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FULL PAPER

The effect of Arabic gum and maltodextrin on the physicochemical properties of vacuum-dried stevia (*Stevia rebaudiana* Bertoni) extract powder

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Abstract

Stevia extract powder was one form of natural sweetener that has not been widely produced. The antioxidant and phenolic content provided benefits as a sweetener. The purpose of this research was to examine the physicochemical features of stevia extract powder. Stevia extract powder contains health-beneficial antioxidant compounds. In the vacuum-dried encapsulating technique, Arabic gum and maltodextrin (DE 18) were used as two coating ingredients. Physicochemical characteristics such as hygroscopic rate, repose angle, colour analysis, magnitude estimation of sweetness level, hedonic test, antioxidant activity using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) method, total phenolic activity using spectrophotometric techniques, and stevioside with High-Performance Liquid Chromatography (HPLC) in stevia extract powder. Arabic gum: maltodextrin ratio 1:1, 1:2, 1:3 were added to the coating material. Maltodextrin used in this study can lead to an increase in the rate of hygroscopicity and the angle of bulk stevia extract powder, while the use of Arabic gum could decrease the rate of hygroscopicity and the repose angle of stevia extract powder. Arabic gum produced a powder with a more stable stevia extract. Stevia extract powder ratio 1:1, 1:2, 1:3 have hygroscopic rate were 1.40×10^{-4} gH_2O/g, 1.47×10^{-4} gH_2O/g, 1.54×10^{-4} gH_2O/g respectively, angles of repose were 31.35±0.4º, 33.21±0.1º, 34.05±0.09º respectively, antioxidant activity (IC_{50}) of 205.24 µg/mL, 304.22 µg/mL, 431.30 µ/mL respectively, total phenolic activities were 1.52%, 0.9%, 0.48% respectively, stevioside contents were 0.0731%, 0.0498%, 0.0406% respectively, and of the treatment with stevia extract powder 1:1, 1:2, 1:3 were 4.70, 4.41, 3.28 times respectively, (the 10 times corresponds sucrose concentration). Based on the physicochemical properties, it can be seen that the best ratio of Arabic gum and maltodextrin in stevia extract powder was 1:1, but the highest ratio of 1: 3 was the most favoured by the panellist.

1. Introduction

Sweeteners are in high demand in society today. The production of cane sugar was about 7.13 million tons in 2018. In 2018, sugar import data reached 731,4 thousand tons and exports reached around 1,82 thousand tons (Directorate General of Plantation, 2018). Therefore, aside from seeking solutions for natural sweeteners which are not detrimental to health and to fulfilling the intake of domestic sugar. It is possible to use this sweetener in stevia leaves (*Stevia rebaudiana* Bertoni) (Yulianti *et al*., 2014).

Stevia rebaudiana Bertoni produces stevioside, which is the primary sweetness portion of S*tevia rebaudiana*. Stevia includes glycosides of steviol terpene such as stevioside, steviolbioside, rebaudioside A, rebaudioside B, rebaudioside C, rebaudioside D, rebaudioside E, rebaudioside F, rebaudioside A, rebaudioside R, and rebaudioside S (Ibrahim *et al*., 2016). Chemical compounds containing sugar (glycone) and not sugar (aglycone) are glycosides (Zain, 2019). Rhamnose, fructose, glucose, xylose, and arabinose are the core components of glycone. In general, stevioside contains about 4-13% of the dry weight of the leaves (Tavarini and Angelini, 2013). However, approximately 2-4% of rebaudoside A (Salehi *et al.,* 2019).

Stevia leaves contain stevioside and rebaudioside with 300 times the sweetness amount relative to sucrose. It is known that Stevia liquid sugar has an amount of sweetness of about 1.2 or 240 times sweeter than sucrose (Zain, 2019). Stevia leaves are low in calories, but they

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are healthy to eat (Salehi *et al.,* 2019). Apart from sweetness, in the aspects of a sour flavour, stevia leaves have an aftertaste. This is attributed to the occurrence of polyphenol substances (Arriola *et al*., 2015).

Polyphenol compounds usually contain antioxidant compounds. Chlorogenic acid is a class of polyphenol esters, including hydroxycinnamic acid and quinic acid, which have excellent hydrophilic antioxidant activity and medicinal properties. Chlorogenic acid is the primary polyphenol portion of the leaves of *S. rebaudiana* Bertoni. Stevia leaves contain steviol glycosides, which can be a food source for new antioxidants or chemicals used in antidiabetic foods and medicines (Myint *et al.,* 2020).

Flavonoid compounds usually contain antioxidants. Stevia leaves produce five phenolic compounds, namely 4-HAI-β-D-glucopyranoside vanillic acid, protocatechuic acid, caffeic acid, chlorogenic acid and chlorogenic crypto acid (El-Nassag *et al.,* 2019). Compounds of stevia leaf polyphenol are presented in Table 1. Consequently, phenolic compounds that can neutralize stress can have antioxidant properties (Salehi *et al.,* 2019). The antioxidant activity of stevia can prevent the spread of free radicals, such as superoxides that cause DNA damage (Tavarini and Angelini, 2013). The antioxidant components of stevia will also inhibit cell damage and reduce the chance of developing carcinogenesis and tumours. In general, for plant growth and protection against infection and injury, phenolic compounds are important. Oxidative stability can be greatly impaired by phenolic compounds (Pacifico *et al.,* 2019). Antioxidant polyphenols are common constituents in edible plants. Furthermore, polyphenols are characterized as food antioxidants (Pasrija and Anandharamakrishnan, 2015).

