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FULL PAPER

Formulation and characterization of functional andaliman lozenges

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Abstract

In a previous study, the ethanolic extract of andaliman fruit (*Zanthoxylum acanthopodium*) has been reported to exert potential anti-inflammatory and anti-diabetes activities by ameliorating gene markers related to inflammation and diabetes *in vitro*. Here, andaliman ethanolic extract was formulated into a lozenge tablet and further tested for its functional efficacy to prevent metabolic syndrome through antioxidant and inhibitory enzyme activity against alpha-glucosidase and lipase *in vitro*. The lozenge was made from andaliman ethanolic extract and formulated in 3 variants, i.e. original andaliman lozenge, andaliman lozenge with honey additive, and andaliman lozenge with sorbitol additive. Gas chromatography-mass spectrometry (GC/MS) profiling showed that all andaliman lozenges contained limonene as a major essential compound found in andaliman extract. All lozenges were able to scavenge >50% of free radicals, indicating their antioxidant potency. This is also linear with their total phenolic contents (~160 GAE/mL). Andaliman lozenges also blocked alpha-glucosidase (50-70%) and lipase activities (~50%). Organoleptic results showed that among all, most panellists prefer andaliman lozenge with sorbitol additive over others. In conclusion, andaliman lozenges may offer an alternative functional supplement for the prevention of metabolic syndrome.

1. Introduction

Lozenges are a supplement type that has a characteristic sweet taste, easily dissolves in the mouth, and does not require water. Nowadays, people have begun to pay attention to health problems, including metabolic syndrome. Thus, the use of supplements like lozenge can be an alternative for those who have difficulty taking tablets (Abdoli *et al*., 2012). To present, only a few studies reported the use of lozenges as functional supplements. Most commercial lozenge tablets are grouped in antioxidants and vitamins. Interestingly, a recent study by Elvan *et al*. (2021) showed lozenge formulation with microencapsulated probiotic *Lactiplantibacillus pentosus* exerted antimicrobial activity against oral pathogens, indicating its potency to be applied for oral care functional food products. Thus, developing functional lozenges from spices, herbs and other plants for promoting health and preventing diseases may become an alternative strategy that may contribute to modern functional food products.

Metabolic syndrome is a condition of metabolic health disorders that occurs due to a combination of insulin resistance, hypertension, obesity, and atherogenic dyslipidemia which increase the risk of cardiovascular disease. In overcoming these health problems, various supplements have been created and commercialized through evidence-based scientific reports. Andaliman (*Zanthoxylum acanthopodium*) is an endemic spice plant from North Sumatra (Indonesia) that is often traditionally used for medicine and Bataknese cuisine. Andaliman contains most aromatic terpenoids, such as geraniol, limonene, citronellal, and sanshool with a spicy and bitter taste that causes the tongue to feel numb when consumed (Wijaya *et al.,* 2018; Yanti *et al.,* 2019). The taste and aroma of andaliman fruits resemble lemons, thus it is also well known as lemon pepper. Andaliman has been reported to exert antioxidant activity for the protection and preservation of oily or fatty food products (Siregar, 2013). Terpenoid contents in andaliman have antioxidant activity that could be used as the main ingredient in drugs and food supplements. Our previous study demonstrated that the ethanolic extract of andaliman possessed anti-inflammatory and antidiabetic activities by attenuating several proteins and genes

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related to inflammation and diabetes, including TNF-apha, iNOS, COX-2, MMP-9, MCP-1, and CRP in macrophages induced by lipopolysaccharide and hepatocytes *in vitro* (Yanti *et al*., 2011; Yanti and Limas, 2019). In order to add the ingredient value of andaliman extract, it is important to develop the use of andaliman extract in functional food products and supplement formulation. Therefore, this study aimed to formulate a lozenge as a functional supplement made from andaliman ethanolic extract and characterize its chemical profiling and functional efficacy for the prevention of metabolic syndrome *via* antioxidant and enzymatic inhibitory activities towards alpha-glucosidase and lipase.

