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Innovation of Local Food of Banten-Palm-Sugar -Soybean-Extract Powder as A Nutritious Sweetener and Drink

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Abstract

Palm sugar is one of the potential commodities in Banten Province, Indonesia. The palm sugar-based innovations are needed to increase the palm sugar market. One of the innovations proposed in this research was the production of palm sugar-soybean extract which can be used as a powdered drink or sweetener in a practical form. This research aimed to study the effect of the palm sugar to soybean extract ratio on the hedonic test responses and nutritional value. Palm sugar solution and soybean extract were mixed in various ratios namely 80:20, 70:30, and 60:40 on a volume basis. The solution mixture was heated to evaporate all water and form a palm sugar-soybean extract crystal. The crystal was then crushed and sieved into an 80-mesh powder. The ratio of 70:30 resulted in the best product composition which obtained “like very much” responses and contained the best nutritional value namely 91.15 % of total sugar, 4.66 % of protein, and 1.12 % of fat. The products also contained antioxidants and essential elements.

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Introduction

Banten Province is one of the centres of plantation of sugar palm *Arenga pinnata Merr.*, also so-called Aren, in Indonesia.[1] The plantation covers an area of 1,633 ha which is centred in Lebak and Pandeglang.[2] *Arenga pinnata* Merr is a natural forest plant belonging to the family of Palmae, the subfamily of *Arecoideae*, and the tribe of *Caryoteae*.[3] It grows quickly and easily even in infertile soil. The plant can live in various types of soil. *Arenga pinnata Merr.* is a multipurpose plant.[3] All its parts, from the roots to the top leaves, are beneficial and can be used for various daily human needs. Therefore, this plant attracts widespread economic interest. The most important product of the plant is sap or "nira" which is a natural resource for palm sugar production.

Sugar palm sap is a sweet liquid that contains 88.76 % of water, 10 – 15 % of total sugar, 0.36 % of protein, 0.36 % of fat, and 0.21 % of ash. The freshly collected sap is oyster white and has an opaque appearance.[4] The sugar palm sap is used as a feedstock in sugar production.[4]

Sugar palm sap is obtained from the male flower bunches of 6-12-years-old sugar palm trees.[5] Every sugar palm tree produces sap about 20 – 30 litres per day which can result in 3 – 4 kg of palm sugar solid per day. Sugar palm sap is traditionally tapped in the morning and afternoon. It is collected using a bamboo pipe with 1.5 m in length and 7 cm in diameter.[5] Before the sap collection, the bamboo pipe is usually smoked to prevent the deterioration of the sap during its storage. Many materials such as the stem bark of jackfruit6, stem bark of mangosteen, mangosteen shell, guava leaves, clove leaves,[7] etc. are also added to the sap as natural preservatives.

Palm sugar is a well-known natural sweetener which has a brown colour, unique aroma and rich flavours.[8] The sweetness, toasty, and nutty caramel-like aroma of palm sugar are due to some components such as pyrazine, furans, ketones, fatty acids, and organic acids.[4] Palm sugar is considered a healthier sweetener9 than cane sugar because the former contains higher nutrients such as antioxidant, phenolic, and essential elements such as iron, copper, zinc, potassium, and magnesium. It is also mostly produced traditionally and it is more free from chemicals in the manufacturing process than cane sugar.[10] Palm sugar is claimed to have a low glycemic index (GI)9,[11] which is a tool for the dietary management of diabetes, weight reduction, peak sport performance, and degenerative disease prevention9. Low GI food uptake can slow carbohydrate absorption hence preventing the rise of blood sugar.[12] Therefore, the popularity of palm sugar has increased globally because its consumption has become more preferred to cane sugar.

