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SENSORY AND BIOACTIVE PROPERTIES RESPONSE TO REFORMULATION AND PROCESSING OF JAVA-TEA-BASED FUNCTIONAL DRINK: A REVIEW

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ABSTRACT

Java-tea-based (*Orthosiphon aristatus* B. Miq) functional drink is reported to have privileges, mainly its physiological functions and bioactive properties such as antioxidant activity and antihyperglycemic ability. Java-tea-based functional drinks contain bioactive compounds from natural materials, including java-tea leaves, ginger, sappan-wood, curcuma, lime, and kaffir lime. Several innovations and challenges have been carried out during its development, affecting the drinks' quality and stability. The stability of the beverage, especially in the aspects of sensory and bioactive properties, is still considered inferior. This review focuses on the formulation and processing technology conducted from 2007 to 2019. In the case of the reformulation, it showed that the addition of kaffir lime extract, lime extract, and flavor enhancer could improve the sensory properties in terms of aroma and taste. Furthermore, the changes in the specific java-tea plants' variety as the main ingredient and replacing the sucrose with non-sucrose sweeteners increased the bioactive properties. Recently, the formula has been enriched with a red fruit oil emulsion to improve the drink's appearance due to contains abundant carotenoid pigments. However, the addition also created another hurdle, particularly in the flavor sensory aspect and emulsion stability. In the case of processing, applying microencapsulation and nanoencapsulation in java-tea drinks has increased the bioactive properties, especially antioxidant activity and antihyperglycemic, and also improved the product's stability which prolonged the shelf life. The development of java-tea-based functional drinks might become a milestone to reference other similar product development.

Keywords: antihyperglycemic; antioxidant; java-tea-based functional drink; reformulation; technology

ABSTRAK

Minuman fungsional berbasis kumis kucing *(Orthosiphon aristatus* B. Miq) memiliki keunggulan berupa fungsi fisiologis dan aktivitas biologis seperti aktivitas antioksidan dan antihiperglikemik. Minuman fungsional berbasis kumis kucing memiliki senyawa aktif yang berasal dari bahan baku alami meliputi daun kumis kucing, jahe gajah, kayu secang, temulawak, jeruk nipis, dan jeruk purut. Rangkaian inovasi dan tantangan dalam pengembangan produk memengaruhi kualitas dan stabilitas minuman fungsional berbasis kumis kucing. Kestabilan minuman dinilai masih rendah ditinjau dari aspek sensori dan aktivitas biologis. Review ini difokuskan pada pengembangan dari aspek formulasi dan teknologi pengolahannya pada periode 2007-2019. Pengembangan dari aspek reformulasi minuman fungsional berbasis kumis kucing menunjukkan bahwa penambahan ekstrak jeruk purut, ekstrak jeruk nipis, dan penguat rasa dapat meningkatkan sifat sensori dari aspek aroma dan rasa. Perubahan varietas tanaman kumis kucing sebagai bahan baku utama dan penggantian sukrosa menjadi pemanis non-sukrosa dapat meningkatkan aktivitas biologis. Penelitian terbaru, formula diperkaya dengan emulsi minyak buah merah untuk meningkatkan penampilan minuman karena mengandung pigmen karotenoid. Namun, penambahan tersebut juga menimbulkan kendala lain, terutama dalam aspek sensori rasa dan stabilitas emulsi. Pengembangan dari aspek pengolahan menunjukkan bahwa penerapan mikroenkapsulasi dan nanoenkapsulasi pada minuman fungsional berbasis kumis kucing meningkatkan aktivitas biologis, terutama aktivitas antioksidan, dan antihiperglikemik, serta meningkatkan stabilitas sehingga memperpanjang umur simpan produk. Pencapaian dalam pengembangan minuman fungsional berbasis kumis kucing berpeluang menjadi acuan bagi pengembangan produk sejenis lainnya.

Kata kunci: antioksidan; antihiperglikemik; minuman fungsional berbasis kumis kucing; reformulasi; teknologi

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INTRODUCTION

Food product development is a strategy to fulfill consumer needs and market segmentation (FAO 2006). Food product innovation and development is an ample opportunity to produce functional drinks along with the increasing market demand for food products that also provide health benefits (Bigliardi and Galati, 2013; Ogundele et al., 2016). According to Laura (2020), the market trend of functional drinks is estimated to increase by 8.08% Cumulative Annual Growth Rate (CAGR) by 2023.

The strategy of product innovation and development is conducted through reformulation and processing modification aimed at improving the characteristics of the final product to meet the customer specifications (Luo et al., 2019; Souza et al., 2019). The parameters of product development based on functional drinks have been done through the use of natural ingredients, the addition of prebiotics and probiotics, the reduction of sucrose through non-sucrose sweeteners substitution, processing technology modification, non-thermal application, and optimization of formulas and processing processes (Waziiroh, 2013; Corbo et al., 2014; Ogundele et al., 2016; Food review, 2019).

The java-tea-based functional drink is a non-alcoholic drink that gives physiological functions through its bioactive properties. It is made from spices and herbs with the initial ingredients including java-tea leaves, ginger, sappan wood, curcuma, and lemon (Wijaya et al., 2007). The drawback of java-tea drink has a slightly bitter aftertaste detected from the spices (Kordial, 2009; Afandi, 2011; Febriani, 2012). Based on sensory properties, java-tea drink has a hedonic preference score on the "slightly like" scale. The sensory properties with a lower level of preference for consumers are still unacceptable as a functional food, even though the products have health benefits (Wijaya, 2007).