The extraction method is microwave-assisted extraction (MAE). This method can maintain better antioxidant activity than ultrasound-assisted extraction (UAE) using distilled water as a solvent (Periche *et al.,* 2015). This is influenced by the relatively short extraction duration and the microwaves used during the extraction process. Microencapsulation technology is the incorporation of substances into a matrix to maintain the physical structure of the compounds that are maintained, protect them from degradation by environmental factors, such as sunlight, oxygen, humidity, and heat, prevent exposure to volatile compounds, inhibit possible side effects of compounds on the body, and increase bioaccessibility by controlling the release of the encapsulated substance (Chen *et al.*, 2019).

This drying is carried out in the processing of amorphous stevia extract powders because it is carried out at atmospheric pressure, allowing the drying to be carried out with the addition of a coating below the glass transition temperature of the stevia solution. It is equivalent to using a vacuum oven to dry honey powder (Nurhadi, 2016). According to the ideal gas law, at low absolute pressure (vacuum conditions), air or water vapour can evaporate at a lower temperature than normal conditions (1 atm). This enables drying to occur at lower temperatures and faster (Nurhadi *et al*., 2012). Vacuum

Table 1. Polyphenol content in *Stevia rebaudiana* Bertoni leaves

Name	References
Roseoside	Pacifico *et al.* (2019)
Quercetin-3-O-glucoside	Pacifico *et al.* (2019)
1,4-Dicaffeoylquinic acid	Pacifico *et al.* (2019)
1,3-Dicaffeoylquinic acid	Pacifico *et al.* (2019)
Quercetin-3-O-glucoside	Pacifico *et al.* (2019)
Caffeic acid	Lemus-Mondaca *et al.* (2018)
Trans-ferulic acid	Lemus-Mondaca *et al.* (2018)
Isochlorogenic acid A	Zhang *et al.* (2017)
Isochlorogenic acid B	Zhang *et al.* (2017)
Isochlorogenic acid C	Zhang *et al.* (2017)
Quercitrin	Zhang *et al.* (2017)
Galuteolin	Zhang *et al.* (2017)
Neochlorogenic acid	Zhang *et al.* (2017)
Cryptochlorogenicacid	Zhang *et al.* (2017)
Catechin	Can and Baltas (2016)
Luteolin	Can and Baltas (2016)
Gallic acid	Can and Baltas (2016)
Vanillic acid	Can and Baltas (2016)
Syringic acid	Can and Baltas (2016)
Cinnamic acid	Can and Baltas (2016)
Caffeic acid	Can and Baltas (2016)
4-Coumaric acid	Kim *et al.* (2011)
4-Methoxybenzoic acid	Kim *et al.* (2011)
4-Methylcatechol	Kim *et al.* (2011)
Pyrogallol	Kim *et al.* (2011)
Sinapic acid	Karakose *et al.* (2011)
1,3,5-Tricaffeoylquinic acid	Karakose *et al.* (2011)
3,4,5-Tricaffeoylquinic acid	Karakose *et al.* (2011)
Tricaffeoylquinic acid	Karakose *et al.* (2011)
4-Caffeoyl-5-feruloylquinic acid	Karakose *et al.* (2011)
3-Feruloyl-5-caffeoylquinc acid	Karakose *et al.* (2011)
3,4-Dicaffeoylquinic acid	Karakose *et al.* (2011)
3,5-Dicaffeoylquinic acid	Karakose *et al.* (2011)
4,5-Dicaffeoylquinic acid	Karakose *et al.* (2011)
3-Feruloylquinic acid	Karakose *et al.* (2011)
5-Feruloylquinic acid	Karakose *et al.* (2011)
3-Caffeoylshikimicacid	Karakose *et al.* (2011)
4-Caffeoylshikimic acid	Karakose *et al.* (2011)
5-Caffeoylquinic acid	Karakose *et al.* (2011)
5-p-Coumaroylquinic acid	Karakose *et al.* (2011)
5-Caffeoylshikimic acid	Karakose *et al.* (2011)

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drying may decrease the degree of non-enzymatic browning, which is a temperature-influenced phenomenon. The relationship between increasing non-enzymatic browning and increasing temperatures is linear (Mitra *et al.,* 2015). More amorphous forms can also be produced by vacuum dryers than crystalline ones (Nurhadi *et al.*, 2018). Vacuum drying is capable of drying thermoformable surfaces at low temperatures and is ideal for the removal of solvents from solid solvent-containing products. Basically, by moving steam or hot water through a hollow shelf, heat is delivered. As it can dry heat-sensitive goods, vacuum drying is used exclusively. Vacuum dryers tend to be more costly than those operating at near atmospheric pressure (Parikh, 2015).

An additional coating material is given to render stevia extract powder. Coating materials are materials that serve in the microencapsulation phase as a coating for the central material (active ingredient) (Masters, 1979 cited by Purnomo *et al.*, 2014). The coating that is often used in microencapsulation is maltodextrin (Reineccius, 1988 cited by Zorzenon *et al.,* 2020). Maltodextrins are carbohydrates, which are often used as encapsulation agents because of their affordable price, high solubility and efficiency, good taste, bright colour, increased oxidation resistance, and the absence of sweetness (Hussain *et al.,* 2018). Maltodextrin consists of D-glucose units linked by glycosidic bonds (α1-4), giving a D-glucose polymer of variable length. The reduced amount of reducing sugar is fined by the dextrose equivalent (DE) value, which is calculated based on dry weight, ranging from 0 to 20.