Palm sugar is mostly used in southeast and south Asian countries such as Indonesia, Thailand, Philippines, and India, where various palm trees are naturally grown in abundance.[13] Palm sugar is mostly used in sweets, sauces, drinks, and various traditional cakes and cuisines.[8,13] Its utilization is considerably enjoyed and acknowledged for its good taste, colour, and flavours.[13] Palm sugar also has a spread compatibility taste which can be mixed with various foods and beverages to get tastier. The demand for palm sugar-based food and beverage products increases. Therefore, innovations are needed to improve the marketability of the products.[14]

One of the Palm sugar-based product innovations is the formulation of palm sugar by the addition of herbs and spices, vitamins, proteins, and minerals. Ginger or red ginger is a herb that is commonly added to palm sugar to produce drinks or syrup. Red ginger contains a high antioxidant activity which is important to protect the human body from free radical exposure.[15] The palm sugar-based ginger syrup contains higher antioxidants and total phenolic than cane sugar-based ginger syrup.[15] The palm sugar-based ginger syrup, composed of ginger extract to water by 1:3, contains an antioxidant of 88.56% and a total phenolic of 6,299 ppm.[15] *Temulawak* (*Curcuma zanthorriza*) has also mixed with palm sugar to produce *temulawak* drinks which have antioxidant activity of 13.740 – 15.861 %.[16] Herein, the antioxidant activity was found higher than the cane sugar-based *temulawak* drinks.[16] *Temulawak* is a herb plant that contains a curcuminoid compound which has the potential as an antioxidant and anti-inflammation.[16] Many other herbs that can be mixed with palm sugar are cinnamon, clove, and lemon grass.[8] Palm sugar has also been added as an exotic sweetener to lemongrass-based isotonic drinks.[17] Palm sugar with the addition of African pepper and citric acid results in a fresh beverage

containing a higher antioxidant content than palm sugar with a pomegranate addition.[11] The innovation of palm sugar by the addition of moringa leaf extract has increased the antioxidant activity from 16.74 to 22.27 %.[10]

Many works have been conducted to transform traditional palm sugar into global sweetener products. The works have reported the use of palm sugar as chocolate sweetener,[18–20] probiotic ice cream,[21] and yoghurt products.[22] The addition of palm sugar has improved the aroma volatile, chemical composition, particle density, and moisture content of the chocolate products.[19] Ibrahim *et al*. reported that the palm sugar-based chocolate had a slightly higher moisture content and a soft texture, and was acceptable by the sensory panellists.[20] Coconut palm sugar provided a better environment for inoculation of Lactobacillus acidophilus than cane sugar.[21] Hence, the palm-sugar-based probiotic ice cream had higher antioxidants and was preferred by panellists compared to the cane-sugar-based product.[21] Palm sugar jaggery has been reported to replace 100% of cane sugar in yoghurt products without changing physicochemical, microbiological, texture, and taste.[22]

In this research, palm sugar was formulated with soybean extract (soy milk) to produce palm sugar-soybean extract powder. Soybean is a natural resource of high-quality proteins (40%), polyunsaturated fatty acids (18%), carbohydrates, soluble fibres, and many essential elements.[14,23] Soybeans also contain phytochemicals such as isoflavones, phytosterols, and lecithin.[23] Recently, soy foods are gaining considerable interest due to their health benefits as the cholesterol-lowering effect which reduces cardiovascular and coronary heart disease risk.[23] Soybean extract, so-called soy milk, is produced by soaking soybean[14] in water followed by crushing and filtering. Soybean extract is a plant-based milk which can substitute cow milk for lactose-intolerant individuals.[14] The consumption of soy milk can increase insulin sensitivity quantitatively and decrease the insulin resistance score.[14] The formulation of soybean extract in a practical powder drink form will ease the delivery of soy-rich nutrition for individual daily intake. Moreover, a combination of palm sugar and soybean extract can result in a rich flavour and delicious taste. Then, this soy-based drink can be proposed as a candidate for a favourite drink for all ages.

The formulation of palm sugar with soy extract has not been reported elsewhere. This research was conducted to prepare the powdered palm sugar-soy extract products by varying the palm sugar to soybeans extract ratios and to study the effect of the ratios on the resulting powder product quality through the organoleptic responses and nutritional compositions.

Materials and Methods

Materials

Banten palm sugar was obtained from Munjul, Pandeglang, Banten Province, Indonesia. Red ginger, cinnamon, and soybeans were purchased from the local traditional market.

