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POTENTIAL OF MANGOSTEEN PEEL EXTRACT JELLY CANDY (*GARCINIA MANGOESTANA L*)TO CONTROL THE BLOOD GLUCOSE LEVEL IN DIABETES MELLITUS PATIENTS

Ratna Kurniawati[1], Suryono Suryono[2]
[1]Alkautsar Nursing Academy, Temanggung, Indonesia
[2]Department of Physics, Diponegoro University, Semarang Indonesia 50273

Email korespondesi: ratnaummudzaky@gmail.com

ABSTRACT

Introduction: Mangosteen peel (Garcinia mangostana) contains bioactive compounds, like antioxidants, founded able to reduce blood glucose levels. Mangosteen rind can be consumed as jelly candy for diabetes mellitus patients. Controlling blood glucose levels is important in diabetes mellitus treatment. The use of mangosteen peel in the form of candy aims to increase the patient's enthusiasm for controlling blood sugar easily, simply and happily. The concentration of mangosteen peel extract used in study were 80 mg each candy. **Methods**: used in this study were pre-experimental, pre test-post test design, 18 respondents, non-random, and purposive sampling. **Results:** The research results showed that 77,8% (14 respondents) experienced a decrease in blood glucose and 16,7% (3 respondents) experienced an increase in blood glucose levels, and 5,5 % (1 respondent) didn't experience changes before and after the intervention, with significance p-value 0.010 (<0.05). A total of 4 pieces of mangosteen peel candy were consumed for 1 day every before meals. The highest decrease in blood sugar levels obtained in this study was 240 mg/dl and the lowest decrease was 10 mg/dl. **Discusion:** This shows that the use of mangosteen peel extract in the form of jelly candy can help control the blood glucose. Disruptive factors in decreasing glucose levels in the blood including comorbidities such as hypertension and diet.

Key Words : Blood glucose, Diabetes mellitus, Mangosteen jelly candy

Latar belakang: kulit manggis (*Garcinia mangostana*) memiliki kandungan senyawa bioaktif seperti antioksidan yang dapat menurunkan kadar glukosa dalam darah. Kulit manggis dapat dimanfaatkan menjadi permen jelly bagi pasien diabetes mellitus. Pengendalian glukosa darah merupakan hal penting dalam penanganan diabetes melitus. **Tujuan:** pemanfaatan ektrak kulit manggis menjadi permen bertujuan untuk meningkatkan semangat pasien dalam mengendalikan gula darah secara mudah, sederhana dan meyenangkan. **Metode:** penelitian menggunakan pre ekperimental, pre test-post test desaign, jumlah sampel 16 responden tak acak, secara *purposive sampling*. **Hasil:** dari penelitian 0,81% mengalami penurunan glukosa darah (13 reponden) dan 0,25 % (3 responden meningkat) nilai signifikansi (α 0,05). Jelly candy kulit manggis dikonsumsi tiga kali sehari sebelum makan. Nilai penurunan terbesar 240 mg/dl dan penurunan ter kecil 10 mg/dl. **Diskusi:** penggunaan ekstrak kulit manggis dalam bentuk jelly candy dapat membantu mengendalikan glukosa darah. Faktor penganggu penurunan kadar glukosa dalam darah diantaranya penyakit penyerta seperti hipertensi dan pola makan.
Kata kunci : Diabetes mellitus, glukosa darah, permen jelly kulit manggis

INTRODUCTION

Hyperglycemia is a condition of increased blood glucose that often occurs in diabetes mellitus patients. The risk of diabetes mellitus increases, especially when a person is aged 45 years and over and is overweight so that the body is no longer sensitive to insulin.[1] Diabetes mellitus is a chronic disease that requires long-term treatment, with side effects and high costs. The first-line drugs for type 2 DM, after lifestyle modification, are the metformin and sulfonylurea types. Metformin has side effects on the gastrointestinal system, whereas sulfonylurea impacts on weight gain and hypoglycemia. Other side effects include headaches, dizziness, nausea, and hypersensitivity reactions.

Therefore, non pharmacology method such as herbal medicine is becoming an alternative treatment for diabetes mellitus patients, due to fewer side effects and lower costs.(1) Some herbs that have been shown to show medicinal effects in clinical trials in treating diabetes mellitus are *Gymnema sylvestre, Momordica charantia, Folium mori, Trigonella foenum graecum, Rhizoma coptidis, Ginkgo biloba, Radix ginseng*, dan *Garcinia mangostana*. (1, 2)

The pharmacological mechanism of these ingredients is by increasing glycogen production, stimulating insulin secretion, increasing glucose absorption in peripheral tissues, increasing insulin sensitivity, and reducing carbohydrate absorption.(1)