2. Materials and methods

2.1 Sample preparation and extraction

Andaliman fruit was purchased from a traditional market in Balige, North Tapanuli region, North Sumatra province (Indonesia). The fruit was freeze-dried and crushed into powder for further extraction. Andaliman extraction was done using kinetic maceration according to the method of Yanti and Limas (2019) method with slight modification. Andaliman powder (10% w/v) was dissolved in 70% food-grade ethanol and placed in a waterbath shaker at 50°C, 70 rpm for 3 hrs, followed by incubation at room temperature for 24 hrs. The solution was concentrated using a rotary evaporator with a pressure of 90 mbar at 55°C, 60 rpm until the solvent was evaporated. The remaining solution was dried by overnight incubation at 60°C to obtain andaliman ethanolic extract.

2.2 Lozenge formulation

Andaliman lozenges were made from andaliman ethanolic extract as the main ingredient and formulated into three variants, i.e. original andaliman lozenge (AC), andaliman lozenge with honey additive (AH), and andaliman lozenge with sorbitol additive (AS). Lozenges were also added with other supported ingredients, such as mannitol, magnesium stearic, talc, aerosil, sodium carboxymethyl cellulose (CMC-Na), and sweetener (honey and sorbitol). Each formula was prepared according to the composition in Table 1. The CMC-Na was firstly activated in aquadest and heated at 80°C in order to form a mucilage. All ingredients except andaliman extract were mixed with the soluble CMC-Na until the formation of wet granules, followed by drying overnight in an oven at 60°C to obtain dried granules. The granules were crushed into powder, added to dried andaliman extract, and sifted using a mesh 40 sieve. Finally, the granules were pressed using a hand tablet press machine to obtain lozenge tablets. Further, all andaliman lozenges (AC, AH, and AS) were characterized for their physicochemical and functional efficacy properties.

Table 1. Formulation of andaliman lozenges.

Composition	AC	AH	AH
	Content per lozenges (mg)		
Andaliman extract	150	150	150
Mannitol	1400	1300	1300
Mg Strearic : Talc (1:9)	120	120	120
Aerosil	25	25	25
CMC-Na	120	120	120
Honey	(-)	100	(-)
Sorbitol	(-)	(-)	100
Total	1815	1815	1815

AC: original andaliman lozenges, AH: andaliman lozenges with honey addition, AS: andaliman lozenges with sorbitol addition.

2.3 Gas chromatography-mass spectrometry analysis

Andaliman ethanolic extract and its lozenge formulas (AC, AH, and AS) were identified for their chemical profiling by using a gas chromatography-mass spectrophotometry(GC/MS) analysis (Yanti and Limas, 2019). The sample was previously filtered using a microsyringe filter before injection. A 100 mL sample was injected into TG-5MS GC column (Thermo ScientificTrace Gold) and converted into the vapour phase and flowed through a column as a stationary phase with a helium carrier gas with a flow of 5.4 mL/min, temperature set from 40°C increased every 5 mins until 230°Cfor an hour. Then, the compound mixture was separated into a single compound based on the chemical property and the specific time for each compound. Compound detection was determined by mass spectrometry through firing electrons in compounds with electron ionization (EI) mode into ionized molecules, followed by recording the fragmentation patterns arranged *via* comparison using the similarity index (SI) standard.

2.4 Dissolution time test

The dissolution time of andaliman lozenges (AC, AH, and AS) was assayed by the method of Perioli *et al*. (2007). The lozenge tablet was dissolved in 800 mL of 50 mM phosphate buffer pH 6.75 at 37°C and stirred at a speed of 150 rpm until it was dissolved and homogenous. Lozenge was made to dissolve in the mouth or slowly erode for about 5 mins. All experiments were conducted in triplicate.

2.5 Antioxidant activity analysis

The antioxidant activity of andaliman lozenges (AC, AH, and AS) was analyzed using 2,2-diphenyl-1-picrylhydrazyl (DPPH) assay (Yanti *et al.,* 2017). The

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lozenge tablet was diluted in absolute ethanol. A 200 µL sample was added with 100 µL of 0.6mM DPPH reagent and mixed, followed by incubation at room temperature for 30 mins. Control was prepared by mixing absolute ethanol and DPPH reagent. All solutions were measured at 517 nm using a microplate reader. All experiments were conducted in triplicate. Antioxidant activity was calculated using the following formula: Antioxidant activity (%)= [1-(Asample / Acontrol)] × 100%.

