Introduction

Diabetes mellitus (DM) is a chronic metabolic disorder due to insulin function insufficiency which may due to a lack of insulin production in pancreas. Hence, this condition leads to carbohydrate, lipid, and protein metabolism disorders characterized by high blood glucose levels [1], [2]. Prolonged uncontrolled diabetes may lead to some long-term complications which were retinopathy, nephropathy and neuropathy [3]. On the other hand, diabetes also has high risk to cause some comorbid condition such as heart failure, periphery artery diseases, cerebrovascular disease, obesity, cataract, erection dysfunction, and non-alcoholic fatty liver disease, moreover some communicable disease such as tuberculosis [4].

American Diabetic Association reported that Indonesia was 7th rank in the number of diabetic patients (around 8.5 million patients) in 2013 [5]. Meanwhile, International Diabetes Federation (IDF) also reported that prevalence of diabetic in South-East Asia was 78.3 million people and Indonesia was 7th rank in the number of diabetic patients after China, India, United States, Brazil, Russia, and Mexico [6]. Furthermore, estimated incidence rate of DM was 463 million people (9.3% of total global population) who were aged between 20 and 79 years old in 2019. This rate was expected to increase until 578 and 700 million people in 2030 and 2045, respectively. Due to these reasons, it is become important to implicate and develop multi-sectoral strategies to treat diabetes [7].

Kidney disorders in diabetic patients as one of long-term complication is the most common complications of both of diabetes, and fall into end stage kidney disease (ESKD) which is about 50% of cases in developed countries. Based on IDF data (2019) reports, the percentage of diabetic patients that has chronic kidney disease (CKD) in the UK and US were 25% and 36%, respectively. Nineteen percent from these cases were CKD with stage 3 or more. Furthermore, decrease in the incidence of CKD in diabetic patients was observed in patients with type 1 diabetes but not in patients with type 2 diabetes [8], [9].

Sunkist from Citrus family is known as a rich source of ascorbic acid, flavonoid, phenolic compounds, and pectin. Some flavonoids in Citrus family were hesperidin, narirutin naringin, and eriocitrin. These compounds have an antidiabetic by inhibiting the activity of glucose-6-phosphate and phosphoenolpyruvate; moreover, others mechanism that responsible for antidiabetic effect were antiperoxidation, inhibition of
α-amylase enzyme, stimulation of insulin secretion, and recovery damage of pancreatic tissue [10].

Previous studies reported that the Sunkist (IC50, 732 µg/ml) had an antioxidant activity by scavenging of DPPH which was more potent than others type of orange like kaffir lime (Citrus hystrix D. C.) with IC50 value of 1255.07 µg/ml, lime (Citrus aurantifolia) with IC50 value of 1631.80 µg/ml, pomelo (Citrus maxima Merr) with IC50 value of 1739.72 µg/ml and arrowroot (Citrus nobilis Lour) with IC50 Value of 2192.2 µg/ml [11].

Based on the information above, this study was design to explore the health benefits of Sunkist peels against a long-term complication of diabetes which was diabetic nephropathy, when the incidence of kidney disorders in diabetic patients is quite high in various countries. Kidney disorders in diabetic patients can gradually fall and ended into ESKD which can greatly interfere with the person’s quality of life.

Methods

This study was an experimental study. This study was performed in June 2020 at the Pharmacology Laboratory of the Faculty of Medicine, Universitas Prima Indonesia. This study has been approved by Health Research Ethics Committee from Universitas Prima Indonesia. The materials used in this study were 96% ethanol, Sunkist peels, sodium carboxymethylcellulose powder into 30 ml (Na-CMC), Metformin, distilled water, rat pellets, chloroform, Streptozotocin (STZ), and alcohol. This study was used male Wistar rats was the animal trial. The number of sample size was estimated by the Federer formulation, and it was obtained that n higher than 4.75. Hence, this study was used 25 Wistar rats, furthermore these rats were divided into 5 groups, included control, standard, Sunkist Peels Extract-I (500 mg/kg body weight [BW]), II (750 mg/kg BW), and III (1500 mg/kg BW). All rats were acclimatized for 2 weeks before they received the intervention.