Garcinia mangostana or mangosteen is a type of tropical fruit commonly found in Southeast Asia.(1) The mangosteen fruit has a sweet, sour and slightly chelish/chelate taste. Mangosteen fruit consists of pulp and peel (perikarp). Mangosteen peel is composed of quite a lot of polyphenol compounds, including anthocyanins, xanthones, tannins, saponins and phenolic acid compounds. Xanthones is widely found in mangosteen peel which has a function as an antioxidant. The largest component of the mangosteen fruit is the peel, around 70-75%, while the pulp is only about 10-15%, and the seeds are around 15-20%. The highest xanthones content is found in mangosteen peel, amounting to 107.76 mg per 100 grams of peel.(2)

G.mangostana has been popularly used to treat inflammation, skin infections, and diarrhea. The main constituent in the pericarp is α-mangostin. Other constituents contained in it including isomangostin, mangotinone, 8-deoxygartanin, gartanin, dan β-mangostin. Among these elements, α-mangostin has been extensively studied and exhibits antioxidant, anti-cancer, antibacterial effect, and anti-inflammatory, as well as apoptosis induction potential. Studies have also shown that G. mangostana extract can help prevent and treat type 2 diabetes mellitus. (1)

In addition to the xanthone compounds, the mangosteen peel also contains anthocyanins. Anthocyanins are important flavonoids and have several positive responses to the body. Anthocyanins and several flavonoids are very beneficial in the health field which are used as anti-carcinogens, anti-inflammatory, antihepatoxic, antibacterial, antiviral, anti-allergenic, anti-thrombotic, and as protection from damage caused by UV radiation and as antioxidants.(2)

Previous research by watanebe in twenty two patients were randomized given mangosteen and 20 completed the 26 week study. The mangosteen group reported a significant improvement in

insulin sensitivity (homeostatic model assessment-insulin resistance, HOMA-IR −53.22% vs. −15.23%, p = 0.004), and no side effect attributable to treatment was reported. Mangoesteen ektrak given the positive preliminary results, excellent safety profile, treatment of obesity, insulin resistance, and inflammation.(3) Extract *garcinia mangostana* was found to suppress adipogenesis, regulate lipid homeostasis, improving lipid profiles, demonstrated hypoglycemic properties, including the ability to decrease fasting blood glucose and mildly increase pancreatic β-cell numbers and activity. indicating improved insulin sensitivity, less damage to pancreatic β cells, hepatocytes and central veins heltiers antioxidant effect was shown to protect against the micro and macrovascular damage caused by diabetes mellitus(1)

WHO reports that the average level of patient adherence in carrying out long-term therapy for chronic disease is still low in developing countries, while in developed countries it reaches 50%.[1,2] The success of treatment can be proven by the laboratory results of checking fasting blood glucose which decreased to 70-130 mg/dl.(4)

One of the causes of non-compliance of diabetes mellitus patients in consuming drugs is the appearance of boredom when having to take medication. Therefore, it necessary to find a fun new method in taking blood glucose controlling medication so that diabetes mellitus patients will be enthusiastic in consuming drugs with herbal raw materials made from the extraction of mangosteen peel.(5) The purpose of this study was to determine the effect of administration of mangosteen peel extraction in the form of jelly candy on blood glucose levels controlling in patients with type 2 diabetes mellitus.

1. Material and method

Material : There are two main activities carried out in this study, namely taking blood glucose samples and making mangosteen peel extract jelly candy. Meanwhile, the equipment used to measure blood glucose includes: glucometer, tensimeter, weight measurement, height measurement, gloves, and alcohol swabs. The main ingredients for making mangosteen peel jelly candy are mangosteen peel extract 80 mg, mineral water 20%, seaweed jelly powder 70%, honey 10% and molds.

METHOD

The first stage is making the basic ingredients of jelly from seaweed flour, then heating it over low heat until it boils. After the jelly solution boils, the stove is turned off and the mangosteen peel extract was poured into the jelly material. The solution was stirred rapidly until well blended and then poured into the mold. The second stage is drying the jelly candy by cutting the jelly into small pieces and drying it in the air for 3 days.

This research was conducted quantitatively with a pre-experimental pre-test-post-test group design without a control group. Sampling was done by purposive sampling and non-random, Inclusion criteria were male or female, suffering diabetes mellitus more than 6 months, fasting blood sugar >125 mg/dl, without diabetic wounds, and willing to be research respondents. Data isn't normaly distributed with Kolmogorov Smirnov test pre test asym sig 0,109 and post test 0,042.

Analysis data used non parametric test Wilcoxon sign rank test . The research was conducted during June-July 2020 in Temanggung, Central Java. There were 18 respondents with varying blood glucose levels. Measurement of blood glucose and supporting physical assessment were carried out on the respondents before consuming mangosteen peel candy. Mangosteen peel candy was was consumed before breakfast, lunch and dinner for 1 day, then the respondent's blood glucose and blood pressure levels were re-measured.