Preparation of Soy Extract

The selected soybean was cleaned and macerated for 6 hours. The soybean was blended with water (1:3 in volume) and crushed into a slurry-like mixture. The mixture was then filtered to separate solid material and to obtain a soy milk-like extract. Then, the soybean extract was pasteurized at 100 ^{o}C for 30 minutes.

Formation of Palm-Sugar-Soybean-Extract Powder

Formation of palm-sugar-soybean extract powder included mixing and refining.

Mixing

Granulated palm sugar was added to 1000 mL of warm water (60oC), followed by red ginger (3.5 %w/v) and cinnamon (0.03 %w/v). The mixture was stirred until all granulated palm sugar dissolved. Then, the soybean extract was added to the mixture while continuing to stir. Ratios of palm sugar solution: soybean extract were varied to 80:20, 70:30, and 60:40 (v/v).

Refining

The mixture was heated to evaporate the water and to crystallize the product. The crystal was then crushed and sieved to get 80-mesh powder.

Organoleptic Test

The organoleptic test was carried out according to the work of Windari *et al*.10 with some modifications. The samples were prepared as palm sugar-soy bean extract drinks (45 grams of fortified palm

sugar powder in 200 mL of water). The 15 panellists tested and evaluated the drinks by filling out the questionnaire involving four parameters namely colour, texture, flavour, and taste. The collected responses were analysed using SPSS to evaluate the significance using sigma f distribution and to obtain the conclusion of the response using the Duncan equation.

Total Sugar Analysis

Total sugar analysis was conducted using the luff schoorl method according to SNI 01-2891-1992. The sample of 5 gr of fortified Banten palm sugar powder was refluxed with 200 mL of 3%v/v HCl at 100 °C for 3 hours in an Erlenmeyer equipped with a condenser. The refluxed sample was then cooled and neutralized by concentrated NaOH solution. The 3%v/v acetic acid was added dropwise to increase the slight acidity of the neutralized mixture. Then, the mixture was transferred into a 500-mL volumetric flask followed by adding distilled water up to mark and shaking to homogenize. Furthermore, the mixture was filtered to obtain a filtrate sample for analysis. As much as 10 ml of filtrate sample was pipetted into an Erlenmeyer 500 mL. The 25 mL of luff schoorl reagent was added to the sample in the Erlenmeyer with some boiling stones and 15 mL of distilled water. The mixture was heated with a constant flame. The solution was previously boiled for 3 minutes (use a stopwatch). The boiling was continued for 10 minutes (counted using a stopwatch when the mixture started to boil). The mixture was then cooled in the ice bath. After cooling, about 15 mL of 20 % KI solution and 25 mL of 25 % H_2SO_4 solution were added slowly. The mixture was titrated with 0.1 N $Na_2S_2O_3$ solution using 0.5 % starch indicator solution. The titration was also repeated for a blank sample. The glucose content was determined using a correlation table.

Total Fat Analysis

Total fat analysis was conducted using the Soxhlet extraction method according to SNI 01-2891-1991 point 8. About 2 grams of sample was wrapped in a thimble and placed in a Soxhlet extractor. The fat extraction was carried out using hexane solvent at 80°C for 6 hours. The extracted fat was then separated from the hexane solvent by a rotary evaporator. The extracted fat was weighed as total fat content.

Total Protein Analysis

The protein was analysed using the Kjeldahl method. About one gram of sample was inserted in the Kjeldahl flask followed by the addition of SeO_2 catalyst and 25 mL of concentrated H_2SO_4 solution. The destruction was conducted in a Kjeldahl flask at 375°C for 30 minutes until a clear solution was reached. After cooling down, the distilled water was added to the solution up to the 100 mL mark. The solution was then transferred into the distillation flask and mixed with 50 mL of 40% NaOH. The distillation was conducted, and the distillate was recovered in Erlenmeyer which contained 25 mL of 4 % H_3BO_3 solution and 3 drops of mengsel indicator. Finally, the distillate was then titrated with HCl 0.1 N until the solution colour turned violet.

