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POTENTIAL OF NATURAL SWEETENER IN INDONESIA: A SYSTEMATIC REVIEW

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ABSTRACT

Natural sweetener is a food alternative to sugar obtained from nature through organic chemical processes that produce flavors and characteristics similar to sugar and synthetic sweeteners. This paper is made in the form of a systematic review to collect and identify data related to the potential of natural sweeteners in Indonesia. The writing was designed using PRISMA with PICO with outcomes of total solids, reducing sugar, Dextrose equivalent (DE), glycemic index (GI) as data selection methods. The data obtained showed 15 potential plants from 13 different articles or journals. After being classified, the majority of food ingredients are natural sweeteners of the saccharide type that have the potential to produce liquid sucrose, fructose syrup and glucose products. These product opportunities were selected based on plant commodities with the highest productivity such as cassava, corn, coconut, sugarcane, sweet potato, sago, taro, and sorghum from several regions such as West Java, Central Java, East Java, Riau, North Sumatra, West Sumatra, Lampung, South Sumatra, Central Kalimantan, West Nusa Tenggara, South Sulawesi, North Sulawesi, Gorontalo, Maluku, and Papua. The potential of natural sweeteners can be used directly in food products and can be utilized as raw materials in various food products such as ice cream, candy, syrup, jam, and canned beverages.

Keywords*: natural sweeteners, saccharide, glucose syrup, potential commodities, food product*

INTRODUCTION

Natural sweetener is currently one of the food ingredients that are starting to be widely used by some people. Natural and artificial or synthetic sweeteners play a large role in human energy needs and are very important for various food industries (Arshad et al., 2022) However, many sweeteners added by food manufacturers to food products are not ideal for all food industry applications. Among sweeteners, there are also compounds that have a sweet taste and do not contain (Priya et al., 2011).

Looking at the food issues that have developed in the world today, such as the emergence of nutritional transition patterns in the Southeast Asian region accompanied by a shift in the purchasing power of food products towards the need for sweeteners (Kusuma et al., 2022). This condition has brought many major changes of various food and nutrition policies for each country and is able to increase health awareness for each population (Drewnowski et al., 2019).

In addition, from another perspective or point of view The increase in economic development and urbanization has meant that traditional diets in developing Southeast Asian countries have shifted to a more varied diet that contains more animal protein, vegetables and fruit (Baker & Friel, 2014). Although natural sweeteners especially high potency intense sweetener are safe in use, they do not raise blood glucose or insulin significant which has an impact on reducing the potential for diabetes, and completely non-toxic and cause no distress or any other adverse side effects but some toxic effects of sweeteners (Jain et al., 2015).

Indonesia is the most populous country in Southeast Asia. The problem that arises due to these conditions is the high demand for food and beverages. Indirectly, sweeteners also experience high demand, both in the food industry and consumed by the public directly (Kasiamdari et al., 2019). This statement is supported by BPS data 2021 which notes that the amount of national sugar production of Indonesia and demand in 2020 experienced a large deficit, reaching 500,000 tons. This phenomenon demands a big solution to explore the potential of natural sweetener based on natural resources native to Indonesia.

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METHODS

a. Protocol registration
   The research protocol has been registered with the Open Science Forum (OSF) registry.
b. Design.
   Review in this systematic review was carried out in accordance with the Cochrane Handbook for Systematic Reviews of Interventions and then reported using the Preferred Reporting Items model in the form of PRISMA (Page et al., 2021).
c. Source of data search
   Data searches referring to Tawfik et al., (2019) was conducted electronically on several search engines such as, Pubmed, researchgate, and google scholar supplemented by manual reference searches of selected studies and reviews.
d. Data selection
   The data selection process refers to Cumpston et al., (2021) using PICO population = general population, intervention = saccharide sweeteners (sucrose, fructose, and glucose, comparator = protein and alcohol derived sweeteners, outcome = total solids, reducing sugar, Dextrose equivalent (DE), glycemic index (GI).
e. Data extraction
   Researcher will independently review and extract relevant data from each included journal. Extracted data includes study characteristics (e.g. location, type of ingredients, processing process). In addition, sample size, study design (randomized and non-randomized), duration of study time, and valid outcome data.
f. Result (outcome)
   The desired result is the selection of natural sweetener or natural sweetener that has the potential to be developed for each region in Indonesia based on the producing region of the raw material.

RESULTS AND DISCUSSIONS

The search for sugars or sweeteners from natural sources has led to the discovery of several substances that have a very sweet taste or are capable of altering the flavor (Jacob et al., 2016). About more than 150 plant materials in the world have been found to have a sweet taste because they contain a large number of sugar groups, polyols or other constituents that give a sweet taste response (Priya et al., 2011). Figure 1 shows the literature search and selection process of systematic review data.