The DE value directly interferes with physicochemical parameters, such as hygroscopicity and solubility (Castro *et al.*, 2016). These properties make it the most commonly used wall material in microencapsulation (Mahdavi *et al.*, 2016). In addition, maltodextrin is efficient and stable in wrapping natural products, such as stevia (Chranioti *et al.,* 2016; Zorzenon *et al*., 2019). However, maltodextrin has a higher glycemic index than sucrose, which is around 106-136. This causes maltodextrin to increase blood sugar levels. Therefore, as a coating mixture, Arabic gum was used in this analysis. Maltodextrin is not as high as the frequency of the Arabic gum glycaemic index. The findings of previous studies (Krishnan *et al.,* 2005 cited by Purnomo *et al.*, 2014) indicate that the combination of Arabic gum coating material and maltodextrin is more effective than other coating materials in shielding the active ingredient. Arabic gum has the property of increasing viscosity when dissolved in water (Bertolini, 2001 cited by Purnomo *et al.*, 2014), it helps stabilize the dispersion of the less soluble components. The high viscosity due to Arabic gum can be reduced by the addition of maltodextrins which have fast dispersion properties (Hui, 1992 cited by Zorzenon *et al.,* 2020). Arabic gum is an emulsifier, while maltodextrin can increase the stability of solids by reducing clotting, stickiness, and increasing solubility (Nurhadi, 2016).

To the best of our knowledge, there are no studies on the physicochemical properties of encapsulated and vacuum-dried stevia extract powder. No research was found to evaluate the stevioside content of stevia extract powder. In this sense, this work aimed to microencapsulation process with a vacuum oven obtained from the pre-treatment of stevia leaves, using maltodextrin Arabic gum (DE 18) as an encapsulation agent that aims to increase physicochemical parameters, maintain phenolic content, and provide natural sweeteners that are beneficial to health. It is also assumed that this stevia extract powder will have health benefits based on the findings of previous research on the capacity for antioxidant and phenolic content in stevia leaves (Ruiz-Ruiz *et al.,* 2017). The addition of Arabic gum and maltodextrin, however, will decrease the antioxidant activity of stevia extract powder. The purpose of this research, therefore, was to determine the physicochemical properties of stevia extract powder.

2. Materials and methods

2.1 Materials

The main ingredient used in this research is fresh stevia leaves obtained from "One Home Farm" plantation area, Bogor City, West Jawa, Indonesia with a fresh leaf water content of 74.73% (wet basis). Other additives are aquadest, Arabic gum from the USA (TIC GUMS Brand), and maltodextrin (DE 18) from Qinhuangdao Lihua Starch, Co., LTD Made in China. Materials for analysis include l,l-diphenyl-2-picrylhydrazyl (DPPH) by Sigma, methanol, acetone, deionized water (18 MΩ-cm) by the Milli-Q plus system was purchased from Induslab (Londrina). All reference compounds were provided by Sigma-Aldrich (Brazil).

2.2 Stevia extract powder preparation

2.2.1 Blanching treatment of stevia leaves

Blanching is an effort that is aimed to inhibit enzyme activity, both the enzymes contained in food ingredients and the enzymes produced by putrefying bacteria (Widyasanti *et al.*, 2019). It makes the colour of the resulting stevia extract powder not too brown. The blanching method used is boiling at±97°C for 2 mins. The peroxidase test is useful for determining the effectiveness of blanching (Yang *et al.,* 2015). Fresh stevia leaves were dried using an oven blower at 55ºC for 5 hrs to obtain 8% moisture content (wet basis) (Fishi

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et al., 2020).

2.2.2 Extraction of stevia leaves

Microwave-assisted extraction was used to extract dry stevia leaves (R-88D0(K)-IN) method. Aquadest is used as a solvent (Fishi *et al.*, 2020). Raw material: a solvent ratio of 1:35 (w/v) with 300 watts of microwave power for 5 mins (Wahyuni, 2016). Macerate was evaporated by rotary vacuum evaporator at 40°C, 80 rpm to 10% total solids.

2.2.3 Encapsulation of stevia extract powder

Stevia extract powder was added to Arabic gum as a coating material and maltodextrin as a matrix. Coating materials can protect volatile compounds from oxidation and evaporation (Kania *et al.*, 2015). The viscosity matrix is low at high solids and has high solubility properties. The ratio used in the raw material: solvent ratio is 1:1 (w/w) (Kania *et al.*, 2015). The studies used three ratios of Arabic gum: maltodextrin were 1:1, 1:2, 1:3. The stevia extract that has been given a binder is dried in a vacuum oven (Digital Vacuum Oven by 18-One) for 6 hrs at 50°C. Stevia solids are reduced in size using a grinder and sieved with an 80 mesh sieve.

2.3 Stevia extract powder analysis

2.3.1 Hygroscopic rate of stevia extract powder

In this study the hygroscopic rate was determined by weighing the sample by 0.5 g, placing the sample in a desiccator that had a Relative Humidity of 75%, recording an increase in sample weight every 60 mins by 4 times, making a graph between time and sample weight, and calculating the slope value (GEA Niro Research Laboratory, 2005 cited by Nurhadi *et al*., 2020). The weight change of the sample was recorded at certain intervals for 4 hrs.

2.3.2 Repose angle of stevia extract powder

Repose angle was used to determine the flowability of stevia extract powder. The simplest method is the "poured" angle method. Repose angle can be determined by placing 1 g of the sample in a "Buchner funnel modification" with the open-end conditions closed. Next, the bottom of the funnel was opened and the sample was allowed to fall to a flat surface to form a balanced stack (Barbosa-Canovas *et al.,* 2005). The pouring of the sample is stopped when the heap reaches a predetermined height or width. The repose angle (α) was calculated as follows in Figure 1, the repose angle is measured by the inverse tangent (arc tan) rule at which the average radius of the formed conical shape and the maximum height of the heaped material is measured. The repose angle is determined with arctan of the maximum height to average radius ratio as following Equation 1 and Equation 2 (Nurhadi *et al.,* 2020).

$$\text{Tan } \alpha = \frac{x}{y} \quad (1)$$

$$\alpha = \text{arc tan} \frac{x}{y} \quad (2)$$

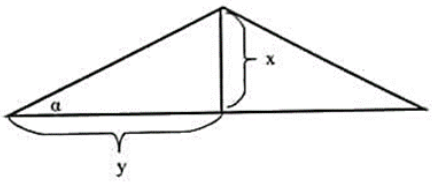

Figure 1. Statistic Repose Angle (º)