Antioxidant Analysis

Antioxidant analysis was conducted according to Jang *et al*. method 24 with modifications. About 2 grams of the sample was dissolved in 100 mL of water. As much as 1 mL of sample was pipetted into an Erlenmeyer followed by the addition of 1 mL of 0.2 M of phosphate buffer (pH 6.6) and 1 mL of 1 % $K_3Fe(CN)_6$ solution. The mixture was then incubated for 20 minutes at 50oC. After incubation, 1 mL of TCA (trichloro acetic acid) was added and centrifuged at 3000 rpm for 10 minutes. After centrifugation, 1 mL of the upper layer was pipetted and transferred into a reaction tube followed by the addition of 1 mL of distilled water and 0.5 mL of 0.1 % $FeCl_3$ solution. The solution was left for 10 minutes and the absorbance was measured at 720 nm. The oxalic solution was used as a blank solution. A calibration curve was plotted using ascorbic acid at various concentrations. FRAP value was calculated as the mmol equivalent of ascorbic acid/100 grams of extract.

Mineral Analysis

About 2 – 5 grams of sample was mixed with 10 mL of HNO_3 solution (1:1). The mixture was stirred in a beaker glass with a glass disk cover. The mixture was then refluxed at 95°C for 10-15 minutes without boiling. After cooling, 5 ml of concentrated HNO_3 was added and the mixture was refluxed for 30 minutes at 70 – 80 °C. The mixture was heated below its boiling temperature to vaporize the water until the volume was only 5 mL rest. After cooling, 2 mL of deionized water and 3 mL of 30% H_2O_2 solution were added

to the mixture in the beaker glass. The heating was continued without boiling. The 30 % H_2O_2 solution was added gradually per 1 mL into the warm mixture (the addition of H_2O_2 no more than 10 mL). After cooling, 5 mL of HCl and 10 mL of demineralized water were added. The mixture was heated for 15 minutes without boiling. After cooling, demineralized water was added to the 100 mL mark. The mixture was filtered and ready for Atomic Absorption Spectrophotometer (AAS) measurement.

Moisture Analysis

Moisture analysis was conducted using a moisture analyser using 2 grams of sample.

Total Ash Analysis

Total ash analysis was conducted using SNI 01-2891-1992 point 6. About 2 grams of the sample was carbonized in an open flame, followed by an ashing sample in a furnace at 550°C. After cooling, the sample was weighed.

Results and Discussion

Sugar is a widely consumed commodity and is involved in a wide variety of food products. The innovation of sugar is interesting because it provides many essential nutrients.[25] Palm sugar also can be innovated by fortification to enhance its nutritional content. The fortification of palm sugar by the addition of some herbs and spices such as ginger, turmeric, tamarind, lemon grass, and aromatic ginger has attracted many interests because it results in a pleasant and unique taste. Moreover, these herbs and spices have well-known benefits for human health. In our previous work, palm sugar has been fortified by the addition of green bean extract to increase the protein content and many other minerals.[26] In this research, palm sugar was innovated by adding soybean extract and prepared in powder form for practical use. Soybean extract is a well-known natural source of protein, fats, carbohydrates, and some essential nutrients.[14]

The palm sugar-soybean extract powder products were prepared by mixing palm sugar solution and soybean extract/soy milk. The mixtures were in three different ratios (palm sugar: soy extract) namely 80%:20%, 70%:30%, and 60%:40% which were then coded as PS/80-20, PS/70-30, and PS/60-40, respectively. The powder products, obtained by recrystallizing the mixtures, are shown in Figure 1a. The three powder products have a size of 80 mesh and have a creamy colour, sweet and savoury taste.