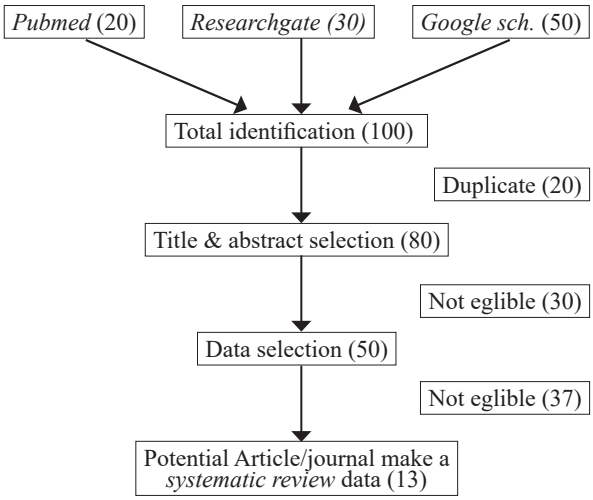

Figure 1. Selection data *systematic review.*

Of the 100 articles identified, 80 were selected based on title and abstract. 50 research literatures article/journal reviewed in full, 50 were excluded based on full article review.

The final results of articles or journals that meet the criteria focus keyword natural sweetener on research with natural sweetener products as the main topic. However, in the selection process, 20 articles or journals were found in the same search engine or referred to as duplication, 30 articles or journals that did not match the desired outcome, and 37 research articles or journals were in accordance with the outcome, but there were many misinformation that caused less support for the data generated. For this reason, in final stage, only 13 articles/journals were obtained to be used as systematic review data in this paper.

Arshad et al., (2022) explained that currently there have been many discoveries that focus on efforts to replace refined sugar with natural sweeteners from various potential resources that can be used in food applications, both in liquid forms. Natural sweeteners generally contain various bioactive compounds, and that can improve product characteristics. The antioxidant potential of sugar is also influenced by the level purification (Chéron et al., 2018)

Table 1. Variety of Indonesia's potential natural sweetener sources

Plants Name	Part Utilized	Sweetener compound	Analysis (*outcome*)				Literature refrence
			Total solid	Reducing sugar	Dextrose equivalent	Glycemic Index	
Coconut (*Cocos nucifera*)	Nira (Bunch of flowers)	Sucrose	73.5%	4.6%	18%	67	(Saraiva et al., 2023)
Sorghum (*Sorghum* spp.)	Seeds	Sucrose	80.3%	19.1%	57%	41	(Gillian Eggleston et al., 2022)
Sago (*Metroxylon sago*)	Stem (Starch)	Glucose	65%	50.4%	28.6%	40	(Budiyanto et al., 2019)
Cassava (*Manihot esculenta*)	Tuber (Flour & Starch)	Fructose & sorbitol	68%	32%	56%	46	(Permanasari & Yulistiani, 2017)
Sweet Potato (*Ipomoea batatas*)	Tuber (Pati)	Fructose & glucose	41%	38.1%	20%	63	(Mahmudatussa'adah, 2014)
Stevia (*Stevia rebaudiana*)	Leaf	Steviol	27.8%	5.8%	20%	0	(Marlina & Widiastuti, 2019)
Sugarcane (*Saccharum*)	Stem	Sucrose	65%	1.5%	15%	43	(G. Eggleston & Monge, 2005)
Aren (*Arenga pinata*)	Nira (Bunch of flowers)	Sucrose, dan fructose	80%	4.1%	15%	35	(Barlina et al., 2020)
Kersen (*Muntingia*)	Flowers	Glucose	37%	32.1%	4.6%	28	(Anjani et al., 2023)
Kawista (*Limonia acidissima*)	Fruit	Glucose	40%	35.2%	3.9%	33	(Anjani et al., 2023)
Trembesi (*Samanea saman*)	Fruit	Glucose	65%	34.4%	6.8%	29	(Anjani et al., 2023)
Lumbah (*Curculingo latifolia*)	Flower	Neoculin	45%	37%	8.1%	20	(Gusmalawati & Mayasari, 2017)
Corn (*Zea mays*)	Fruit (Starch)	Fructose	55%	78.4%	15%	55	(Mardawati et al., 2019)
Taro (*Colocasia esculenta*)	Tuber (Starch)	Glucose	4.9%	4.7%	96%	58	(Putra et al., 2015)
Gembili (*Dioscorea esculenta*)	Tuber (Starch)	Glucose	28.5%	26.6%	88.9%	75	(Hidayah et al., 2021)

Alternative sweeteners or sugars are sugar substitutes that resemble the characteristics of sugar in terms of flavor with less energy or caloric value (Drewnowski et al., 2019). Some sugar substitutes are natural and some are synthetic. Jain et al. (2015) explained that there is a division of natural sweeteners based on the constituent ingredients, components and structure of the sweetener compound. Based on Table 1, it can be classified sweetener compound as a type of carbohydrate sweetener and alcohol and polyol sweetener is the most dominant type of natural sweetener to be a high potency essence sweetener in Indonesia.