Moreover, the stability of the java-tea ready to drink type is characterized by the decreasing of its physicochemical, sensory properties, antioxidant activity, and microbiological activity. Reformulation through substitution or addition of other ingredients might improve the product characteristics so it will prolong the shelf-life. Modifying the type of product by processing such as through nanoencapsulation and non-thermal technology can increase the product's shelf life and maintain the final product's stability and quality during storage (Hartyáni et al., 2011; Plaza et al., 2011).

The development of java-tea based on functional drinks has been implemented through reformulation and modification of processing technology to improve the quality of drinks and extend the product shelf life (Afandi, 2011; Indariani, 2011). This series of research results for 2007-2019 related to java-tea based on the functional drink has been used as a reference for food innovations and development (Wijaya, 2007; Michael 2019). Recently, the topic of the development of functional drinks is in great demand by scientists and industry practitioners to meet market trends. The scientific review discusses on the effect of reformulation and processing modification on java-tea based on a functional drink that can affect sensory and bioactive properties might enrich the inquiry.

MATERIALS AND METHOD

Writing the literature reviews involves brainstorming and exploring the literature related to the topic through collection, analysis, interpretation, and conclusions. The inclusion criteria of literature used to find the relevant topic discuss the characteristics of java-tea-based functional drinks and the effect of product development based on aspects of reformulation and processing supported by articles published in national and international scientific journals. Internet sites used to access primary information sources include the IPB Repository (www.repositoryipb.com), Mendeley Web (www.mendeley.com), Elsevier (www.elsevier.com), Wiley Online Library (onlinelibrary.wiley.com), Springer Link (www.springer.com), Google Scholar (www.scholar.google.com), and Science Direct (www.sciencedirect.com). Secondary sources of information used in writing scientific reviews are electronic books, scientific magazines, Google Books (www.books.google.com), News Letters-

IFT (www.ift.org), and Food Insight (www.foodinsight.org). There were 224 literature sources used as primary sources of information, comprising 15 undergraduate theses, five graduate thesis, three patents, 22 national journals, and 179 international journals. Also, 32 literature sources were used as secondary sources of information completed on scientific review. The scientific literature should fulfill the inclusion criteria, there is a thesis about “java-tea based functional drink” product developments, as the main source of literature conducted from 2007 to 2019. The journals were used as complementary information which must be published in the last ten years. The national and international journals had been validated through Sinta and Scimago. The literature was analyzed and interpreted to obtain the findings of a comprehensive scientific review. The type of data analysis carried out was in the form of comparative analysis and cause-effect analysis on each critical source of information. Data and information were interpreted and synthesized to answer the problem formulation and obtain a novel study. The scientific reviews were evaluated through the Turnitin website (www.turnitin.com) to check for plagiarism with the condition that the similarity percent is below 20%.

RESULTS AND DISCUSSIONS

JAVA-TEA-BASED FUNCTIONAL DRINK CHARACTERISTICS

The physicochemical and sensory properties of the java-tea-based functional drink are shown in Table 1. The functional drink is characterized as a low-calorie-based beverage with lower sugar content. The java-tea-based functional drink has a citrus flavor characterized by a citrus, fresh, fruity sensation. The java-tea-based functional drink has a reddish-yellow color to a yellow color based on color parameter through (Hue) method analysis. The yellow color of its beverage is derived from the sappan wood that contains brazilin pigment formed at a low pH after the addition of kaffir lime extract and lime extract, which also acts as an acidulant (Herold, 2007; Yemirta, 2010; Nirmal et al., 2015).

The java-tea-based functional drink has a total solids (TPT) of 14.52 °Brix, influenced by the concentration of each ingredient, especially the concentration of sucrose (Herold, 2007; Indariani, 2011). The java-tea-based functional drink has a low pH value due to lemon extract and contains bioactive compounds from spices dominated by the flavonoid group (Indariani, 2011). The extract of each natural ingredient for making the java-tea-based functional drink contains active compounds that are analyzed through high-performance liquid chromatography. Further information about the active compounds in each ingredient can be seen in Table 2.

Table 1. Physicochemical of Java-tea-based Functional Drink

Parameters	Value	Unit
Moisture content	98.88 ± 0.10	% b.b
Protein content	0.14 ± 0.01	% b.b
Fat content	0.60 ± 0.01	% b.b
Ash content	0.14±0.02	% b.b
Carbohydrate content	0.24 ± 0.14	% b.b
Calorie	6.92	kcal/100 g
Color	94.20	°hue
pH	3.7 ±0.1	-
Total phenol	426.73 ±37.81	pm GAE*/ml

Source: (Indariani, 2011)
*GAE: Gallic Acid Equivalent

Table 2. Bioactive Compounds Indicator in Each Ingredient

Ingredients	Bioactive compounds	Concentration (mg/mL)
Java-tea leaves	Sinensetin	0.024
Curcuma	Curcumin	0.35
	Desmetoksi curcumin	0.15
Ginger	6-gingerol	1.019
	8-gingerol	0.2
	6-shogaol	0.067
	10-gingerol	0.472
Sappan wood	Brazilin	1.32
Kaffir lime	Hesperidin	0.092
	Naringin	0.01
Lime	Hesperidin	0.026

Source: (Indariani, 2011)