2.3.3 Colour evaluation of stevia extract powder

Colour characteristics of stevia extract powder were determined with a spectrophotometer (Konica Minolta CM-5 Sensing Singapore Pte Ltd). In the standard method, the spectrophotometer was used and the results were expressed as L ∗, a ∗, and b ∗ (L is the lightness, black, L = 0, white, L = 100, +a is redness, −a is greenness, +b is yellowness, −b is blueness) (Nurhadi *et al.,* 2020). Hue angle (H°) was calculated using following Equation 3 and Equation 4. Hue angle (H°) indicates the colour of the sample (0 or 360 = red, 54-90 = yellow-red, 90 = yellow, 180 = green, and 270 = blue), while Chroma (C) indicates purity or colour saturation.

$$H = \tan^{-1} \frac{b*}{a*} \quad (3)$$

$$C = [(a^{*2} + b\ a^{*2})^{1/2}] \quad (4)$$

2.3.4 Magnitude estimation of sweetness level in stevia extract powder

A subjective quantitative approach of 10 qualified panellists using sucrose sugar as a guide is this magnitude estimation. Build a log-log graph, where the concentration is the x-axis (% w/v), and the log value of sensory sweetness is the y-axis. An equation will be created by the regression results from the curve, where the results of the equation will be compared to Equation 5.

$$S = aC^n \quad (5)$$

Where S = sensory sweetness, C = extract concentration, a = intercept and n = slope.

2.3.5 Hedonic evaluation of stevia extract powder

Selection processes must be conducted to locate the required panellists, particularly the types of trained panels. In addition to being able to dedicate specific time for assessment and possessing the necessary sensitivity, panellists must generally pay attention to and be interested in this task. The panellists were evaluated on their skills after obtaining enough training, and the tests were repeated so that the panellists' reliability and

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sensitivity increased. The panellists are prepared to become trained panellists after completing several phases. Hedonic test in this study using fifteen trained panellists and 7 levels of assessment. Taste, colour, scent, aftertaste, and overall evaluation were the parameters examined. A score was assigned to each sample as part of the processing of the hedonic test findings data. According to the panellists' assessments as consumers, the taste organoleptic test on the sample tries to determine its level of sweetness. Five samples of sugar water concentration were 5%, 7.5%, 10%, 12.5%, and 15% in 100 ml were made to test the sweetness parameter.

2.3.6 Antioxidant activity of stevia extract powder

The sequestering activity of the microcapsules and the extract by their ability to remove 1,1-diphenyl-2-picrylhdrazyl (DPPH) radicals by Sigma. The initial stage of testing for antioxidant activity is to prepare a DPPH solution with a concentration of 160 ppm 50 mL dissolved in methanol p.a. DPPH solution was homogenized using a magnetic stirrer for 45 mins. The process of making the DPPH solution is carried out in conditions protected from sunlight. The R-value of the DPPH solution that had been made was measured using a Spectrophotometer (UV-9200/VIS = 7220G) at a wavelength of 517 nm which was placed in a test tube worth 2 mL of DPPH solution and 0.5 mL of methanol. A blank DPPH solution using 2.5 mL of methanol in a test tube. The preparation of the sample solution is the next step. In a 25 mL volumetric flask, the stevia extract powder sample was dissolved in acetone p.a with a concentration of 625 ppm. The sample solution was homogenized using a magnetic stirrer for 10 mins. The antioxidant activity test for stevia extract powder was performed at a concentration of 500, 250, 125, 62.5, 31.25 and was put in 5 test tubes as samples tested and 5 test tubes as blanks in test tubes with a combined solution of 2.5 mL. The resulting absorbencies ranging from ≤ 50 ppm showed very strong antioxidant activity, >50-200 ppm was strong, >200-600 ppm was weak, and > 600 ppm was very weak. Samples were analysed in duplicate and expressed in ppm. Means and standard deviations of the data were presented.

2.3.7 Total phenolic content of stevia extract powder

Phenolic compounds were quantified by Folin-Ciocalteau reagent. 100 mg of the sample was added, 0.5 mL of the reagent, and added 2.5 mL of Na-$_2CO_3$ 20% in a 10 mL volumetric flask and vortexed the solution for 1 min. The solution was incubated at room temperature for 40 mins in the dark. Absorbance was measured at 725 nm using a spectrophotometer (UV-9200/VIS=7220G). Total phenolic concentration was expressed in g gallic acid equivalent (g GAE/100 g), determined by the gallic acid analytical curve (20.0, 40.0, 60.0, 80.0, 100, and 120 µg/mL, $R^2 = 0.9993$).

2.3.8 Stevioside by High-Performance Liquid Chromatography of stevia extract powder

The concentrations of stevioside were determined by high-performance liquid chromatography (HPLC), using HPLC Alliance detector UV-Vis at wavelength λ = 210 nm. Optimal chromatographic column size 250 mm × 4.6 mm at a mobile phase flow rate of 1 mL/min. The mobile phase was a mixture of phosphate buffer at 10 mmol/L and pH 3.00 and acetonitrile (68:32, v/v) (Wojoweda *et al*., 2018). Stevia extract powder as a sample (about 0.1 g), 5 mL Milli-Q and 5 mL acetone were added, then stirred with sonic for 5 mins. The solution was put into a 25 mL volumetric flask with Milli -Q. The solution was filtered by 0.45 µ. 20 µL was injected to determine the concentrations of stevioside. Stevioside was analysed comparing with a standard stevioside using Equation 6. The results were expressed in g/100 g.

$$\frac{\text{Sample Area}}{\text{Standard Area}} = \frac{\text{Concentration of Sample}}{\text{Concentration of Standard}} \quad (6)$$

