sweetening ingredient.

- *Reasons for the low consumption of Non-Centrifugal Sugar in the sweeteners market*

The main reasons for low consumption of NCS in the sweeteners market are lack of awareness, identity problems, image problem, and colour and until recently a lack of innovation. This omission could be explained by the different names for the same or related product produced in the different countries with research published in the local languages, mainly in Spanish and Japanese. These publications sometime lack the English abstracts therefore contributing to a lack of awareness and an image problem (Maria, 2013).

- ***Types of Panela***

The Panela is produced in three forms: liquid, solid, and granular, which are described subsequently in detail.

- *Liquid Jaggery (Panela)*

It is that product which is obtained during concentration of purified sugarcane juice during jaggery(Panela) making, and is semi liquid syrup like product. The quality of liquid jaggery(Panela) largely depends upon quality and composition of cane juice, type of clarificants used, and striking temperature at which concentrating juice is collected. For quality liquid jaggery(Panela), the juice concentrate is removed from boiling pan, when it reaches striking point temperature of 103^0C-106^0C, depending upon the variety and agroclimatic zone. In order to avoid crystallization and to make liquid jaggery(Panela) attractive in color, citric acid is added at 0.04% (400 mg/kg of liquid jaggery), whereas to improve the shelf life of liquid jaggery(Panela) without deterioration in quality, potassium metabisulphite at 0.1% (1 g/kg of liquid jiggery (Panela)), or benzoicacid at 0.5% (5 g/kg of liquid jaggery(Panela)), is added. Liquid jiggery (Panela) is then allowed to settle for period of 8-10 days at ambient conditions. Later after filtration, it is properly packaged in sterilized bottles. Chemical composition of typical liquid jiggery (Panela) could be: water 30%-36%, sucrose 40%-60%, invert sugar 15%-25%, calcium 0.30%, iron 8.5-10 mg/100 mg, phosphorus 05/100 mg, protein 0.10/100 mg, and vitamin B 14/100 mg (Singh *et al.*, 2013; Singh & Singh, 2008; Kumar & Singh, 2020).

- *Granular or powder Jaggery(Panela)*

The process of making granular Jaggery (Panela) is similar up to concentration. The concentrating slurry is rubbed with wooden scrapper, for formation of grains. The granular Jaggery (Panela) is then cooled and sieved. It is yellow to golden brown in color and 3 mm sized crystals are found to be better for quality granular Jaggery (Panela). Raising of pH of cane juice with lime, up to 6.0-6.2, and striking point temperature of 120°C was found to yield quality granular Jaggery (Panela) with high sucrose content of 88.6%, low moisture of 1.65%, with good color, friability and crystallinity. Jaggery (Panela) in the form of granules (sieved to about 3 mm), sun dried and moisture content reduced to less than 2%, and packed in polyethylene polyester bags or polyethylene bottles, can be stored for longer time (more than 2 years), even during monsoon period with little changes in quality. The caloric value of Jaggery (Panela) is the same when compared with solid Jaggery (Panela). The composition per 100 g of granular Jaggery (Panela) is 80-90 g sucrose, 5-9 g reducing sugar, 0.4 g protein, 0.1 g fat, 9 mg calcium,4 mg phosphorous, and 12 mg iron (Kumar & Singh, 2020).

- *Solid Jaggery (Panela) (cube shape)*

The filtered cane juice was pumped into open pans kept on triple pan furnace, and heated with the bagasse as fuel. The juice was clarified with herbal clarificant (deola extract at 45 g/100 kg juice), to make light colored Jaggery (Panela) by eliminating impurities in suspension, colloidal and coloring compounds by accumulation. The juice was then boiled and concentrated to make Jaggery (Panela) in desired shape and size. Mandal *et al*. studied the effect of common packing materials on keeping quality of sugarcane Jaggery (Panela) during monsoon season. In their studies, it was revealed that the best packing material for storing Gur during monsoon season was heat sealed low-density polyethylene (LDPE) packet of 150 gauge followed by glass jars. LDPE packets prevented moisture ingress, fall in pH and inversion of sucrose in the stored Gur to the maximum extent (Kumar & Singh, 2020).