BIOACTIVE PROPERTIES OF JAVA-TEA-BASED FUNCTIONAL DRINK

The java-tea-based functional drink has an antioxidant activity of 783.78 ± 9.08 moles Trolox/L, which was analyzed using the DPPH method (2,2-diphenyl-1-picrylhydrazyl) with the principle of hydrogen donor from the hydroxyl component to stabilize free radicals in the form of DPPH. (de Souza et al., 2013; Liu et al., 2017; Michael et al., 2019). The antioxidant activity of the java-tea-based functional drink should be abundantly influenced by phytochemical compounds such as flavonoids, alkaloids, tannins, saponins, triterpenoids, steroids, and hydroquinones (Indariani, 2011). High antioxidant activity has the potential to have antihyperglycemic abilities (Naibaho, 2018). High antioxidant activity can inhibit the oxidation of peroxide compounds when blood glucose levels are high (Monroy and Cristina, 2013), therefore this java-tea drink has been reported for having antihyperglycemic activities.

The antihyperglycemic abilities of the java-tea based functional drink have been analyzed by *in vivo* and *in vitro* methods (Diana, 2010; Indariani, 2011). The antihyperglycemic ability worked through the inhibition of α-glucosidase and α-amylase enzymes with IC_{50} values of 217.12 and 217.41 mg/mL (*in vitro*), and increased glucose absorption by mice diaphragm cells by 37.48 g. glucose/g cells indicate that the absorbed glucose will be converted into an energy source in the cells *(in vivo*) (Diana, 2010). Furthermore, the java-tea-based functional drink ready-to-drink showed an antihyperglycemic activity of 65.83% at a concentration of 16 times the formula based on in vivo model, increased insulin sensitivity, and suppressed pancreatic cell damage (Indariani, 2011).

THE INGREDIENTS PROFILE OF JAVA-TEA DRINK

Java-tea leaves (*Orthosiphon aristatus* B. Miq)

The java-tea plant (*Orthosiphon aristatus* B. Miq) also populer called as “kumis kucing” plant, in terms of flavor, has a characteristic woody aroma which is often described as the smell of "wet wood" or "wet cardboard" derived from β-caryophyllene as the highest compound content (Omowaye et al., 2015; Zaidan and Djamil, 2015; Joshi, 2020). In case of the bioactive properties of the java-tea plant are containing the rosmarinic acid, eupatorium, and sinensetin which act as antioxidants (Yuliana et al., 2016; Michael et al., 2019). Rosmarinic acid in java-tea leaves has the highest antioxidant activity by inhibiting the Reactive Oxygen Species (ROS) formation (Yuliana et al., 2016). The java-tea’s compound is also reported to inhibit the activity of the α-glucosidase enzyme, thereby inhibiting the postprandial increase in glucose levels.

Yuliana et al., (2016) reported that the java-tea plant had conducted the metabolomic analysis resulting in the antihyperglycemic activity from the aspect of α-glucosidase enzyme inhibition. Kim et al., (2010) reported that metabolomic analysis aims to observe of secondary metabolite profile and biological activity of each secondary metabolite specifically. The java-tea plant has the bioactive compounds as antihyperglycemic activity indicator is sinensetin which can inhibit the activity of the α-enzyme and α-glucosidase. On the other hand, the active compounds-based java-tea plant have antihyperglycemic abilities namely betulinic acid, through reducing insulin resistance (Indariani, 2011; Yuliana et al., 2016; Ko et al., 2016).

Ginger (*Zingiber officinale Roscoe*)

Ginger (*Zingiber officinale Roscoe*) is containing active compounds in the form of nonvolatile and volatile components, which can be observed based on the flavor and bioactive properties. The nonvolatile components in ginger in the form of 6-gingerol and 6-shogaol compounds contribute to a pungent trigeminal. Volatile components derived from terpenoids such as zingiberene, β-sesquifelandrin, α-farnesin, ar-curcumin, β-bisabolene contribute to flavor profiles of warm, spicy, herbal, sweet-balsamic, and woody (Purnomo, 2010; Manuhara et al., 2018).

The antioxidant activity of ginger is contributed by several active compounds, including gingerol, shogaol, and zingerone which play a role by inhibiting the formation of oxidative stress. The shogaol compound in ginger contributes to antihyperglycemic activity by inhibiting the activity of the α-glucosidase enzyme, thereby reducing the impact of the postprandial increase in glucose levels by slowing glucose absorption in the brush border membrane of the small intestine (Dugasani et al., 2016; Sampath et al., 2017; Mao et al., 2019).

Sappan wood (*Caesalpinia sappan* L)

Sappan wood contain brazilin and brazilein as the major compound which contribute as the colorant agents also have the bioactivity. The brazilin compound in the sappan wood contributes to the formation of color in food products. This compound is odorless and does not give specific flavor into the food products. The stability of the brazilin pigment is influenced by the pH value, around pH 2 to 5, to form a stable color from brazilin pigment because of acid condition. Meanwhile, pH 5 to 7 impacted the instability of brazilin pigment showed with changes of color from red to yellow, and the pH value of 8 is shown red and purplish-red color in the final product due to the alkaline condition. The compounds of brazilin and brazilein showed the stability of active compounds as bioactive properties can neutralize free radicals and inhibit lipid peroxidation. Quercetin in sappan wood also plays a role in α-glucosidase and α-amylase inhibition, suppressing postprandial blood sugar rises (Padmaningrum, 2012; Nirmal et al., 2015; Sakir and Kim, 2019).

Curcuma (*Curcuma xanthorrhiza* Roxb.)