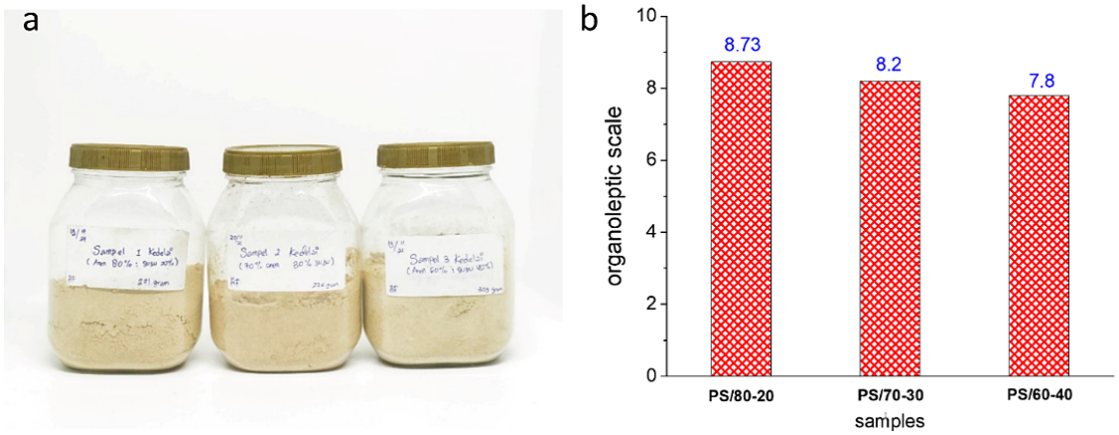
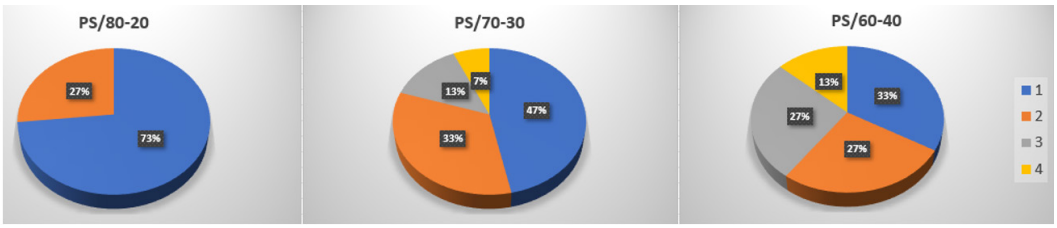


Figure 1 : a. Palm sugar-soybean extract powder products, b. hedonic test score

The palm sugar-soybean extract powders were also panelled as drinks by dissolving about 24 grams of powder in 200 mL of warm water. Response data analysis showed that the hedonic test score was in the range of 7.8 – 8.73 (Figure 1b). The scale > 8 was classified as a "like very much" response while the scale < 8 was classified as a "like moderately" response. The drinks with palm sugar:soybean extract ratios of 70%:30% and 80%:20% were mostly liked very much by respondents and the drink with a palm sugar:soybean extract ratio of 60%:40% was liked moderately. Figure 1b shows

the organoleptic scale according to respondents' evaluation. Soy products are often described as having a beany odour and a slightly bitter taste due to many components such as aliphatic carbonyls, volatile fatty acids, and various organic compound derivatives.[27] Therefore, the soybean extract in the mixture should not exceed 30 % to avoid a decrease in the hedonic test level. Figure 2 shows the hedonic test respondents' percentage of the three products. The PS/80-20 product, composed of 80 % palm sugar and 20 % soybean extract, was liked extremely by about 73 % of respondents. Whereas, the PS/70-30 and PS/60-40 were only liked extremely by about 47% and 33 % of respondents. Moreover, these two products lead to two lower hedonic levels namely "like moderately" and "like slightly".