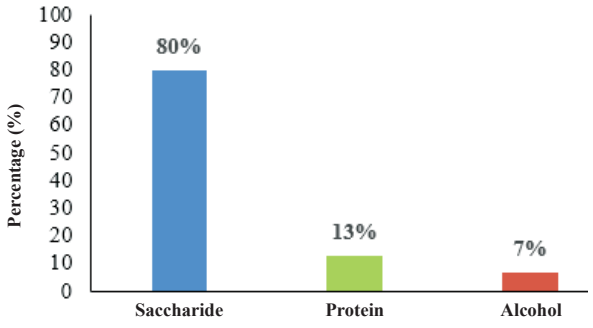

Figure 2. Classification of sweetener types

Based on Figure 1, it shows that most of the potential of natural sweeteners in Indonesia comes from the saccharide group which is part

of carbohydrates. Jain et al. (2015) explained that saccharide sweeteners are one of the sweeteners that have nutrients to supply calories in the form of carbohydrates, such as sucrose, fructose, and glucose (Figure 2). Sucrose was anciently found from the extraction of sugar cane in India since 6000 (Priya et al., 2011). Sucrose, commonly known as sugar, but more precisely -D-glucopyranosyl - D-fructofuranose side has been reported to have the highest production in the world and is sourced from a single, natural, organic chemical. Sugar is widely used when its association refers to sucrose (Cooper, 2006).

Over time, the utilization of sucrose from sugar cane began to shift due to its limited availability, to the potential for various diseases due to exceeding sugar consumption limits (Stull, 2016). Based on the analysis of two trials conducted by Wiebe et al. (2011) found that the use of sweeteners in the diet resulted in lower energy intake compared to carbohydrate groups such as sucrose, which was about 500 kcal/day lower for or 250 kcal/day. This is closely related to controlling obesity and diabetes.

Fructose can exist as a monosaccharide or as part of sucrose (Fattore et al., 2021). Fructose, or fruit sugar, is a monosaccharide commonly found in various plants and is one of the important blood sugars along with glucose and galactose, which can be directly absorbed into the bloodstream during digestion (Drewnowski et al., 2019). Unfortunately, not everyone has the same ability to absorb fructose. This condition is known as fructose malabsorption. This occurs because the small intestine is unable to absorb fructose, so it collects in the gastrointestinal tract. Some symptoms that are often complained of include indigestion, such as abdominal pain, diarrhea, and vomiting (Gillespie et al., 2023).

Rizkalla (2010) reported that fructose in food is less satiating and more lipogenic than other saccharides. However, not enough relevant data have been presented to explain the direct relationship between dietary fructose intake and health risk markers such as obesity and insulin resistance in humans. This concern is supported by Dornas et al. (2015) who showed that fructose may be a pre-disposing cause in the development of insulin resistance in association with the induction of hypertriglyceridemia. In addition to sucrose and fructose, the most easily encountered type of saccharide is glucose. Glucose is one of the carbohydrates known as simple sugar monosaccharides.

Glucose is taken from the Greek “glykys” which means sweet (Beeley, 2011). Glucose is found in many foods with high levels such as fruits, and honey which is the main free sugar circulating in human blood. Glucose is an important source of energy in cell function, and influences metabolic processes (Zhang et al., 2009). Glucose in starch molecules is the main energy reserve of plants consisting of thousands of linear glucose units. Another major compound composed of glucose is cellulose, which is also linear. Dextrose is a molecule of D-glucose (Ridhani & Aini, 2021).

Figure 3. shows the various characteristics of sweeteners from various natural resources in Indonesia. Each region has its own superior commodity according to the geographical location of the region. Characteristics that are commonly used to determine the quality of sweeteners include total solids analysis, reducing sugar, and dextrose equivalent. These quality parameters have been regulated in national standards for various sweetener products such as liquid sucrose sugar (SNI 8779: 2019), fructose syrup (SNI 2985: 2021), and glucose syrup (SNI 2978: 2021). Meanwhile, the glycemic index is a health parameter for those who consume these sweeteners.