Curcuma contains active compounds such as xanthorrhizol, which contribute to the bitter, spicy, and bitter taste. This compound is also reported to increase insulin sensitivity to suppress hyperglycemia. Other active compounds such as β-curcumin and ar-curcumin have a spicy-herbal aroma profile. (Jantan, 2012; Tiara et al., 2017). Dosoky and Setzer (2018) reported that curcuminoids such as curcumin, desmethoxycurcumin, and bisdemethoxycurcumin act as antioxidants by inhibiting nitric oxide (NO).

Kaffir lime (*Citrus hystrix* DC) and lime (*Citrus aurantifolia)*

Kaffir lime and lime-containing volatile compounds have unique flavors, there are limonin, naringin, and hesperidin. These compounds have been identified as major bioactive compounds and bioactivity through thin layer chromatography. Kaffir lime has a fruity, citrus, fresh, flowery, and floral taste. Meanwhile, the volatile compounds in lime are dominated by limonin compounds, with the other flavor being citrus, minty, orange, and lemon-like (Szczygiel et al., 2018a; Szczygiel et al., 2018b). These two citrus varieties act as flavor modifiers that can increase the palatability of the final product. Both oranges contain naringin as active compounds that play a role in increasing the activity of antioxidant enzymes such as superoxide dismutase (SOD) and catalase (CAT) (Oon et al., 2015; Warsito et al., 2018). This compound also plays a role in α-glucosidase and α-amylase inhibition (Keskes et al., 2015). Other compounds such as hesperidin can inhibit the activity of the α-glucosidase and α-amylase enzymes and can increase insulin production, affecting the decrease in blood sugar levels (Enejoh et al., 2015; Al-Aamri et al., 2018; Pangestu and Arifin, 2018).

JAVA-TEA-BASED FUNCTIONAL DRINK FORMULATION AND PROCESSING

The initial formula for a java-tea-based functional drink can be seen in Table 3. The main ingredients used in the initial formula of this drink are included java-tea leaves (*Orthosiphon aristatus* B. Miq), ginger (*Zingiber officinale* Roscoe), and sappan wood (*Caesalpinia sappan* L), curcuma (*Curcuma xanthorrhiza* Roxb.), and lemon (*Citrus*). medica var. Lemon). The supporting ingredients used are included sucrose and various food additives such Carboxymethyl Cellulose (CMC) as stabilizers and sodium benzoate as preservatives. Sucrose stock solution can improve the palatability of beverages, especially related to the taste and intensity of sweetness, as well as the mouthfeel and body characteristics in the final product (Winarno 2008; Alothman et al., 2018). Carboxymethyl Cellulose (CMC) stock solution is a stabilizer to ensure the stability of mixed extract and preserve the sediment in the final product. Meanwhile, the stock solution of sodium benzoate functions as a preservative capable of inhibiting the growth of molds and yeasts in the final product (Herold, 2007).

The processing steps of the java-tea-based functional drink are: formulation, preparation of solutions, extraction, mixing of each ingredient, pasteurization, and packaging. The sugar stock solution was obtained from white granulated sugar and water (2:1). Ten grams of CMC was dissolved in 1000 mL of hot water at 65 °C. Meanwhile, a 5000 ppm sodium benzoate stock solution was obtained from 5 g of powdered sodium benzoate dissolved in 1000 mL of drinking water. The initial stage in processing java-tea-based functional drinks is the extraction of herbs and spices. The spice extract was vacuum filtered to remove the insoluble components that resulted in the formation of turbidity. The extract was pasteurized at 75 ºC for 30 minutes.

Table 3. Java-tea-based Functional Drink Formulation

Ingredients	Concentration
Mixture of extract ingredients	X g (X % b/v)
Lemon	Y g (Y % b/v)
Stock solution of sucrose (69-72 °Brix)	Z g (Z % b/v)
Sodium benzoate solution 5000 ppm	10 mL (final concentration 500 ppm)
Stock Solution of CMC* 1 %	10 mL (final concentration 0,1% v/v)
Water	Added till 100 mL

*CMC: Carboxymethyl cellulose
Source: (Herold, 2007)

The squeezed lemon has been prepared by using a juice extractor, then filtered with a filter cloth to separate the pulp and seeds. The next step is a mixture of spice and herb extracts, sugar stock solution and CMC stock solution, and sodium benzoate, which then were added to water and stirred until homogeneous. Lemon extract is added freshly at the final stage of mixing to avoid the loosing of aroma and prevent the enzymatic reactions (Ningrum, 2016). The final mixture solution, is immediately pasteurized at 75°C for 30 minutes, followed by a shock cooling process. The java-tea-based functional drink is ready for packaged in a dark-colored glass bottle.

PRODUCT DEVELOPMENT OF JAVA-TEA BASED FUNCTIONAL DRINK

The java-tea-based functional drink reported has advantages from the aspect of biological activity compared to commercial-based spice drinks. Herold (2007) reported that the antioxidant activity of java-tea-based functional drinks was higher than commercial ginger drink, commercial curcuma drink, commercial turmeric-tamarind drink, ginger-based fresh drink, lemon-flavored fresh drink, and orange-flavored fresh drink. However, this java-tea-based functional drink during storage in temperatures 30ºC and 55ºC was stable for 15 days, as indicated by the decrease in the characteristics of physicochemical properties, sensory properties, and biological activities (Herold, 2007; Indariani, 2011).