The Sunkist was obtained from one of the traditional markets in Medan City, then it was identified at the Medanese Herbarium at FMIPA, University of North Sumatra. Amount of 500 g Sunkist peel was dried by aerating for 7 days then pulverized to become simplicia powder.

The simplicia powder was extracted by maceration method. Firstly, simplicia powder was macerated by 96% ethanol as a solvent in a ratio of 1:10 for 3 days. The mixture was stirred regularly every day. After 3 days, it was filtered by filter paper, and then the residue was re-macerated with 600 ml of 96% ethanol for 3 days. The filtered remaceration and maceration were evaporated by rotary evaporator at a temperature of 70°C and then followed by concentrated using the oven at 40°C until they become thick extracts [12], [13].

Phytochemical screening was performed as qualitative measurement according to a modified Farnsworth method. It consists of the identification of polyphenols, steroids/triterpenoids, glycone, aglycone, anthraquinone, saponins, flavonoids, tannins, and alkaloids [14], [15], [16].

A total of 1 ml of sample was added in 1 ml of 50% ethanol, and then 0.1 ml of 10% AlCl3 solution was added. After being incubated for 30 min, absorbance readings were carried out at the maximum wavelength. Determination of total flavonoid content was determined by equation (1) [17].

\[
TFC = \frac{\text{Equivalent Quersetin Mass}}{\text{Concentration}}
\]  

A milliliter of the sample solution was taken and put into a 10 ml volumetric flask. Add 0.5 ml of Folin-Denis reagent and 1 ml of saturated sodium carbonate solution (35%) (Na2CO3), then add distilled water up to 10 ml. As a blank, distilled water was used instead of the sample. As a standard used tannic acid at various concentrations, total tannin content is expressed in units of mg equivalent of tannic acid/g sample (mg TAE/g). Determination of total tannin content is determined by equation (2) [18].

\[
TTC = \frac{\text{Equivalent Tannic Acid Mass}}{\text{Concentration}}
\]  

A total of 0.1 mL of extract was added with 0.5 mL of Folin–Ciocalteu reagent. Stir the solution and let stand for 6 min. Add 2.5 mL of 5% sodium carbonate solution. Then, the mixture was incubated for 30 min at room temperature. Absorbance readings were carried out at the maximum wavelength. As a blank, aquadest was used instead of the sample. Gallic acid is used as a standard at various concentrations. Phenolic content is expressed in units of mg equivalent of gallic acid/g sample (mg GAE/g). Determination of total phenolic content was determined by equation (3) [19].

\[
TPC = \frac{\text{Equivalent Gallic acid Mass}}{\text{Concentration}}
\]  

The Sunkist peels ethanol extract was suspended into the Na-CMC to form oral suspension. The oral suspension used 0.5% sodium carboxymethyl cellulose as vehiculum. It was made by mixing 0.5 g sodium carboxymethyl cellulose powder into 30 ml hot distilled water in the mortar for 15 min until it formed a clear phrase. Then, it was grounded until homogeneity and dissolved in a volumetric flask by the remaining distilled water to form a vehiculum for extract and standard drugs [12]. After that, the metformin and Sunkist peels extract was suspended into the vehiculum, the 500 mg, 750 mg, and 1500 mg of Sunkist peels extract was suspended into 5 ml of vehiculum to form oral suspension of Sunkist orange peel extract at a dose of 500 mg/kg BW, 750 mg/kg BW,
and 1500 mg/kg BW, respectively [20]. Furthermore, Metformin oral suspension was prepared by mixing 100 mg (20 mg/200 g of body weight rats) tablets of metformin which had been mashed with 0.5% Na-CMC suspension using a 5 ml volumetric flask to the mark.