3. Results and discussion

3.1 Processing of stevia extract powder

Stevia leaf was the part of the stevia plant used for extraction and the most steviol glycoside aggregation was found in leaves and a bit on stems and flowers (Kinghorn, 2002 cited by Fishi *et al.*, 2020). The inactivation process of the enzyme was shown in Figure 2, it can be shown that the colour of food can be affected by blanching treatment with the boiling process. Air oxidation triggers a browning reaction due to the impact of food enzymes (Widyasanti *et al.*, 2019), as seen in Figure 2 (b). Stevia leaves were dried at 55°C for±5 hrs in this analysis. The stevioside content will decrease marginally if the leaf drying is conducted above 70°C while using temperatures up to 80°C will not only induce a decrease in the sugar content in the leaves but will also appear blackish-brown in colour (Fishi *et al.*, 2020). The moisture content of dry stevia leaves was considered to exceed 8.61% (wb) and stevia extract powder 9.73% (wb) (AOAC, 2005 cited by Nurhadi *et al.,* 2020).

Dried stevia leaves that will be extracted are not reduced in size to reduce the browning of the resulting stevia extract powder. In this study, the extraction of stevia leaves used the microwave-assisted extraction (MAE) method. Distilled water is used as a solvent in this study because it can produce a high enough total phenolic content with halal safety for food products. Conventional extraction methods, such as maceration

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and Soxhlet extraction, consume large amounts of organic solvents and long extraction times, providing lower efficiency (Poojary *et al.,* 2017).

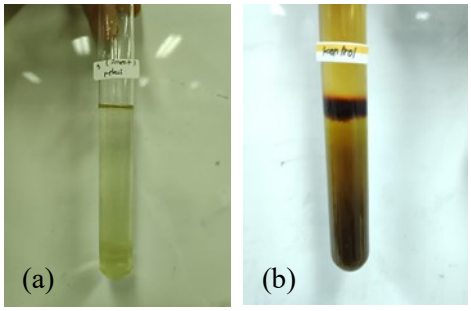
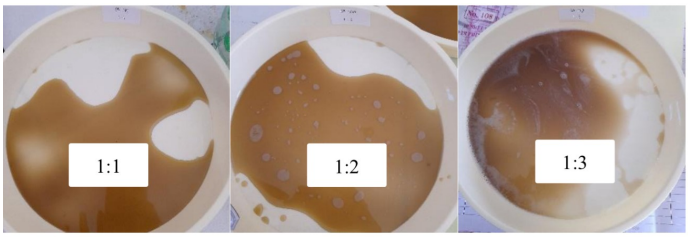


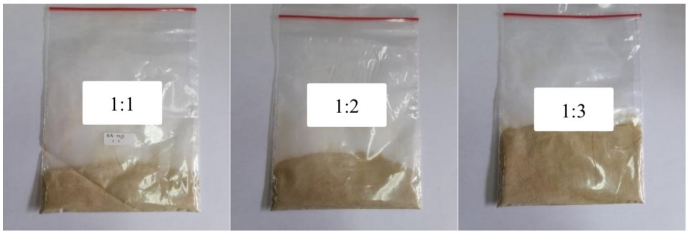
Figure 2. Peroxidase test of (a) blanched and (b) stevia leaves

Evaporation of solvent evaporation with the sample using a rotary vacuum evaporator. Evaporation was carried out until the stevia extract solution had±10% total dissolved solids. Stevia leaf extract that has been evaporated is brownish and slightly thick. The stevia extract supplied with Arabic gum and maltodextrin was dried for 6 hrs at a temperature of 50°C by vacuum drying (Nurhadi *et al.*, 2015). Using a grinder, the solid is reduced in size after the stevia solid is formed and sieved using an 80 mesh sieve. The processing of stevia extract powder with different ratios were shown in Figure 3.



(a) Encapsulation Process of Stevia Extract Powder

(b) Granul of Stevia Extract Powder



(c) Stevia Extract Powder

Figure 3. Processing of stevia extract powder

3.2 Physicochemical properties of stevia extract powder

3.2.1 Hygroscopic rate of stevia extract powder

Based on Figure 4, the rate of hygroscopicity of stevia extract powder with the addition of Arabic gum and maltodextrin in the 1:3 ratio is higher than that of other therapies, but the higher the concentration of Arabic gum and maltodextrin applied, the higher the rate of hygroscopicity. At a ratio of 1:3, this can be shown, the hygroscopy rate just exceeds 1.54×10^{-4} g H_2O/g solid/hour. The increased concentration of Arabic gum and maltodextrin, and the growing incidence of hygroscopicity and responsible for this increase. The further the Arabic gum and maltodextrin are applied, the less the area of Arabic gum and maltodextrin is affected by this boost. Perhaps as result, the smaller the area on the surface of Arabic gum and maltodextrin, the better the moisture penetration. In addition to that, the initial moisture content of the material affects the hygroscopicity rate. The 1:3 moisture content of stevia extract powder is higher than the 1:2 and 1:1 water content of stevia extract powder. The water content of the stevia extract powder increases with more Arabic gum and maltodextrin. Products with low water content will cause the absorption rate of water from the environment until the water content reaches equilibrium (How and Siow, 2020).