As reported by Indariani (2011), the shelf life of the java-tea-based functional drink was only 21 days at±4 °C due to the hydrolysis of sucrose into glucose or fructose by the activity of microorganisms. The changes reduced the sensory acceptability (Herold, 2007; Kordial, 2009; Farikha et al., 2013). The activity of microorganisms also causes a decrease of flavor and taste quality with its fermented characteristics and bitter taste. The pH value was also decreased due to the fermentation of glucose and fructose by anaerobic microbes (Herold, 2007; Kordial, 2009).

The decreased of antioxidant activities of the java-tea-based functional drinks predicted due to the oxidation process due to light and oxygen factors during storage (Indariani, 2011). The development of java-tea-based functional drinks referred to the review in two ways: reformulation and modification of processing. These were considered necessary to improve its functional drink based on sensory and bioactive properties.

REFORMULATION

As reported above, the initial formula for java-tea-based functional drink had a low sensory quality and a short shelf life. Reformulation was able to improve the beverage sensory quality through the addition of kaffir lime (Kordial, 2009). A combination of adding a mixture of lime and kaffir lime extracts, as well as flavor enhancers (Afandi, 2011), optimization of the concentration of non-sucrose sweeteners and citrus varieties (Febriani, 2012), optimization of the concentration of citrus varieties (Waziiroh, 2013), changing varieties of java-tea plants (Indariani, 2011), and adding red fruit oil emulsion (Sonatha, 2017; Michael, 2019) had been conducted. Furthermore, the java-tea-based functional drink is also added with lemon flavor, salt, and substitution of CMC with xanthan gum. The reformulation of java-tea-based functional drinks causes changes in sensory properties in terms of improving the flavor and decreasing herbs taste, also the antioxidants and antihyperglycemic. Ogundele et al., (2016), Luo et al., (2019), and Astray et al., (2020) stated that reformulation could improve the characteristics of the final product from physicochemical and bioactivity, such as improved of stability of flavors, vitamins, colorants in beverages, reduced sugar intake, and improved antioxidant properties.

Java-tea harvesting time and the variety of java-tea plant

The variety of java-tea plants affected the bioactive properties of java-tea-based functional drinks. Indariani (2011) and Afandi (2011) reported that a variety of java-tea plant extract on a single component has a different total phenolic compound. The java-tea plant extract characterized by the variety aspect resulted in different total phenol content (Indariani, 2011). Afandi (2011) also reported that java-tea plants' harvesting age and variety affected the total phenol content. The extended harvest time of plants resulted the decreasing of the total phenol concentration due to the decreasing of water content (Setiawan et al., 2019). Furthermore, Afandi (2011) reported that the extract of white-flowered java-tea plant produces antioxidant activity of 570 ppm lower AEAC compared to purple-flowered java tea plant extract at 729 ppm AEAC. This finding has also been confirmed by Herold (2007), Kordial (2009), and Indariani (2011) who showed that the java-tea plant with white-flowered had higher antioxidant activity.

Lime and kaffir lime

The initial formula for java-tea-based functional drink used lemon extract, yet the addition of its ingredient showed "slightly like" in the final product. Kordial (2009), Afandi (2011), and Febriani (2012) reported that the addition of kaffir lime extract affects the taste and flavor of java-tea-based functional drink to improve the level of acceptance of its product. Based on sensory properties, kaffir lime contains more volatile compounds, 83% of which come from the terpene group. Kaffir lime is dominated by terpinene-4-ol and linalool compounds with a fruity, fresh, flowery aroma profile (Szczygieł et al., 2018a). Moreover, kaffir lime contains an aldehyde group (22%) which can improve the taste of the described aroma aspect fruity and fresh aroma profile. In comparison, the ketone (26%) and ester (46%) groups described a pleasant fruity aroma profile (Szczygeł et al., 2018b). Volatile components in kaffir lime extract act as "top notes" and can synergize with lime extract in improving the taste of a java-tea-based functional drink and increasing the level of acceptance of the product (Afandi, 2011).

Afandi (2011) and Febriani (2012) stated that lime extract added to a java-tea-based functional drink could improve the flavor and taste. The lime extract with its flavor characteristics, which is soft, refreshing sensation, will stand out when mixed into the functional drink formula of java-tea-based functional drink. The lime extract contains limonin as the most extensive compound, which has a citrus aroma profile, mint, and orange (Hausch et al., 2015). Carboxylic acids, such as malic and citric acids, also contribute to the sour taste (Ladaniya, 2008; Szczygeł et al., 2018b). Therefore, lime extract can act as a "base note" because it can give the impression of a long-lasting sour taste (long-lastingness) in the java-tea-based functional drink.

Based on the bioactive properties aspect, the reformulation with kaffir lime and lime can increase the antioxidant activity of java-tea-based functional drinks (Indariani, 2011). It contains components of polyphenols, flavans, flavones, and tannins (Szczygeł et al., 2018b). The active compounds which are belonging to the flavonoid group are naringin, and hesperidin can donate a hydrogen group to a radical compound (Indariani, 2011). Vitamin C in kaffir limes and limes acts as an antioxidant because of the structure of 2,3-enediol which facilitate the reducing of the free radical compounds.

Meanwhile, the reformulation carried out by Kordial (2009), Afandi (2011), and Febriani (2012) reported that the addition of kaffir lime and lime extract mixture showed improved antioxidant activity actual comparing to the initial formula. It is influenced by the synergism between components bioactive in each ingredient. The results of the study conducted by Hyardin et al., (2012) showed that the synergism factor between the bioactive components of each ingredient has a significant effect on antioxidant activity. The antioxidant activity of its functional drink should adjust through *in vitro* digestion (INFOGEST) to maintain the stability of the bioactive compound in the gastric and intestinal phase so that the role of the functional drink as antioxidants can be uptake optimally by the body (Brodkorb et al., 2019).