2.6 Total phenolic content analysis

Total phenolic content (TPC) of andaliman lozenges (AC, AH, and AS) was measured using Folin-Ciocalteau reagent according to the method of Agustinah *et al*. (2016). A total of 1 mL sample, 1 mL ethanol absolute, 5 mL aquadest, and 0.5 mL Folin-Ciocalteau reagent (50% w/v) was added into the test tube and incubated for 5 mins at room temperature. Later,1 mL sodium carbonate (5% w/v) was added. All tubes were incubated in a dark room for an hour. The solution was transferred from the tube into a cuvette and measured at 725 nm using a UV-Vis spectrophotometer. The blank was made from 0.05% (w/v) NaCl in absolute ethanol. Gallic acid was used as a standard and TPC was expressed in gallic acid equivalent (GAE) as the number of milligrams of gallic acid equivalence in one gram of the sample. All experiments were conducted in triplicate. A standard curve was set using gallic acid at various concentrations (100-500 mg/mL). TPC was quantified based on regression value from the standard curve equation.

2.7 Alpha-glucosidase and lipase inhibitory activity assay

Andaliman lozenges (AC, AH, and AS) were determined for their functional efficacy against diabetes and obesity by measuring their capability to inhibit alpha -glucosidase and lipase enzymes (Mayur *et al*., 2010; Gondoin *et al.,* 2010). For alpha-glucosidase assay, a 50 µL of 0.1 M phosphate buffer (pH 7) was mixed with a 10 µL sample and 25 µL alpha-glucosidase (1 U/ml), followed by incubation for 10 mins at room temperature. The mixture was added with 25 µL of 0.5 mM 4-nitrophenyl-α-D-glucopyranoside substrate and incubated for 5 mins. Next, a 100 µL of 0.2 M sodium carbonate was added to stop the enzymatic reaction. Control was made by replacing enzymes with phosphate buffer. Absorbance (A) was measured at a wavelength of 410 nm using a microplate reader. All experiments were conducted in triplicate. The percentage of inhibition of alpha-glucosidase enzyme activity was quantified using the following formula:% Inhibition = [1 - (Asample / Acontrol)] × 100%.

For lipase assay, one mg pancreatic porcine lipase (1 U/mL) was dissolved in one mL distilled water, and then centrifuged for 15 mins at a speed of 712 ´g. A 150 µL supernatant was added with 400 µL of 100 mM Tris-Cl buffer (pH 8.2), 450 µLp-nitrophenyl laurate (pNP laurate) substrate, and 50 µL sample. The solution was incubated at 37°C for 2 hrs, followed by measuring the absorbance at a wavelength of 400 nm using a microplate reader. Control was prepared by substituting the enzyme with Tris-Cl buffer. All experiments were conducted in triplicate. The percentage of inhibition of lipase activity was calculated using the following formula:% Inhibition = [1 - (Asample / Acontrol)] × 100%.

2.8 Organoleptic test

Organoleptic test of andaliman lozenges (AC, AH, and AS) was done according to the method of Meilgaard *et al.* (2016). The parameters for organoleptic tests included shape, taste, aroma, after-taste, and colour. The range of values was 1 to 7 (1 = very dislike, 2 = dislike, 3 = somewhat dislike, 4 = neutral, 5 = somewhat like, 6 = like, 7 = very like). The panellists were thirty-three students from the Faculty of Biotechnology, Atma Jaya Catholic University of Indonesia.

2.9 Statistical analysis

Data were processed using SPSS 24 series to determine the standard deviation and the average. The significant data was statistically analyzed by using the analysis of variance (ANOVA).