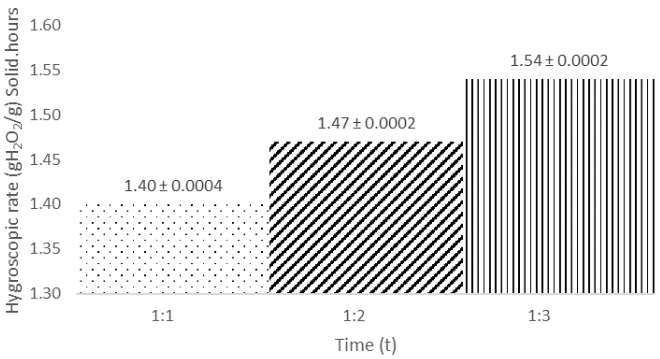


Figure 4. Hygroscopic rate of stevia extract powder

As it is formed from vacuum drying, stevia extract powder has an amorphous structure. This is in line with Nurhadi *et al.* (2018), which creates an amorphous structure from vacuum drying in powdered coconut sugar, whereas the effects of traditional cooking have a crystal structure. Particles with an amorphous structure typically have higher hygroscopicity than particles with a crystalline structure, and when deposited at low water activity, the amorphous structure absorbs water more quickly. Particles of an amorphous structure have irregular molecules, are more open, and have a wide volume, making it possible for them to connect with the atmosphere and readily consume water. Compared with non-hygroscopic goods, hygroscopic products agglomerate more readily when processed (Nurhadi *et al.*, 2018).

3.2.2 Repose angle of stevia extract powder

The bulk angle is the angle created on a flat foundation by the slope of the mound of material poured

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horizontally. In a balanced mound of the material lies the corner of the material. The bulk angle is the measure of a product's flowability, the lower the bulk angle (ramps) the greater the product's flowability (Barbosa *et al*., 2005 cited by Nurhadi *et al*., 2020). When pumped through a funnel on a flat surface, free-flowing and granular materials create a cone with a slight resting angle of 35° or less, whereas cohesive powders, by comparison, have a higher resting angle (higher than 55°). Based on Table 2, it can be seen that the stevia extract powder produced from the ratio of Arabic gum and maltodextrin 1:3 has a higher bulk angle value compared to the concentration ratio of 1:2 and 1:1.

Table 2. Repose angle stevia extract powder

Samples	Repose Angle (º)
1:1	31.35±0.4
1:2	33.21±0.16
1:3	34.05±0.09

Vacuum-dried results in an amorphous structure of the product that induces clumping and it is very hard for the product to flow freely. The moisture content of the substance is another aspect that can impact the amount of bulk angle, where the bulk angle will rise with increasing moisture content. Based on Table 2 above, it can be seen that the moisture content of stevia Arabic gum powder and maltodextrin 1: 3 has the highest value between the 1:2 and 1:1 treatments. This causes the flowability of the stevia extract powder to decrease, resulting in stickiness between particles or cohesiveness. The adhesiveness between these particles causes the angle of bulk to increase as the water content of the product increases. The meaning of the bulk angle of food can be grouped according to Carr (1976) cited by Nurhadi *et al.* (2020), <35º (free-flowing), 35º- 45º (slightly cohesive), 45º-55º (strong cohesive and non-flowing) and >55º (strong cohesive and non-flowing) (very cohesive). Stevia extract powder has an angle of <35º in this analysis, indicating that stevia extract powder has a free-flowing ability.

3.2.3 Colour evaluation of stevia extract powder

Based on Table 3 the L* value of stevia extract powder derived from the ratio of Arabic gum: maltodextrin 1:1 indicates that the L* value of stevia extract powder produced from the ratio of Arabic gum: maltodextrin 1:1 is higher in other therapies and decreases at a 1:2 ratio, then increases again at a 1:3 ratio. This can be caused by the brownish-white colour of Arabian gum (cream), and the white colour of maltodextrin affects the brightness of the stevia extract powder. The addition of unnecessary Arabic gum will create a colour that is too dark to decrease the level of brightness closer to 0. A product's brightness is closely related to the L* value ranging from 0 (black) to 100 (black) (white). The meaning of L* reflects the reflected light that creates a white achromatic hue.

The colour derived from a 1:2 ratio of stevia extract powder is lower than in other comparisons. This is due to the occurrence of two reactions, namely the Maillard reaction and caramelization. The 1:1 ratio of stevia extract powder produces a darker colour than other ratios in order to achieve a better 1:1 ratio of the colour value of the stevia extract powder. Compared to other therapies, the 1:1 ratio of stevia extract powder has the lowest b* colour strength, and the greater the concentration of Arabic gum: maltodextrin ratio applied, the higher the powdered sugar colour b*. The natural colouration of Arabic gum, which is brownish-white and maltodextrin in colour, which reduces the brightness but increases the yellow colour of the stevia extract powder, will induce the increased strength of the b* colour. In the Yellow Red Chromaticity Colour Spectrum (YR) area with a value range of 54-90, the ºHue value of all stevia extract powder treatments was used.

3.2.4 Magnitude estimation of sweetness level in stevia extract powder

The sweetness similarities study was applied to stevia extract powder to determine the sweetness range of granulated sugar. The sweetness test was achieved by using the method of magnitude estimation. The sweetness of the five concentrations of stevia extract powder from each stage I and stage II procedure was measured by ten qualified panellists relative to the reference group (10% sucrose) which had a value of 100 and 4 other sucrose concentrations. The sweetness evaluation (S) results were translated into logs, and then plotted on the log-log graph with the concentration (C).

The findings of the regression of the linear sweetness equation of sucrose and stevia extract powder include an equation that generates the y vector, which is the sweetness evaluation (S), the intercept component, the concentration variable x (C), and the slope variable n. The 10% sweetness value (S) of sucrose for the (C) concentration was 55.16. The C value is looked for when deciding the concentration of stevia extract powder

Table 3. Colour analysis of stevia extract powder

Samples	L*	a*	b*	C	º Hue
1:1	72.12±0.007	0.26±0	21.49±0	21.49±0	89.31±0
1:2	69.81±0	0.46±0	22.38±0.02	22.38±0.02	88.82±0.001
1:3	70.43 ±0	0.51±0.007	22.49±0.01	22.50±0.01	88.71±0.01

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having the same sweetness amount (S) in sucrose, so in the sweetness equation of stevia extract powder, by entering the value S = 55.16. The sucrose concentration would create a degree of sweetness of the stevia extract powder relative to the stevia extract powder concentration with a value of S = 55.16. Figure 5 displays the sweetness level of stevia extract powder with 10% sucrose.