**1 like extremely 2 like very much 3 like moderately 4 like slightly*

Fig.2: Pie chart of hedonic test respondents' percentage

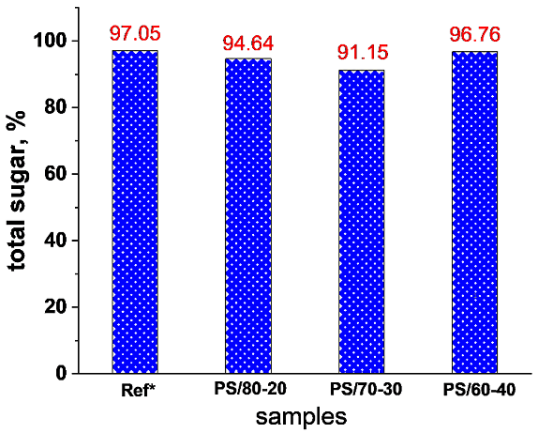


Fig.3: total sugar content of the products

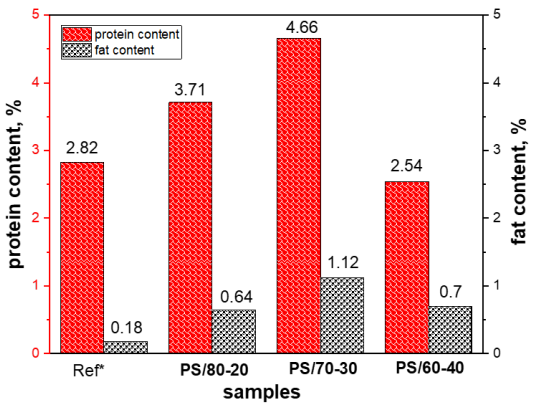


Fig.4: The protein and fat content of the palm sugar-soybean extract powder products

Total Sugar

Figure 3 shows the total sugar content of the palm sugar-soybean extract powder products, which was in the range of 91.15 – 97.76 %. Our previous work shows that Banten palm sugar originally contains 97.05 % total sugar[2] with sucrose as the main component.[28] The addition of soybean extract to palm sugar insignificantly reduced the total sugar content. Therefore, palm sugar-soybean extract powder not only can be consumed as a powdered drink but also as a sweetener. The addition of soybean extract can dilute the sugar concentration which tends to decrease the sugar content in the mixture. It can be seen from the decrease in total sugar with the increasing the soybean extract addition until 30% (Figure 3). However, at a ratio of palm sugar:soybean extract of 60:40, the total sugar was higher than that at a ratio of 70:30 (Figure 3). That phenomenon was caused by that the mixture of palm sugar solution and soybean extract in a ratio of 60:40 might lead to inhomogeneity that led an inconsistent analysis result.

Protein and Fat Content

The protein content of sugar palm sap was 0.05%.[29] Whereas, the granulated palm sugar contained about 2.82 % of protein.[30] The granulated palm sugar was formed by boiling the sap which evaporated most of the water content. As the water content decreased, the other components of the sap became

more concentrated. Thus, the protein content in granulated palm sugar was higher than that in the sugar palm sap. The protein content of our produced palm sugar-soya powder was 2.54 – 4.66 %. Soybeans are well-known as a vegetal protein source. The addition of soybean extract can improve the protein content. Herein, the palm sugar-soybean extract powder has a slightly higher protein content than the original palm sugar (Figure 4).

Fat content corresponds to the savoury taste of the palm sugar.[30] The fat content of palm sugar was 0.18 %30. The palm sugar-soybean extract products in this research contained a total fat in the range of 0.64 – 1.12 % (Figure 4). The addition of soybean extract contributed to increasing the fat content of palm sugar.

The PS 70/30 product, composed of 70 % palm sugar and 30 % soybean extract, had higher protein and fat contents than the two other products. Palm sugar is highly soluble in water to form a homogeneous solution. Whereas, soybean extract in water forms a colloidal solution due to many non-soluble components such as fatty acids. Therefore, the mixture of palm sugar and soybean extract with a ratio of 70:30 was the best. A higher soy extract addition of more than 30% led to a non-homogeneous mixture which led to the sampling error as well as decreased the hedonic level.

Table 1 : Antioxidant content of the palm sugar-soybean extract products

Sample	code	Antioxidant content (mmol/100 g)
1	PS/80-20	18.34
2	PS/70-30	13.25
3	PS/60-40	21.41
Ref[31]	Palm sugar	4.39
Ref[32]	Yellow Soybean	2.55

Antioxidants

Palm sugar is well-known to contain antioxidants.[6,28] Antioxidants are important to protect the human body from a free radical attack, which can trigger chronic diseases such as cancer or heart attack.[15] The antioxidant contents in the produced palm sugar-soybean extract were in the range of 13.25 – 21.41 % (Table 1). Based on Table 1, the antioxidant of the products was higher compared to the antioxidant in common palm sugar.[31] These results showed that the addition of soybean extract improved the antioxidant content of all three products.