3. Results and discussion

3.1 Formula of andaliman lozenges

In this study, andaliman fruit was used as the main ingredient for lozenge tablet products. Andaliman extract was prepared using kinetic maceration in ethanol (Figure 1a) with a yield of 14% w/v, respectively. Lozenge formulation consisted of andaliman extract as the main ingredient, binders, fillers, crushers, lubricants, and sweeteners or dyes. Sweeteners such as sorbitol and honey were added to the lozenge tablet in order to reduce the bitter taste of andaliman extract. Figure 1b showed there were 3 lozenges made from andaliman extract, including original andaliman lozenge (AC), andaliman lozenge with honey addition (AH), and andaliman lozenge with sorbitol addition (AS).

3.2 Profiling of andaliman lozenges

Andaliman lozenge and its variants were further characterized by GC/MS analysis (Figure 2). The main compounds in all lozenges was presented in Table 2. In the chromatograms, there were 13 peaks for AC, AH, and AS lozenges. Among all peaks, 6 peaks with SI

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Figure 1. Andaliman ethanolic extract (left) and lozenge formulations (right). AC: original andaliman lozenges, AH: andaliman lozenges with honey addition, AS: andaliman lozenges with sorbitol addition.

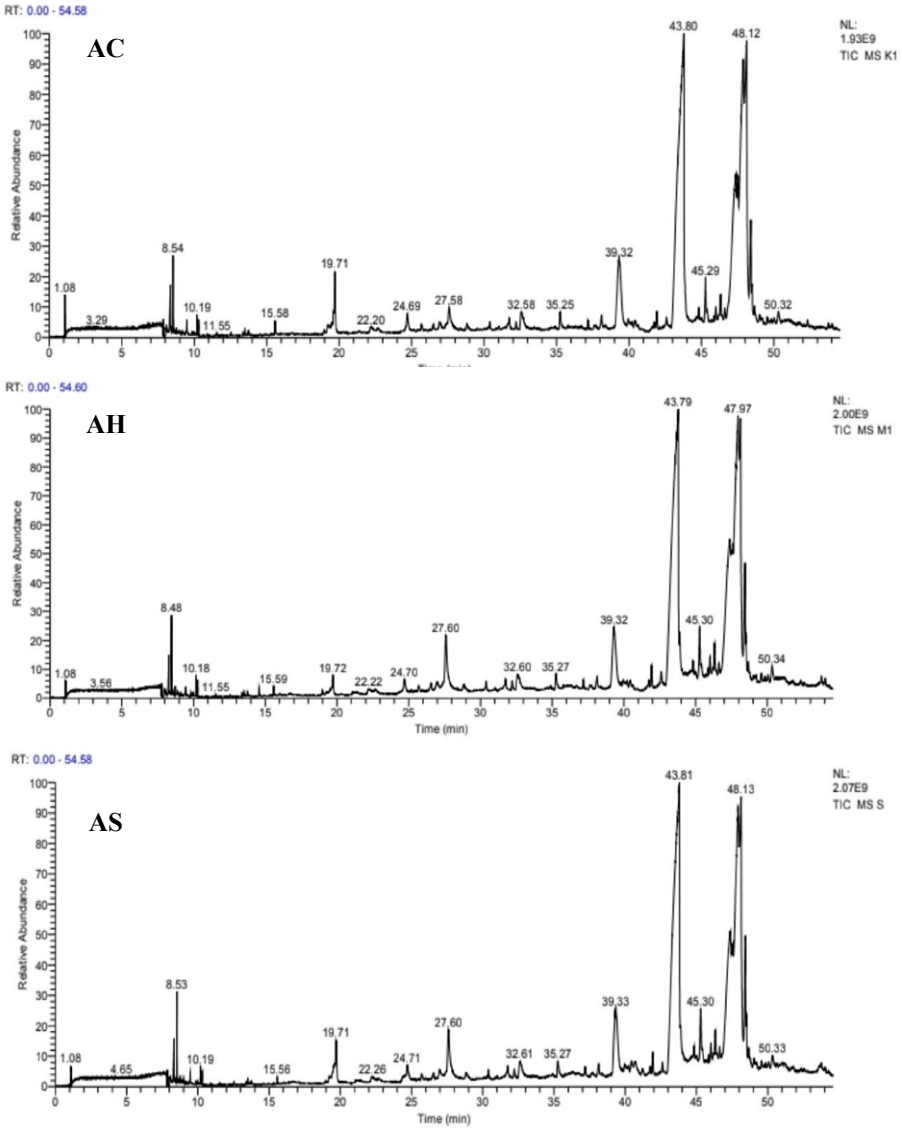

Figure 2. GC/MS chromatograms of andaliman lozenges. AC: original andaliman lozenges, AH: andaliman lozenges with honey addition, AS: andaliman lozenges with sorbitol addition.