**Treatment**

In the beginning, all rats were induced by a single intraperitoneal injection of STZ (50 mg/kg BW) in 0.1 M citrate buffer (pH = 4.5). 3 days after the induction, the fasting blood glucose level was measured by glucometer. Fasting plasma glucose (FPG) was measured in the rat fasted for 10–12 h before measuring blood glucose levels. Blood samples from all rat were taken from a vein in the tail of rats before induction (FPG 0), 72 h after induction (FPG 1), and on day 28 (FPG 28) after rats were given Sunkist peels extract and metformin as standard [21].

After 28 days of intervention, all rats were sacrificed by inhalation of chloroform in a closed room, and the blood was collected by cardiac puncture using a 5 ml syringe and 25G-Needle. Moreover, the serum was obtained by centrifugation of obtained blood at 2500 RPM for 10 min [12], [22]. Determination of urea and creatinine levels is based on enzymatic reactions using the Dyasis® reagent kit. The procedure for determining the activity of urea and creatinine catalysts is based on the working procedure of Dyasis®.

All data were analyzed descriptively. After that, all data were analyzed distribution data by Shapiro–Wilk. If data distribution was normal, then it was expressed as Mean ± SD and analyzed by one-way analysis of variance (ANOVA). Elseif data distribution was not normal, then it was expressed as Median (Min-Max) and analyzed by Kruskal–Wallis.

**Results**

Sunkist that was used for extraction was obtained from a traditional market in the Medan, North Sumatera. The Sunkist was identified in Herbarium Medanesea, Faculty of Mathematics and Natural Sciences, University of North Sumatra, with the following identification results:

- **Kingdom:** Plantae
- **Division:** Spermatophyta
- **Class:** Dicotyledoneae
- **Order:** Rutales
- **Family:** Rutaceae
- **Genus:** Citrus
- **Species:** Citrus sinensis L. Osbeck

Local Name: Sunkist

Based on determination of sample, the Sunkist peel has the scientific name as *C. sinensis* L. Osbeck which comes from Citrus family.

**Phytochemicals screening**

The result of phytochemicals screening in Sunkist (*C. sinensis* L. Osbeck) peels ethanol extract was described in the Table 1.

<table>
<thead>
<tr>
<th>Phytochemicals</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Alkaloid</td>
<td>–</td>
</tr>
<tr>
<td>Tannin</td>
<td>+</td>
</tr>
<tr>
<td>Saponin</td>
<td>+</td>
</tr>
<tr>
<td>Flavonoid</td>
<td>+</td>
</tr>
<tr>
<td>Triterpenoids</td>
<td>+</td>
</tr>
<tr>
<td>Steroid</td>
<td>+</td>
</tr>
<tr>
<td>Glycone</td>
<td>–</td>
</tr>
<tr>
<td>Aglycone</td>
<td>–</td>
</tr>
<tr>
<td>Anthraquinone</td>
<td>–</td>
</tr>
<tr>
<td>Polyphenol</td>
<td>+</td>
</tr>
</tbody>
</table>

Based on Table 1, Sunkist ethanol extract has some phytochemicals such as tannin, saponin, flavonoid, triterpenoids, steroid, and polyphenol. However, this test did not determine the phytochemical level. Hence, further investigation was performed to determine the total phenol, tannin, and flavonoid content by spectrophotometry ultraviolet (UV)-Vis. The result of this analysis was described by Table 2.

<table>
<thead>
<tr>
<th>Phenolic compound</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total phenolic content (mg GAE/g extract)</td>
<td>9.89 ± 0.19</td>
</tr>
<tr>
<td>Total tannin content (mg TAE/g extract)</td>
<td>44.27 ± 0.29</td>
</tr>
<tr>
<td>Total flavonoid content (mg QE/g extract)</td>
<td>3.83 ± 0.00</td>
</tr>
</tbody>
</table>

Based on the Table 2, it can be seen that the highest level of phenolic compound was tannin (44.27 ± 0.29 mg TAE/g extract), followed by phenolic (9.89 ± 0.19 mg GAE/g extract), and the lowest one was flavonoid (3.83 ± 0.00 mg QE/g extract).