In terms of total solids, Aren and sorghum had the highest total solids of 80%, while taro had the lowest total solids of 4.9%. (Weliana, 2019) explained, in general, total solids in fresh ingredients are lower than in products. It is suspected that the increase in total soluble solids

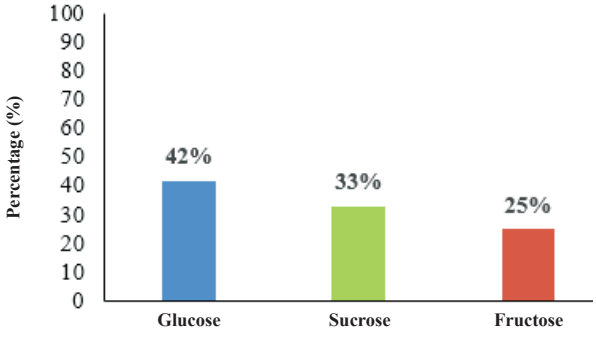

Figure 3. Classification of saccharide sweeten er types.

Table 2. SNI quality requirements for various sweetener products

Parameter	Product Standard		
	Sucrose liquid	Fructose syrup	Glucose syrup
Total Solid (%)	Min. 70	Min. 70	Min. 65
Reducing sugar (%)	-	Min. 55	Min. 50
Dextrose Equivalent (%)	Min. 30	Min. 30	Min. 20

of the product is due to the processing process and other additives that are able to bind a number of soluble particles in the mixture. Kusuma et al. (2022) reporting that total dissolved solids increase because free water is bound by particle material bound by stabilizing materials, so that the total soluble solids increase so as to reduce the sediment formed.

For the value of reducing sugar, Maize from corn obtained the highest value, which amounted to 78.4%. While the lowest value was obtained by Coconut with a value of 4.6%. Reducing sugars are a class of sugars (carbohydrates) that can reduce electron-receiving compounds (Wilberta et al., 2021). The ends of reducing sugars usually contain aldehyde or ketone groups. All monosaccharides such as glucose, fructose, and galactose are included as reducing sugars. The reducing sugar produced is closely related to enzyme activity (Istia'nah et al., 2020).

The dextrose equivalent value of taro was the highest at 96%, in contrast to kawista which had the lowest DE value at 3.9%. Dextrose equivalent (DE) is a quantity that expresses the total reducing value of starch or starch modified products in units of percent. Commercially, the use of high-carbohydrate materials such as starch as a natural sweetener is influenced by the DE value. Meriatna (2013) reported that the greater the DE indicates the greater the percentage of starch that turns into reducing sugar. In the process of processing glucose syrup in particular, maltodextrin will be formed from glucose syrup where starch has been enzymatically degraded from the glucoside bonds of starch which is characterized by a dextrose equivalent value. (Rayhani et al., 2018). In addition to the parameters that determine the quality of natural sweeteners, another factor that must be considered is the health impact when consumed.

The glycemic index is one of the right indicators to describe the speed of absorption of sugar in the glycogen (Barclay et al., 2021). Generally, foods that have a high GI will quickly raise sugar levels which make the pancreas work hard to produce insulin after eating (Arif et al., 2013). There are several types of plants that have