Flavor enhancer (GMP:IMP)

The initial formula of the java-tea-based functional drink is having a typical spicy taste (jamu-type specific taste) and slightly bitter aftertaste sensation because characteristic of each ingredient. The specific flavor of this drink is challenging when it has to be formulated like a commercial “soft drink” product. The reformulation of the java tea-based functional drink by Afandi (2011) with the addition of a flavor enhancer guanosine monophosphate: inosine monophosphate (GMP: IMP) produces a higher level of preference than the initial formulas by Herold (2007) and Kordial (2009). The addition of a flavor enhancer (GMP: IMP) to the formula of a java-tea-based functional drink could strengthen the taste of oranges and suppress the bitter taste and aroma of herbs and spices which are less favored (Afandi, 2011). The combination of GMP and IMP flavor enhancers produces a better taste impact than a single component (Pszczola, 2010).

Flavor enhancers (GMP: IMP) can increase the value of palatability (richness and pleasantness) of a food product because of the excellent interaction between the taste components and the food matrix (Pszczola, 2010; Gaudette and Pickering, 2011; Asioli et al., 2017). Asioli et al., (2017) stated that adding glutamate to vegetables can improve the palatability of the food product with a preferred taste. The addition of a flavor enhancer (GMP: IMP) to a java-tea-based functional drink can be accepted and liked by panelists might be due its ability to strengthen the taste of orange characteristics.

Artificial sweeteners

Reformulation of a java-tea-based functional drink with the addition of acesulfame-K and sucralose as non-sucrose sweeteners caused changes in the sensory and bioactive properties (Febriani, 2012). Reformulation of a java-tea-based functional drink with the addition of non-sucrose sweeteners of sucralose and acesulfame-K has given the character of flavor profiles are"thin" and "watery," also the presence of a bitter aftertaste in java-tea based functional drink (Febriani, 2012; Burgos et al., 2016; Luo et al., 2019). The reduction of sucrose concentration of java-tea-based functional drink has induced the intensity of sweetness and mouthfeel with "bitter aftertaste", and "thin" characteristic; therefore, the level of consumer acceptance of its product was lower compared to java-tea-based functional drink formulated by Herold (2007) (Wijaya and Mulyono, 2010; de Souza et al., 2013; Burgos et al., 2016; Alothman et al., 2018). The taste profile of a reformulated java tea-based functional drink with non-sucrose sweeteners can be improved by adding xanthan gum. Xanthan gum has been able to contribute to the "body" (mouthfeel) of functional drinks, so there was no different level of acceptance among consumers toward the reformulated drink compared to the initial formula (Wijaya et al., 2018). The usage of non-sucrose sweeteners in java-tea-based functional drinks supports the antihyperglycemic activity of the antihyperglycemic functional drink (Febriani, 2012; Burgos et al., 2016). Java tea-based functional drink with sucralose and acesulfame-K showed higher α-glucosidase inhibition than the initial formula of its beverage (Febriani, 2012; Mardhiyah, 2012).

Capriles and Areas (2013), Gao et al., (2015), and Luo et al., (2019) also reported that the addition of non-sucrose sweeteners to bread can reduce the glycemic index, therefore it can suppress the increase of blood glucose levels postprandial. Non-sucrose sweeteners also can delay the diffusion of glucose and glucose absorption to suppress the increase in blood glucose levels postprandial. In addition, the molecular structure of non-sucrose sweeteners cannot be metabolized by the body so that it inhibits the rise of blood sugar postprandial, as well as sweeteners sucralose and acesulfame-K (Handayani and Ayustaningwarno, 2014; Temizkan et al., 2015).

Enrichment of red fruit oil emulsion

The java-tea-based functional drink has a reddish-yellow color due to the lime extract in its formulation (Kordial, 2009; Waziiroh, 2013). Red fruit oil contains high carotenoids, and its red color has the potential as a natural coloring agent in java-tea drinks. Red fruit oil contains 4,090 - 7,723 ppm of carotenoids depending on the clones and ripening stages, dominated by β-carotene compounds of 23-27 ppm (Murtiningrum et al., 2019; Sarunggalo et al., 2014). Red fruit oil has to be added to the formulation of java-tea drink as an emulsion. The final reddish-orange product had higher viscosity which might be due to the emulsion state and also 5,28 ppm of carotenoids (Sonatha, 2017).

The increase in viscosity will increase the viscosity of red fruit oil emulsion because it used CMC as an emulsifier (Sarunggalo et al., 2014). The number of hydroxyl groups (-OH) of CMC can increase the affinity to bind water molecules through hydrogen bonds. The more bound water molecules can decrease water activity, increasing the final product's viscosity (Michael, 2019; Gossinger et al., 2019).

The addition of red fruit oil emulsion increased the total phenolic content by around 367.43 ± 1.95 mg GAE/L (Sonatha, 2017; Michael, 2019). A high total phenolic content has the opportunity to increase antioxidant activity because both are positively correlated (Khalil et al., 2012).

The usage of red fruit oil emulsion produced a reddish-orange java-tea drink, which increase the level of hedonic color preference compared to the original formulation. However, the higher the addition of emulsion concentration, the lower the level of preference level since the color became darker. The appearance of java-tea-based functional drink with and without the addition of emulsion shown in Figure 1 (Michael, 2019).