Based on Figure 5, it is shown that the sweetness level of the treatment with stevia extract powder is 1: 1, 1: 2, 1: 3 is 4.70, 4.41, and 3.28 times the 10% sucrose concentration. Owing to the inclusion of coating ingredients, including Arabic gum and maltodextrin, and vice versa, a drop in the sweetness level of the stevia extract powder occurred. The coating material can cover the content of stevioside and rebaudioside in the powder of the stevia extract to minimize the sweetness.

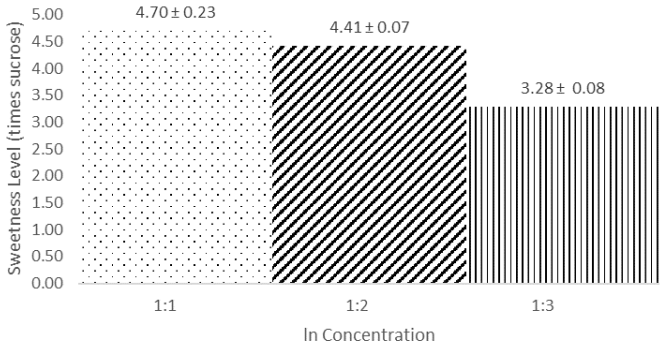

Figure 5. Sweetness level of stevia extract powder

3.2.5 Hedonic evaluation of stevia extract powder

The object of the hedonic test on stevia extract powder is to determine the degree of preference for stevia extract powder for the panellist. The hedonic scale is translated into a numeric scale, with the greater number according to the preference amount, so that the data collected can be statistically interpreted. In this study, panellist was considered consumers because the stevia extract powder was targeted to be marketed and consumed by the public. This test involves fifteen panellists and seven levels of assessment. The parameters tested were taste, colour, aroma, aftertaste, and overall. The hedonic test result data is processed by giving a score for each sample. Organoleptic test data can be seen in Table 4.

Table 4. Hedonic test of stevia extract powder

Parameter	1:1	1:2	1:3
Flavour	3.98	4.07	4.31
Colour	4.47	4.71	5.13
Aroma	4.40	4.51	4.71
Aftertaste	3.78	4.00	4.29
Overall	4.1	4.44	4.78

3.2.6 Antioxidant activity and total phenolic content of stevia extract powder

Antioxidant-active compounds are compounds that can suppress or resist free radicals that can kill body cells. Using diphenyl picrylhydrazyl (DPPH) free radicals is the general method of measuring the antioxidant activity of a substance. DPPH is a free radical that has stable properties and activity by relocating free electrons to a molecule so that the molecule is not reactive like other free radicals. The appearance of a dense purple (violet) colour that can be defined in the absorbance band at a wavelength of 517 nm in ethanol solvent is indicated by this relocation method (Molyneux, 2004 cited by Fahleny *et al*., 2014). Figure 6 shows the findings of the antioxidant activity test on stevia extract powder. Figure 7 shows the inhibition curve of stevia extract powder.

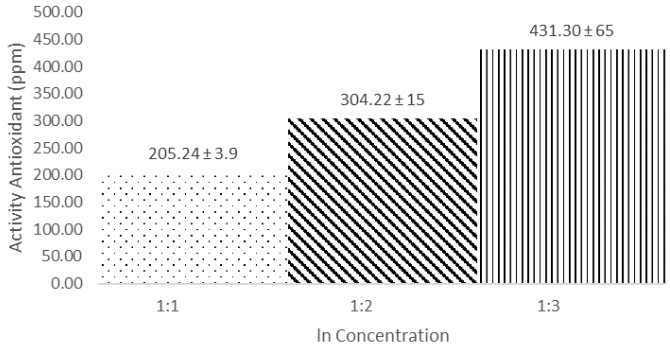

Figure 6. IC_{50} of stevia extract powder

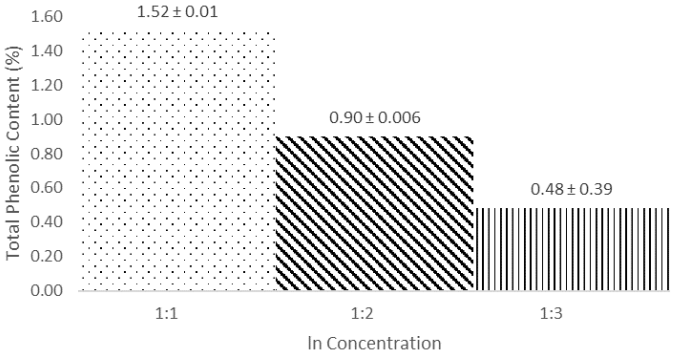

Figure 7. Total phenolic content of stevia extract powder

The occurrence of compounds with antioxidants is associated with the presence of chlorophyll material. When dissolved in a transparent greenish colour, the chlorophyll content of stevia extract powder is evident in the colour of the stevia extract powder. It can be shown that the total IC_{50} content of stevia extract powder exceeds 431.30 ppm based on Table 4 above. The lower the value of IC_{50}, the higher the activity of antioxidants and vice versa. If the IC_{50} value is less than 50 ppm, high if the IC_{50} value is between 50 - 100 ppm, mild if the IC_{50} value varies between 150-200 ppm, low if the IC_{50} value is from 200 - 600 ppm, and extremely weak if the IC_{50} value reaches 600 ppm, an antioxidant function is in the very strong group (Molyneux, 2004 cited by Fahleny

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et al., 2014). The antioxidant activity of stevia extract powder is in the weak category, ranging from 200 - 600 ppm. The weak antioxidant activity of stevia extract powder is influenced by the presence of Arabic gum binder and maltodextrin.