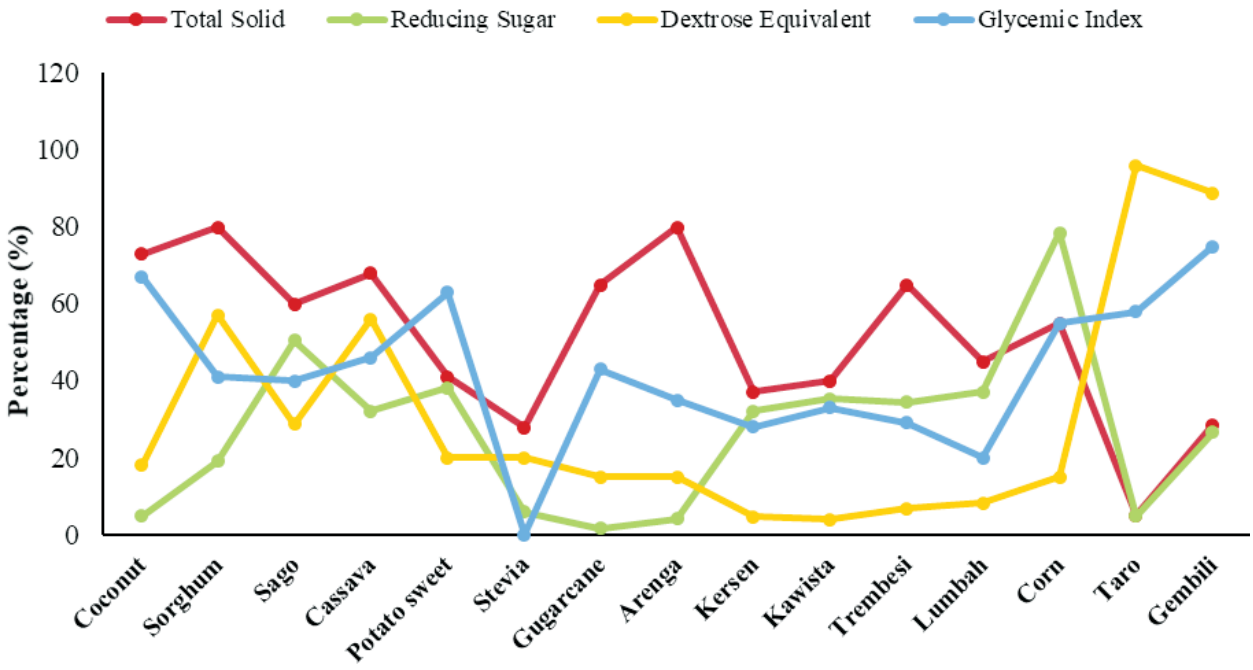

Figure 4. Results Analysis of natural sweetener potential in Indonesia by plant type

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low GI (<55), such as sorghum, sago, cassava, sugar cane, aren palm, kersen, kawista, trembesi, and lumbah.

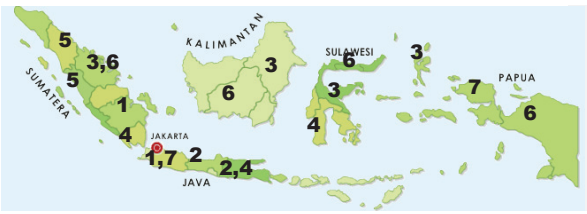
The great potential of natural sweeteners is also inseparable from the availability of its resources in nature. Suroso (2017) reported that the potential for food alternatives to become one of the important aspects of food security is currently very urgent to develop. In addition, food production is generally produced by areas that are food production centers. Meanwhile, food is needed by everyone who lives throughout the country, both production centers and food deficit areas (Hermanto, 2013).

Figure 3 shows the distribution map of the potential of natural sweetener industry in Indonesia based on raw materials. The potential center of natural sweetener raw materials is still in Java, followed by Sumatra and Sulawesi. The Ministry of Agriculture (2022) explained that the distribution of plant commodities cannot be separated from the geographical influence of soil, rainfall and altitude from sea level. Taufik et al. (2021) reported that the potential for food sources and the need for basic staple foods is still an unresolved problem. With the innovation of this natural sweetener development program, it can be handled by the sugar industry in the form of local natural sweeteners sourced from Regional Government reserves.

Table 3. Potential of the largest natural sweetener crops based on the largest amount of production (tons)

Plants Name	Year 2020	Year 2021
Cassava	18.345.810	17.054.648
Corn	12.928.940	13.414.921
Coconut	2.811.900	2.853.300
Sugarcane	2.133.650	2.344.930
Sweet potato	1.424.147	1.511.041
Sago	381.065	365.655
Taro	271.570	260.523
Sorghum	6.114	7.695

Source: Ministry of Agriculture Indonesia (2022)



Remarks
1: Cassava 2: Corn 3: Coconut
4: Sugarcane 5: Sweet potato 6: Sago
7: Taro 8: Sorghum

Figure 5. Potential of natural sweetener plants based on regions in Indonesia

CONCLUSION

Based on the results of the systematic review, 8 leading commodities were obtained, namely cassava, corn, coconut, sugar cane, sweet potato, sago, taro, and sorghum from several regions province such as: West Java, Central Java, East Java, Riau, North Sumatra, West Sumatra, Lampung, South Sumatra, Central Kalimantan, West Nusa Tenggara, South Sulawesi, North Sulawesi, Gorontalo, Maluku, and Papua.

The majority of the potential natural sweeteners are saccharides with liquid sucrose, fructose syrup and glucose products. Although some quality criteria do not meet SNI requirements, the potential to continue to be developed is still very large and can reduce dependence on the consumption of refined sugar and artificial sweeteners. The potential of natural sweeteners can be used directly in food products and can be utilized as raw materials in various food products such as ice cream, candy, syrup, jam, and canned beverages.

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