- ***Nutritional Components & Properties***

Jaggery (Panela) is far complex than sugar, as it is made up of longer chains of sucrose. Hence, it is digested slower than sugar and releases energy slowly and not spontaneously. This provides energy for a longer time and is not harmful for the body. Panela is known to produce heat and give instant energy to a human body. Jaggery also gathers a considerable amount of ferrous salts (iron) during its preparation, as it is prepared in iron vessels. Jaggery (Panela) also contains traces of mineral salts which are very beneficial for the body. Mineral salts present in Jaggery (Panela) come from the sugarcane juice where it is absorbed from the soil (Kumar & Singh, 2020).

- *Proximate composition*

The color of jaggery varies from golden brown to dark brown and it contains 50% sucrose, 20% invert sugar, 20% moisture, and the remainder is insoluble matter such as ash, protein, and bagasse fines (Kumar & Singh, 2020).

- *Vitamins*

Eight vitamins are reported in total. There are solid data for the presence of thiamin, riboflavin, niacin, vitamin B5, B6. The data for vitamin A, folic acid, vitamin C and vitamin D are contradictory and there are insufficient data on vitamin E and K. (Jaffe´, 2015) Vitamins namely; A (3.8 mg), B1(0.01 mg), B2 (0.06 mg), B5 (0.01 mg), B6 (0.01 mg), C (7.00 mg), D (6.50 mg) and E (11.30 mg) per 100 g of Jaggery (Panela) have been reported (Kumar & Singh, 2020).

- *Minerals*

It is rich in important minerals (namely, 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, and chloride: 5.3 mg per 100 g of Jaggery (Panela)) (Kumar & Singh, 2020).

- *Antioxidant*

The first reference found on antioxidants in sugarcane and its products is a 1981 paper in Japanese by Yamaguchi and Yamada reporting antioxidant effects in kokuto, the Okinawan NCS.

The origin of the phenolic compounds in NCS is its presence in the leaves, stalks and juice of the sugarcane plant both in free or bonded forms, as well as in the manufacturing process of sugarcane juice and NCS (Jaffe´, 2015).

- ***Health & Medicinal benefits***

In order to be considered ‘‘healthy’’ by the FDA a food must not only meet the criteria of not exceeding predefined levels of total fat, saturated fat, cholesterol and sodium, but also provide 10% or more of the DRV of protein, fiber, vitamin A, vitamin C, calcium or iron. In this sense, NCS is healthy as it does not exceed the above 200 levels and provides more than 10% of daily iron requirements (Jaffe´, 2015).

Sugarcane contains various phytochemicals including phenolic compounds, plant sterols, and policosanols. Phenols help in the natural defense of plants against pests and diseases, while plant sterols and policosanols are the components of wax and plant oils. The phytochemicals have gained increased interest due to their antioxidant activity, cholesterol-lowering properties, and other potential health benefits. Furthermore, Jaggery (Panela) is very good as a cleansing agent. It cleans lungs, stomach, intestines, esophagus, and respiratory tracts. Those who face dust in their day-to-day life are highly recommended to take a daily dose of Jaggery (Panela).

The strongest evidence for a health effect of NCS to date is the increased formation of hemoglobin and red blood cells caused by its iron content, reported in humans by at least two papers. The cause and effect relationship between iron consumption and hemoglobin and red blood cells increase has been accepted by the European Food Safety Agency and therefore claims in this sense are permitted in Europe (Anon, 2014; Jaffe´, 2015). The statistically significant increase in hemoglobin in preschool children after consumption of a NCS fortified beverage has been demonstrated by a Brazilian group leading them to propose to consider NCS a food fortificant (Jaffe´, 2015).

Conclusion

The aim to this review was to identify and facilitate the use of the available analytical data of acceptable quality on the nutritional, functional and technological properties of NCS by focusing on its contents of minerals, vitamins, antioxidants and other potentially relevant components that was emphasized the sugarcane juice used for manufacturing Panela/jaggery with various nutrients and beneficial health effects when compared with white sugar and other sweeteners. Nevertheless, the variability observed in the acrylamide and other heat-induced compounds as well as physicochemical and antioxidant parameters in panela point out the elaboration of this product is poorly standardized and linked to an artisanal elaboration.

All in all, the recognition of NCS as a promising functional food will be advanced, hopefully there will be increasing research to extend its application in food industry.

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