value ³700 were identified as guanidine, dianhydromannitol, glyclsarcosine, limonen-6-ol, r-limonene, d-limonene, l-(+)-ascorbic acid 2,6-dihexadecanoate, and 1-nitro-2-acetamido-1,2-dideoxy-d-mannitol. GC/MS data were analyzed based on SI value. The higher of SI value, the higher similarity of the compound in the sample with the compound in the GC/MS library. According to the data, all andaliman lozenges contained aromatic compounds like limonene. This has a lemon aroma and is grouped with cycloalkene (Wijaya *et al*., 2018; Reichenbach *et al*., 2019). The use of honey as a sweetener in lozenge is to add its functional value because honey has several active compounds, such as ascorbic acid, tocopherol, flavonoids, and phenolics (Aliyu *et al*., 2012).

3.3 Dissolution time of andaliman lozenges

Lozenge was tested for its dissolution time as one of the physical characteristic parameters. Lozenge was dissolved in phosphate buffer until all the tablets dissolved and dissolution time was recorded. Table 3 described that all andaliman lozenges (AC, AH, and AS) did not show any significant difference in the dissolution time. Lozenge AC had a faster dissolution time

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Table 2. Identification of aromatic compounds in andaliman lozenges.

Lozenges	Retention Time (Rt)	SI	Name of Compound	Peak Area (%)
AC	8.54	848	Guanidine	0.08
	8.61	705	Dianhydromannitol	0.03
	15.58	703	Glyclsarcosine	0.26
	26.94	788	Limonen-6-ol	0.33
	34.22	747	R-Limonene	0.02
	43.78	855	l-(+)-Ascorbic acid 2,6-dihexadecanoate	33.49
AH	8.48	836	Guanidine	0.07
	8.56	710	Dianhydromannitol	0.02
	14.57	877	D-Limonene	0.21
	15.59	706	Glyclsarcosine	0.17
	27.60	876	Benzaldehyde, 3-hydroxy-4-methoxy-	2.37
	30.40	802	Limonen-6-ol	0.26
	43.78	853	l-(+)-Ascorbic acid 2,6-dihexadecanoate	33.56
AS	8.46	705	1-Nitro-2-acetamido-1,2-dideoxy-d-mannitol	0.04
	8.53	840	Guanidine	0.08
	14.22	731	R-Limonene	0.02
	15.56	711	Glyclsarcosine	0.13
	30.40	792	Limonen-6-ol	0.20
	43.79	854	l-(+)-Ascorbic acid 2,6-dihexadecanoate	34.14

AC: original andaliman lozenges, AH: andaliman lozenges with honey addition, AS: andaliman lozenges with sorbitol addition.

compared to that of lozenges AH and AS**.** According to the Food and Drug Supervisory Agency (BPOM Indonesia) standard, the dissolution time for a tablet is 5 mins. Our data showed that all lozenge tablets had a dissolution time of < 5 mins, indicating that all products passed the standard (Table 3).

Table 3. Dissolution time of andaliman lozenges.

Lozenges	Time (mins)
AC	3.53±0.64[a]
AH	4.27±0.48[a]
AS	4.12±0.51[a]

Values are presented mean±SD of triplicates. Values with different superscripts within the same column are statistically significantly different (α = 0.05). AC: original andaliman lozenges, AH: andaliman lozenges with honey addition, AS: andaliman lozenges with sorbitol addition.