The obtained Sunkist peel ethanol extract then used to evaluate the antidiabetic and kidney protection effects. The antidiabetic and kidney protection effects were evaluated by measuring blood glucose level and kidney function test, respectively. Blood glucose level was measured in 3 different time before induction and 3 days after induction (after induction), and 28 days after the first treatment in all groups (after treatment). Initially, all data was analyzed the distribution data. According to the distribution data, fasting blood glucose before induction and blood urea nitrogen (BUN) level was normal and the remain data includes fasting blood glucose after induction, fasting blood glucose after treatment, and creatinine level was not normal. Hence, the result for fasting blood glucose level among the group compared as described in the Table 3.
Based on Table 3, the blood glucose level before (p = 0.103) and after (p = 0.508) induction did not show any significant differences between treatment groups, it was shown by the p < 0.05. However, the fasting blood glucose level before after induction was higher than the fasting blood glucose level before induction in all treatment groups. Moreover, the fasting blood glucose after treatment significantly decreased after the last measurement (fasting blood glucose after induction) among all groups except the control group, it was shown by the p < 0.05. After the treatment, the lowest blood glucose level was found in standard group which was 74 (71–76) mg/dl, followed by Sunkist peel ethanol extract-III (78 [76–78] mg/dl), I (81 [83–95] mg/dl), II (81 [78–83] mg/dl), and the highest one was control group which was 220 (205–250) mg/dl. These data showed that the increased of Sunkist peel extract dose would be followed by decrease of fasting blood glucose level.

On the other hand, this study also evaluated kidney function test in all groups. The result for kidney function test among the group compared as described in the Table 4.

### Table 3: Blood glucose level comparison in treatment groups

<table>
<thead>
<tr>
<th>Group</th>
<th>Fasting Blood Glucose (mg/dl)</th>
<th>Before Induction</th>
<th>After Induction</th>
<th>After Treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>Standard</td>
<td>78.80 ± 2.17</td>
<td>210 (195–224)</td>
<td>74 (71–76)</td>
<td></td>
</tr>
<tr>
<td>Control</td>
<td>81.80 ± 4.02</td>
<td>202 (196–237)</td>
<td>220 (205–250)</td>
<td></td>
</tr>
<tr>
<td>Sunkist peels ethanol extract-I</td>
<td>84.40 ± 4.51</td>
<td>204 (198–219)</td>
<td>86 (83–95)</td>
<td></td>
</tr>
<tr>
<td>Sunkist peels ethanol extract-II</td>
<td>84.00 ± 2.34</td>
<td>218 (204–219)</td>
<td>81 (78–83)</td>
<td></td>
</tr>
<tr>
<td>Sunkist peels ethanol extract-III</td>
<td>82.80 ± 3.11</td>
<td>208 (192–212)</td>
<td>78 (76–78)</td>
<td></td>
</tr>
</tbody>
</table>

Difference in superscript in the same column shown significance at P < 0.05 with post-hoc Test Tukey HSD; *p-value was obtained from one way ANOVA, and data were expressed as mean ± SD; **P value was obtained from Kruskal–Wallis Test, and data were expressed as median (min-max).

Based on Table 4, the BUN and creatinine level were significantly different between treatment groups. Based on the post-hoc test Tukey honestly significant difference, the BUN level from Sunkist peels ethanol extract-III decreased into lower than the standard group and the lower dosage (Sunkist peels ethanol extract-II) showed a similar BUN level against the standard group. Meanwhile the lowest dosage group (Sunkist peel ethanol extract-I) showed a similar BUN level against the control group. On the other hand, creatinine level showed a different result. The standard group was significantly different against other groups, however the lowest and moderate dosage of extract (Sunkist peels ethanol extract-I and II) did not show any significant differences against the control group.