Figure 1. Java-tea-based Functional Drink (a) Without and (b) With Red Fruit Oil Emulsion (Michael, 2019)

It should be noted there is still challenging hurdle in the addition of the emulsion. The java-tea-based functional drink enriched with red fruit oil emulsion showed an unaccepted strange and pungent taste on the tongue and throat (Sonatha, 2017; Michael, 2019). It might be due to volatile components in red fruit oil such as 1,3-dimethyl-benzene (27.46 %), N-glycyl-L-alanine (17.36 %), trichloromethane (15.22 %), and ethane (11.43 %) which has a description of an orange-like aroma, woody, rancid, and phenolic sensation (Noviyanti, 2010; Rohman et al., 2012; Riduwan, 2019). High flavonoids in red fruit oil give a tart taste and bitter aftertaste to the final product (Rohman et al., 2012; Arumsari et al., 2013). In addition, the rancid flavor caused by the activity of proteolytic enzymes and hydrolysis reactions in red fruit oil also influenced the sensory performance of the new reformulation.

PROCESSING TECHNOLOGY MODIFICATION

The java-tea-based functional drinks were also modified through the processing technology. A java-tea-based functional drink in powder form was obtained by applying microencapsulation and nanoencapsulation technology (Afandi, 2014; Rekasih et al., 2021; Naibaho, 2018).

Microencapsulation

The java-tea-based functional drink processed by microencapsulation technique increased the stability, and also improve the beverage characteristics (Pramestia et al., 2015). According to Afandi (2014), the microencapsulated java-tea drink has a size of 563.10 nm, while Naibaho (2018) has been able to produce the microencapsulation with a size of 1785 nm. Total solid content and inlet air temperature spray drying can affect particle diameter size (Tonon et al., 2011). The functional drink based java-tea with the application of microencapsulation has high solubility, shorter dissolving time, uniformly dispersed particle size, lower viscosity, and higher foam volume.

Microencapsulated java-tea based functional drink had lower L and a values, with higher b values compared with the ready to drink type. This phenomenon might due to a chemical reaction that oxidizes the active compound, therefore it turns the final product into more intense in yellow color. The microencapsulated drinks resulted in a higher sweetness intensity than ready-to-drink, while the bitter and sour taste intensity is the opposite (Afandi, 2014). It might occurred due to the small particle size, and also the coating suppressed the bitter taste of phenolic components by controlling the level release of the compound active (flavor release) (Syafii et al., 2016, Safithri et al., 2020). The effect of encapsulation can reduce the intensity of the sour taste of the lime extract and the bitter taste of the spice extract so that in the end it will increase the intensity of the sweetness (Affandi, 2014).

Microencapsulated drink showed also advantages such as increased the stability and biological activity compared to the ready-to-drink drinks because the encapsulation can protect the bioactive components from environmental damage such as oxidation (Sun-Waterhouse et al., 2011; Jatupornwipat et al., 2017; Erminawati et al., 2019). Microencapsulated drinks had lower antioxidant activity (72.237 ppm AEAC) than the ready-to-drink (221.368 ppm AEAC). Moreover, it has a higher antihyperglycemic activity which is 30.74% in α-glucosidase inhibition (*in vitro*) for microencapsulated drinks, compared with ready to drink about 25.90%. The low antioxidant activity in microencapsulated beverages might be due to the slow releases time of the active compounds since the conducted analysis was *in vitro* (Afandi, 2014). The low antioxidant activity in microencapsulated beverages is due to the slow release time of the active compounds since the conducted analysis was in vitro. The high temperature of the spray dryer also can affect the structure of bioactive compounds, causing the antioxidant activity reduced (Rigon and Zapata, 2016). In the case of antihyperglycemic activities, the usage of enzymes can support the breakdown of the encapsulation wall so the bioactive compounds can be released immediately. In the case of antihyperglycemic activities, the usage of enzyme can support the breakdown of the encapsulation wall so the bioactive compounds can be released immediately.

Nanoencapsulation

Nanoencapsulation is a coating technology for active components on nanoscale ranging from 1-100 nm, but for some reason, it can also exhibit up to 1000 nm (Ezhilarasi et al., 2012; FDA, 2014; Zhao et al., 2014). The application of nanoencapsulation can improve the stability of the product quality and shelf life of food products (Anandharamakrishnan, 2014; Jeong et al., 2020; Feridoni and Shurmasti, 2020; Estakhr et al., 2020). Nanoencapsulation has been widely used to improve the taste of a product by regulating retention of flavor release, masking unwanted flavors, and protecting aroma compounds (Oktaviana, 2010; McClement, 2012). The application of nanoencapsulation in food products has the potential to increase the solubility of nonpolar components, prevent oxidation of active components, and increase the bioavailability of active components (Ezhilarasi et al., 2013; Khaled et al., 2014; Mohammadi et al., 2016; Bagheri et al., 2013).