Inorganic Contents

According to our previous work, palm sugar contains some transition metals such as iron, zinc, copper, and manganese.[2]These minerals, in small amounts, are important for metabolism within the living tissue as enzyme function, blood maintenance, immune response, and nerve impulse transmission.[33] The palm sugar-soybean extract powder products in this research showed significantly higher iron, zinc and copper contents (Table 2) as compared to the original palm sugar as reported in previous work.[2] The addition of soybean extract contributed to an increase in these minerals because the soybean contains 164 mg/kg of Fe, 27 mg/kg of zinc[34] and 5.09 mg/kg of copper.[35]

Iron has an important role in various metabolic processes such as oxygen transport, deoxyribonucleic acid synthesis, and electron transport. This metal is also needed during inflammation and the immune response to infection. The daily intake of iron is 8 mg for a male and 18 mg for a female. Iron deficiency can cause anaemia.[33] Zinc is also an essential element for an individual to remain healthy. Zinc has a role in physiological processes, metabolism, cell growth, transduction, and signalling. The daily intake of zinc is 9 and 11 for an adult female and an adult male, respectively. Zinc is also important for the catalytic activity of various enzymes, immune function, protein synthesis, wound healing, DNA synthesis, and cell division. Thus, this metal is essential for normal development during pregnancy as well as during the growth of childhood and adolescence.[33] Copper is an essential trace element which is involved in immune neural function, bone and blood health, and antioxidant defence. Copper deficiency may cause several health problems such as anaemia, neutropenia, and cholesterol metabolism alterations.[33] Daily intake of copper is 1 – 4 mg/ day.

The three products contained very high calcium and phosphor. Calcium intake is important for good health throughout life. Calcium primarily strengthens the bone to support the body weight and anchor the muscle. Calcium deficiency may

cause skeletal weakness and bone fracture.[36] The daily recommended intake of calcium is between 1000 – 1300 mg. Calcium intake is usually from dairy products such as milk, yoghurt, and cheese, which are calcium-rich foods, vegetables such as broccoli and kale, and nuts and seeds such as soybean.[37] Palm sugar contains 81 mg/kg of calcium and 31.7 mg/kg of phosphor.[38] Soybean contains 0.25 g/kg – 32 g/kg of calcium and 0.44 g/kg - 10 g/kg of phosphor.[39]

Table 2 : Essential elements and micronutrient contents of the palm sugar-soy extract products

Sample	Mineral contents (mg/kg)				
	Cu	Zn	Fe	Ca	P
80% : 20%	3.31	4.57	18.74	117.23	500
70% : 30%	5.13	8.58	45.20	122.89	900
60% : 40%	2.94	2.97	13.69	135.33	400
Palm sugar[2]	1.51	1.22	9.66	n.a	n.a

Note: n.a = not available

Table 3 : The ash and moisture content of the palm sugar-soybean extract products

No	Inorganic contents	Sample		
		PS/80-20	PS/70-30	PS/60-40
1	Ash content (%)	1.45	3.8	1.75
2	Moisture content (%)	1.37	0.57	0.54

Moisture content is important to food processes such as size reduction by grinding to produce a fine powder. The material with low moisture content is brittle therefore easing the grinding process.[40] Moisture is also an important factor in food quality such as preservation, and resistance to deterioration .[41] Table 3 shows the moisture content of the resulted palm sugar-soybean extract products in the range of 0.54 – 1.37 %.

Ash refers to inorganic content residue remaining either after ignition or complete oxidation of organic matter in food samples. Ash represents the total mineral content in food.[42] The ash content maximum allowed according to SNI Standar Nasional Indonesia (SNI) 01-4320-1996 for a powder drink is 1.5 %. In this study, the products contained ash in the range of 1.45 – 3.8 % (Table 3).

Conclusion

Palm sugar-soybean extract powder products got positive responses among the panellists, which were marked as “like very much” and “like moderately”. The products contained total sugar > 90 %, thus they can be used as a drink as well as a primary sweetener. The palm sugar-soybean extract powder product with a mixture of 70 % palm sugar and 30 % soybean extract contained the best nutritional values namely 91.15 % of total sugar, 4.66 % of protein, 1.11 % of fat, and 13.25 mmol/100 grams of antioxidant. The products also contained essential minerals such as iron, zinc, copper, calcium and phosphor. The moisture and ash content of the products was also acceptable.

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Conflict of Interest
The authors declare no conflict of interest.

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