3.4 Antioxidant activity of andaliman lozenges

Andaliman lozenge was further tested for its functional efficacy by determining its antioxidant capability to inhibit free radicals. Figure 3 demonstrated that all andaliman lozenges (AC, AH, and AS) had a significant free radical inhibition(70-80%), indicating their potential antioxidant activity. Among all, lozenge AC exerted the highest antioxidant activity (~80%). It has been reported that andaliman fruits also contain phenolics, flavonoids, terpenes, alkaloids, and other types of lignans that have antioxidant activity. Phenolic compounds in andaliman can capture free radicals and complex metals as hydrogen donors to stabilize free radicals (Wijaya *et al*., 2018). In line with our data (Figure 3), all andaliman lozenges exerted potential antioxidant activity *via* free radical inhibition.

Free radicals are molecules that contain one or more unpaired electrons in atomic or molecular orbitals that cause molecular instability. Free radicals tend to capture electrons from other molecules to achieve stable conditions and can be reactive oxidative species (ROS). The instability between ROS production and antioxidant defence systems causes a condition called oxidative stress. Several studies mention that the excessive production of oxidative stress can cause cardiovascular disease, diabetes, ageing, and nerve disorders (Barbieri and Sestili, 2012; Kandikattu *et al*., 2015; Treml and Šmejkal, 2016). Neutralizing free radicals with antioxidants is a form of cell protection against oxidative stress because antioxidants can prevent the oxidation reaction of free radicals by exchanging one of the electrons to stabilize free radicals (Khatua *et al.,* 2013).

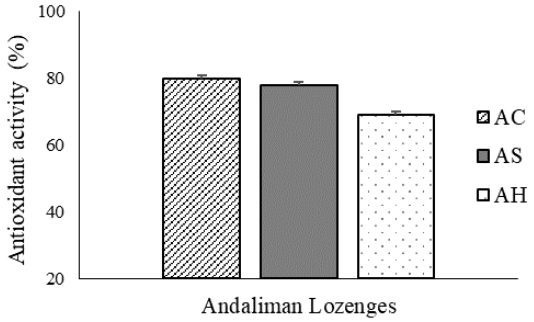

Figure 3. Antioxidant activity of andaliman lozenges. AC: original andaliman lozenges, AH: andaliman lozenges with honey addition, AS: andaliman lozenges with sorbitol addition.
*Significantly different (α = 0.05), all experiments were conducted in triplicates.

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3.5 Total phenolic compounds

Andaliman lozenge was also tested for its total phenolic compounds to ensure the concentration of phenolics in the product. Table 4 shows that all andaliman lozenges (AC, AH, and AS) had similar total phenolic concentrations in the range of 160 GAE/mL, and there was no significant difference among all products. Total dissolved phenolics value is associated with the antioxidant capability because the content of phenolics like flavonoids is known to potentially capture free radicals in the management of stress oxidative. Our data indicate that all andaliman lozenges exerted a high total dissolved phenolic content (Table 4). This may occur due to the polarity of the solvent for extraction. The selected chosen solvent for andaliman extraction may contribute to its capability to dissolve most phenolic compounds.

Table 4. Total phenolic compounds in andaliman lozenges.

Lozenges	Total phenolics (GAE/mL)
AC	163.24±0.96[a]
AH	162.3±1.04[a]
AS	161.83±0.76[a]

Values are presented mean±SD of triplicates. Values with different superscripts within the same column are statistically significantly different (α = 0.05). AC: original andaliman lozenges, AH: andaliman lozenges with honey addition, AS: andaliman lozenges with sorbitol addition.

3.6 Alpha-glucosidase and lipase inhibitory activities of andaliman lozenges

Andaliman lozenge was also tested for its functional efficacy against metabolic syndrome *via* inhibiting the alpha-glucosidase and lipase enzymes. As shown in Table 5, andaliman lozenges exerted 50-70% of alpha-glucosidase inhibition and ~50% lipase inhibition. Among all, lozenge AC had the highest inhibitory activity for alpha-glucosidase and lipase enzymes. A metabolic syndrome is a group of metabolic disorders such as insulin resistance, obesity, hypertension, and impaired glucose tolerance which all together or alone become a major factor in the occurrence of atherosclerosis or stroke (Yanti and Limas, 2019). Metabolic syndromes such as obesity and diabetes can be prevented by taking functional supplements including tablets, capsules, lozenges, liquid concentrate, etc. In this study, andaliman lozenge was designed as one of the alternative modern functional supplements for the protection and prevention of obesity and diabetes. Advances in knowledge and food technology make functional lozenge become an alternative for consumers who have difficulty digesting tablet-based supplements.