Nano encapsulated java-tea-based functional drink had 662.99 ppm GAE in total phenols, which is lower than the ready-to-drink type. The homogeneous system in the nano-encapsulated beverage causes the intermolecular hydrogen bonds to become stronger so that the release of the active components is slower (Rekasih et al., 2021). Therefore, the hydroxyl group in the nano encapsulated beverage only slightly reduced the phosphomolybdate and phosphowalframate components in the Folin Ciocalteu reagent resulted a lower total phenol measured (Yoksan et al., 2010; Opalinski et al., 2016). Nano encapsulated drink has a higher brightness level than ready-to-drink and micro-encapsulated drink (Rekasih et al., 2021). Java-tea nano encapsulated drink has an average particle diameter of 217.17 - 537.80 nm. The particle size of the nano-encapsulated drink affects the product's color because the light that passes through the object is reflected more and is marked with a pale yellow color (Afandi, 2014; Rekasih, 2021). The ratio of the core material to the coating material reported affecting the characteristics of the final beverage product (Wijaya et al., 2017).

Similar to the microencapsulated java tea based functional drink, the nano-encapsulated drink also had a higher sweetness intensity. It might be due to the a decrease of the intensity of the sour taste and masking effect of the bitter taste, tart and bitter aftertaste (Afandi, 2014). Nanoencapsulation can control the slow release of flavor (flavor release), especially the phenolic components of spice and herb extracts which give a bitter taste and astringent sensation; this technology can protect the volatile components that form aromas due to the oxidation, evaporation, thermal, and hydrolysis (Oktaviana, 2010; Nedovic et al., 2011; Magnuson et al., 2011; Khaled et al., 2014; Assadpour and Jafari 2017; Suryanto et al., 2019). Nano encapsulated beverages increase consumer acceptance with the sweeter taste characteristic as also reported by Ratanasiriwat et al. (2013) and Ghorbanzade (2017).

The nano encapsulated beverage showed lower antioxidant activity and α-glucosidase inhibition (*in vitro*) compared to microencapsulation java-tea drink (Afandi, 2014). A similar phenomena in microencapsulated java tea functional drink compared to the ready to drink type, it might be due to the maltodextrin can inhibit bioactive components' release due to strong hydrogen bonds (da Silva et al., 2018). Meanwhile, *in vivo*, measurement, the nano-encapsulated beverage showed a higher antihyperglycemic activity (Rekasih et al., 2021; Naibaho, 2018). The active compounds in the nano-encapsulated drink are predicted to be easier to reach the target site, and the active compounds' release rate is more controlled (Ozturk et al., 2014; Murata et al., 2017; Sudirman et al., 2018. The nano-sized particles have a large surface area in this drink, resulting in the bioactive components being more easily absorbed into the folds of the intestinal wall (Lee et al., 2012; Gupta et al., 2012; Zanotto-Filho et al., 2013; Pereira et al., 2015).

The roadmap of the development of java-tea-based functional drink from the reformulation aspect showed in Figure 2.

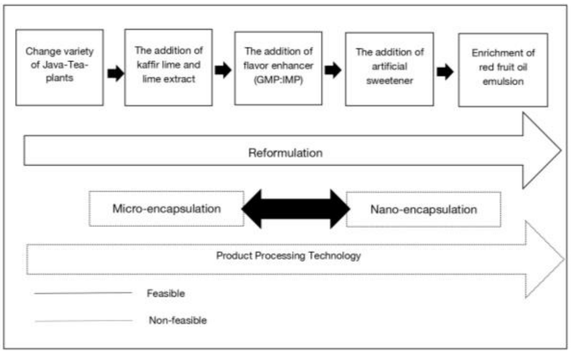

Figure 2. Flow Process of Product Development Java-tea-based Functional Drink in Terms of Reformulation and Processing Technology Modification

The mixture of kaffir lime and lime extracts combined with a flavor enhancer (GMP: IMP) increases the preference for the final product from the aspect of aroma and taste. Meanwhile, changes in the variety of the java-tea plant and the reduction in the concentration of sucrose replaced by sucralose and acesulfame-K sweeteners can increase the biological activity of the final product. The enrichment of red fruit oil emulsion has increased the sensory preference of color attributes. However, the product undergoes a separation of the water-soluble and oil-soluble phases, known as coalescence and flocculation phenomena. The product is also facing a touch hurdle for its flavor and mouthfeel. The reformulation aspect still has the opportunity to be carried out through the use of natural and functional ingredients. The application of microencapsulation in the java-tea-based functional drinks also still has drawbacks. It has a long dissolution time. Meanwhile, the application of nanoencapsulation beside it has unfavorable color, flavor, and stability, it also requires higher production costs which affect the product's commercialization. Therefore, further product development through the application of technology should be done to improve the quality and shelf life of the product, especially in the form of ready-to-drink, which is more in demand by consumers due to its more practical.

CONCLUSION

The java-tea-based functional drink showed the antioxidant activity and antihyperglycemic ability due to the content of bioactive compounds of the identifiable contributed by each ingredient, especially the java-tea plant and sappan wood. However, the low stability of drink quality and weak sensory perform, it needed to be improved. Reformulation with the addition of lime and orange extracts, guanosine monophosphate (GMP): inosine monophosphate (IMP) flavor enhancer, changed the java-tea plant varieties, changed the non-sucrose sweeteners were able to improve sensory properties and bioactive properties, particularly the antioxidant capacity and the antihyperglycemic ability. The addition of red fruit oil emulsion increased the total phenolic content and color based on hedonic test. However, it might need further development due to unaccepted strange and pungent taste on the tongue and throat from java-tea drink enriched red fruit oil emulsion. The application of microencapsulation and nanoencapsulation technology produced the drink in a powder form which able to mask the inferior flavors, increase bioavailability, and extend the final product's shelf life. Further reformulation and processing modifications are still needed to increase the quality of its functional drink.

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