### Discussion

STZ has a cytotoxic glucose analogue property. This substance inhibits DNA synthesis in both bacterial and mammalian cells. In bacterial cells, it interacts with specific cytosine moieties which leads to degradation of bacterial DNA. Meanwhile, this substance also acts as a cytotoxic substance to pancreatic \(\beta\)-cell in mammalian within 70 h after administration based on the dosage. The cytotoxicity of this substance in mammalian begins to uptake STZ through glucose transporter 2 transporter which causes DNA fragmentation due to nitrosourea moiety in STZ. There major pathways associated with the DNA fragmentation viz. DNA methylation, Nitric oxide production, and free radical generation as hydrogen peroxide [23], [24]. Hence, the STZ may cause DNA methylation, Nitric oxide production, and free radical generation which leads to DNA fragmentation of pancreatic \(\beta\)-cell and ended by diabetic mellitus.

Nengah et al. (2018) reported that STZ injection dosage of 45 mg/kg BW could induce hyperglycemic state in 58.4% of animal trial after 3 days of administration. The hyperglycemic rats suffered 3 different severities of hyperglycemic included mild (21.5%), moderate (11.8%), and severe (21.5%) hyperglycemic state. This hyperglycemic state was due to dysfunction of beta cells pancreas that has selective receptor for STZ, interfere to insulin secretion, and lead to insulin deficiency [25].

Long-term hyperglycaemic state can cause significant kidney tissue change, which lead to kidney failure. This damage can cause several abnormalities in histological structure of kidney tissue included accumulation of extracellular matrix, thickening of the glomerular membrane, and glomerular sclerosis [26].

BUN/Urea is the end product with nitrogen atoms from the catabolism of protein and amino acid, while creatinine is a product of the breakdown of creatine phosphate in muscles and excreted by the kidneys. Urea is a parameter to indirectly measure kidney function because the level of urea in the blood is directly related to the excretory function of the kidneys. Meanwhile, creatinine examination is usually used to diagnose impaired kidney function and measure creatinine phosphate in the blood. Urea and creatinine are good indicators of a normally functioning kidney, and elevated serum indicates renal dysfunction. BUN and serum creatinine are widely accepted and are the most common parameters for assessing renal function [27].
Although not as specific as creatinine, urea can also be used as an indicator for assessing clearance kidney, but several factors can affect blood urea levels. Plasma creatinine levels will not increase significantly until extensive renal damage is found [28].

Sunkist peel (C. sinensis (L.) Osbeck) is rich in phenolic compounds that have antidiabetic and antioxidant effects. Based on the phytochemical screening of Sunkist peels ethanol extract, it contains some phytochemical such as alkaloid, tannin, saponin, flavonoid, dan triterpenoids, and steroid. Tannin, flavonoid, and phenol are groups of phenols compound which has hydroxyl group. This study showed that the highest level of these phenols compound was tannin which was 44.27 ± 0.29 mg TAE/g extract. Moreover, the lowest one was flavonoid; this compound as Naringin, class of flavono, was reported to improve hyperglycemic state and maintained expression of some gene that responsible to glucose homeostasis in the body [29].

Some previous study supported the result of this study. Sathiyabama et al. (2018) reported that Sunkist peels extract dosage of 50 mg and 100 mg/kg BW significantly reduced fasting blood glucose than the control group which received placebo after 28 days of interventions [30]. Ahmed (2018) reported that administration of orange peel extract showed a protective effect against the kidneys through significant improvements in kidney function test. In addition, the administration of this extract also counter oxidative stress effects by evaluation of some antioxidant effect such as glutathione (GSH), lipid peroxidation, and GSH peroxidase [31].

Conclusion

Overall, it can be concluded that the Sunkist peel ethanol extract has kidney protection effect against diabetic nephropathy at highest dosage (1500 mg/kg BW). The highest dosage administration of Sunkist peel ethanol extract significantly reduces fasting blood glucose, BUN, and creatinine level than the control and lower dosage of extract.

References

Mutia et al. Sunkist Peels Ameliorates Diabetic Nephropathy