Metabolic processes in the body will produce byproducts in the form of free radicals. Free radicals correlate with oxidative stress that occurs in tissues and causes chronic diseases such as diabetes by suppressing oxidative stress in diabetes mellitus. Diabetes occurs when the body's cells cannot break down blood sugar, causing a buildup of blood sugar levels. Blood sugar accumulation occurs due to the breakdown of oligosaccharides into monosaccharides by the action of alpha-glucosidase. Thus, inhibiting this enzyme avoids the increase in blood sugar (Patil *et al*., 2015). In linear with this study, andaliman lozenges were found to have functional efficacy in blocking alpha-glucosidase activity in the range of 50-70%, respectively (Table 5). This ability might be associated with the flavonoid content in andaliman that had been reported to have antioxidant activity, inhibit the alpha-glucosidase enzyme, increase lymphocytes proliferation, and reduce free radicals (Dash *et al*., 2017). Commercial drugs such as acarbose, voglibose, and miglitol are considered to possess alpha-glucosidase inhibitory activity. Among these drugs, acarbose is commonly used as a positive control for alpha-glucosidase inhibitory activity assay due to its effectiveness in reducing postprandial blood sugar (Sun *et al*., 2017). However, in this study, acarbose was not employed as a positive control because the function of andaliman lozenge was targeted at preventing an increase in blood sugar.

Table 5. Alpha-glucosidase and lipase inhibitory activities of andaliman lozenges

Lozenges	Alpha-glucosidase inhibition (%)	Lipase inhibition (%)
AC	72.03±0.88[a]	54.73±0.84[a]
AH	62.00±0.79[b]	50.83±0.89[b]
AS	53.20±1.13[c]	50.53±0.83[b]

Values are presented mean±SD of triplicates. Values with different superscripts within the same column are statistically significantly different (α = 0.05). AC: original andaliman lozenges, AH: andaliman lozenges with honey addition, AS: andaliman lozenges with sorbitol addition.

In terms of metabolic syndrome, obesity can cause oxidative stress due to an imbalance of pro-oxidants and antioxidants in the body. Obesity occurs when excessive lipogenesis and lipolysis are inhibited. In addition, obesity can accumulate triglycerides, and increase lipogenesis, and adipocyte apoptosis. Lipogenesis is the process of deposition of fat and synthesis of fatty acids into triglycerides. Triglycerides are hydrolyzed into glycerol and fatty acids by lipoprotein lipase enzyme. The accumulation of the results of the breakdown of triglycerides by the lipase enzyme can lead to obesity. Thus, lipase must be inhibited to prevent the accumulation of triglyceride inhibitors (Shahu *et al*., 2017). In accordance with this study, andaliman lozenges exerted potential lipase inhibitory activity around 50% (Table 5). Previous studies reported that andaliman

https://doi.org/10.26656/fr.2017.7(4).124

extract contained bioactive compounds, such as flavonoids, saponins, and tannins that might inhibit lipase activity (Wijaya *et al.*, 2018). It is noted that insulin resistance plays a role in both diabetes and obesity. In obesity, insulin resistance causes a change in fat storage or synthesis, while in diabetes, insulin resistance will increase blood sugar levels (Ji *et al*., 2011). This symptom can be prevented by controlling post-prandial blood sugar. Therefore, this andaliman lozenge might be recommended as a diet supplement before meals in order to prevent an increase in post-prandial blood sugar.