The antioxidant activity increases with the addition of the coating substance. As the inclusion of coating material increases, the antioxidant function is becoming lower. The antioxidant effects of *S. rebaudiana* Bertoni have recently been identified with phenolic compounds. The content of total phenols stevia extract powder expressed as mg of gallic acid equivalents per gram of stevia extract powder was noted respectively 1.52%, 0.9%, and 0.48% as seen in Figure 7. The total phenolic content in stevia extract powder decreased along with the increase in the coating ratio. As predicted, Arabic gum and maltodextrin microcapsules with a coating ratio of 1:1 had higher antioxidant activity than those prepared with a coating ratio of 1:2 and 1:3. This is close to prior findings as well. Another similar research was performed with the inclusion of maltodextrin (ratio 1:2 w/w) in microencapsulated stevia extract, which lowered the bioactive content (Zorzenon *et al.,* 2020).

High retention of the core materials and minimum amounts of the core materials on the powdered particle surface depends on an efficient encapsulation process (Mahdavi *et al*., 2016). A possible way to assess the retention of materials in the nucleus and their quantity at the surface may be the method of microencapsulation efficiency carried out in our work. The total surface mass content was analyzed and the results derived from the mass differences suggest that the bioactive compounds found in the extract were primarily retained in the nucleus (about 80%). The lack of cracks in the microcapsule surface is another point, indicating the impermeability of the wall and, thus, the inconvenience of removing the compounds from the nucleus.

Several studies have stated that antioxidant compounds degrade when exposed to high-temperature processes (Edris *et al*., 2016) such as using a spray dryer. The spray dryer requires a high temperature (above 100° C). In the research of Zorzenon *et al*. (2020), the stevia extract was dried using a spray dryer at a temperature of 135°C. A vacuum oven was therefore used to preserve the antioxidant compounds during heating in this analysis. This is because the temperature of the vacuum oven is below that of the spray dryer. Vacuum drying is a common method used to dry various food items, especially foods containing compounds sensitive to heat (Methakhup *et al*., 2005 cited by Saifullah *et al*., 2019). Last research by Papoutsis *et al*. (2017) showed similar results when drying lemon pomace using various vacuum drying temperatures (70°C, 90°C, and 110°C) and when temperatures rose from 70°C to 110°C, a higher amount of gallic acid was obtained. These may be clarified by faster inactivation at higher temperatures of the oxidase enzyme (polyphenol oxidase) (Lim and Murtijaya, 2007). Another study with *Cayratia trifolia* vacuum drying leaf showed a higher concentration of antioxidant activity than in Freeze-Dryer (Rabeta and Lin, 2015), indicating that oxidative and hydrolytic enzymes are deactivated by high temperatures, preventing loss of polyphenolic components (Han *et al.,* 2018). Vacuum drying would be the most productive drying method for the production of stink bean powder due to its improved antioxidant ability, light colour, and comparatively more durability after storage. The DPPH free radical scavenging behaviour (7.62±1.77 and 10.38±0.63 mg AA/gdb respectively) was recognized in the analysis (How and Lee-Fong, 2020).

3.2.7 Stevioside by High-Performance Liquid Chromatography of stevia extract powder

The highest levels of stevioside were found in the Arabic gum: maltodextrin 1:1 with an average of 0.0731%. Based on Figure 8, the lowest stevioside levels were found in Arabic gum treatment: maltodextrin 1:3 with an average of 0.0406%. Figure 7 indicates that the higher the percentage of coating content, the lower the volume of stevioside. The more Arabic gum and maltodextrin were added, the less stevioside, which is the main sweet taste compound in stevia extract powder, will cause this decrease. This correlates with antioxidant compounds which decrease with the addition of the coating material ratio. It is suspected that the addition of Arabic gum and maltodextrin causes the stevioside level to decrease due to the nature of Arabic gum and maltodextrin as an emulsifier. Maltodextrin as a coating does not have a good ability as an emulsifier, while Arabic gum is a good emulsifier because of the protein component (Khasanah *et al.,* 2015).

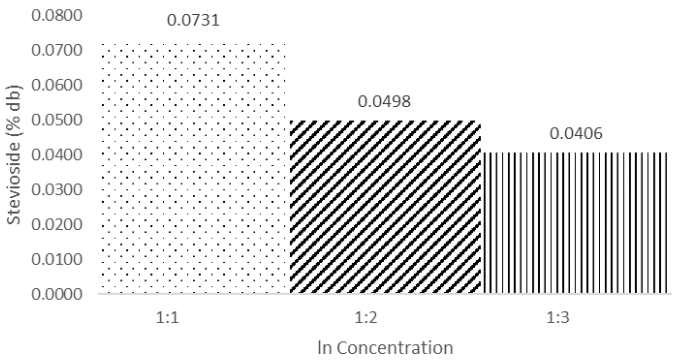

Figure 8. Stevioside of stevia extract powder

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4. Conclusion

In this study, to get the best encapsulation formulation to make stevia extract powder was coated with different ratios of Arabic gum and maltodextrin combinations using vacuum-drying. Arabic gum better protects the bioactive components in the stevia extract powder, while the higher maltodextrin can reduce the bioactive components during vacuum-drying. It appears that the higher the maltodextrin ratio, the lower the sweetness level, antioxidant activity, and total phenolic. Arabic gum can retain free-flowing and repose angle properties. Among the three different coating ratios, the 1:1 ratio was the best. The lower the coating ratio the best physicochemical characteristics of the stevia extract powder, and the higher the coating ratio the fewer physicochemical characteristics of the stevia extract powder. However, the highest ratio of 1: 3 was the most favoured by the panellist.

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