3.7 Organoleptic profile of andaliman lozenges

The organoleptic test for andaliman lozenges (AC, AH, and AS) was conducted using thirty-three untrained panellists with product ratings on a scale of 1 (very dislike) to 7 (very like). The parameters used for the organoleptic test were colour, taste, aroma, aftertaste, appearance, and overall. Organoleptic results for andaliman lozenges were described in the spider chart (Figure 4). For colour parameters, most panellists preferred lozenge AH, while lozenge AS was chosen for aroma, taste, aftertaste, appearance, and overall parameters (Table 6). Lozenge AC was not favoured by most panellists on taste and aftertaste parameters, but other attributes were still acceptable.

Lozenge AH has good visual colour due to the particle contents in honey sweeteners that have brighter and less murky colours. Lozenge AC has a less favourable colour because it is darker and unattractive due to the original colour of andaliman extract. The choice of sweetener is adjusted to the function of lozenge products for preventing metabolic syndrome. The sweetener is selected from low glycemic index groups like sorbitol. This sweetener is claimed as one of the low sugar glycemic index groups, thus, it is safe for diabetic patients and has no limit on the acceptable daily intake. The honey sweetener has a slightly higher glycemic index than sorbitol, but it still can be used for diabetes treatment with a lower dose (Sievenpiper*et al*., 2018). In general, lozenges AH and AS were preferable over lozenge AC (Figure 4). As previously described, lozenge AC only contained andaliman extract without sweetener addition which caused the original taste of andaliman to be more perceived. Andaliman itself gives bitter and peppery flavours that may contribute to the product ratings of organoleptic parameters in a particular taste. The taste parameter for lozenge AC had a significant difference compared to others (lozenges AH and AS) due to the addition of sweeteners. Moreover, other factors may affect the product ratings in terms of physiological, psychological, or poor physical conditions (Meilgaard *et al*., 2016).

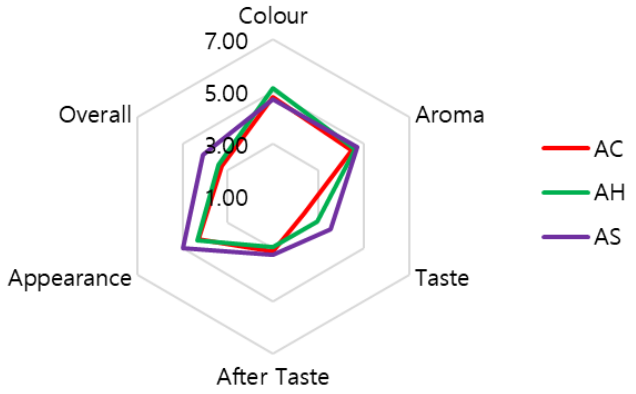

Figure 4. Spider graph of organoleptic data on andaliman lozenges. AC: original andaliman lozenges, AH: andaliman lozenges with honey addition, AS: andaliman lozenges with sorbitol addition.

4. Conclusion

The functional lozenge made from andaliman extract was successfully formulated. There were three variants of lozenges, including original andaliman, andaliman with honey, and andaliman with sorbitol. These lozenges demonstrated functional efficacy for preventing metabolic syndrome *via* antioxidant activity, lipase, and alpha-glucosidase inhibitory activities. Organoleptic results indicate that andaliman lozenges with sorbitol sweetener were most preferred by panellists. These results suggest that andaliman lozenges may offer an alternative functional supplement for the prevention of metabolic syndrome.

Conflict of interest

The authors declare no conflict of interest.

Table 6. Organoleptic results of andaliman lozenges.

Sample	Parameters					
	Colour	Aroma	Taste	After Taste	Appearance	Overall
AC	4.79^{a}	4.48^{a}	2.36^{a}	3.09^{ab}	4.27^{a}	3.27^{a}
AH	5.12^{b}	4.61^{a}	2.94^{b}	2.94^{a}	4.36^{a}	3.39^{a}
AS	4.70^{a}	4.73^{a}	3.55^{c}	3.24^{b}	4.97^{b}	4.12^{b}

Values are presented mean±SD of triplicates. Values with different superscripts within the same column are statistically significantly different (a = 0.05). AC: original andaliman lozenges, AH: andaliman lozenges with honey addition, AS: andaliman lozenges with sorbitol addition.

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