RESULT

In this study, two activities were carried out, namely the process of making jelly candy from mangosteen peel extraction as a blood glucose controlling agent, and the measuring of blood glucose levels before and after consuming mangosteen peel candy. A total of 4 pieces of mangosteen peel candy were consumed for 1 day every before meals. After one day of observation, the respondent's blood glucose level were then measured. All respondents stated that they prefer to consume jelly candy, because they are bored with drugs in the form of ordinary medicines that they have to consume every day. The expression of the respondents when undergoing observation was that they didn't mind consuming 4 pieces of jelly candy every day, and these candies were easier to carry in their pockets without worrying about spilling. The shape of the jelly candy candy is shown in figure 1.

Figure 1. Mangosteen peel extract jelly candy

The results of this study describe the characteristics of the respondents, monitoring of blood glucose levels before and after the intervention of mangosteen peel candy and a description of the value of blood pressure. Based on the results of this study, it is known about the characteristics of the respondents that all respondents were diagnosed with type 2 diabetes mellitus. Female respondents were 14 people (77.7%) and male respondents were 3 people (22.2%), while the age range of respondents was 40-79 years. Their body mass index (BMI) also varied with very thin 2 people, normal 12 people, obese 3 people, and heavy obesity 1 person. The calorie needs of each respondent also vary according to their height, weight, gender and age. This calorie requirement was only used as a reference for the respondent's diet during one day of observation, however, what type of food was right for

consumption wasn't studied in this study. The results of the physical examination of the respondents are described in table 1.

Table 1. Physical examination results

Respondent	Age	Gender	Weight (Kg)	Height (Cm)	Body mass index		Calorie Requirements
1	57	Female	50,8	152,5	21,8	Normal	1248
2	55	Female	57,5	157	23.3	Normal	1347
3	55	Female	92,7	151	40,7	Obesity II	1670
4	61	Female	60,7	150,5	26,8	Obesity I	1364
5	40	Female	53,5	166	20,1	Normal	1342
6	62	Female	50,9	153	21,7	Normal	1229
7	59	Male	55,1	151	24,2	Normal	1192
8	59	Male	41,6	165	15,4	very thin	1272
9	59	Female	45,6	146	21,7	Normal	1092
10	79	Female	50	160	19,5	Normal	1067
11	54	Female	66	160	25,7	Obesity I	1338
12	58	Female	50	143	24,4	Normal	1134
13	59	Male	59	160	23,0	Normal	1574
14	59	Female	59	159	23,4	Normal	1246
15	66	Female	55,4	140	28,2	Obesity I	1151
16	59	Male	41	165	15,1	very thin	1261
17	55	Female	45	140	22,9	Normal	1094
18	57	Female	44	148	20,0	Normal	1090

Several measurements were made of the respondents before and after consuming mangosteen peel candy, including blood glucose, blood pressure and pulse, while body mass, height, BMI and calories were only measured once before the study. The measured blood glucose values varied from the lowest pre-intervention blood glucose values of 137 mg/dl and the highest values read HI (more than 599, cannot be read on a glucometer). There were three changes in blood glucose values when after the intervention, namely, 14 respondents experienced a decrease in blood glucose, 4 respondents experienced an increase in blood glucose levels (respondent number 7 from 256 mg/dl up to 578 mg/dl, number 10 from 137 mg/dl up to 157 mg/dl, number 12 from 271 mg/dl up to 277 mg/dl), and 1 respondent didn't experience changes before and after the intervention.

In blood pressure measurements were also obtained some changes were varied, but the blood pressure was not observed specifically in this study. Measurement of blood pressure before and after the intervention was required to find out the medical history and comorbidities that have the potential to prevent respondents from lowering blood glucose levels. The pulse above the normal value (60-100x / min) was found in 4 respondents, which then decreased after the intervention. Changes in the measurements results of blood glucose, blood pressure and pulse can be seen in table 2.

Table 2. measurements results of blood glucose, blood pressure and pulse (pre test dan post test)

Respondent	Blood Glucose (mg/dl)			Blood Pressure (mmHg)		Pulse	
	Pre test	Post test	Changes	Pre test	Post test	Pre test	Post Test
1	319	274	45 (-)	134/80	146/98	82	76
2	448	298	150 (-)	145/90	124/82	78	83
3	209	109	100 (-)	167/81	124/74	112	77
4	137	122	15 (-)	159/85	141/84	68	63
5	137	112	25 (-)	103/84	100/69	69	64
6	406	391	15 (-)	122/76	149/83	80	86
7	256	578	322 (+)	113/63	121/76	70	81
8	593	380	213 (-)	125/104	96/84	121	100
9	219	131	88 (-)	121/81	127/74	77	71
10	137	157	20 (+)	182/89	172/98	90	85
11	557	394	163(-)	184/141	174/100	102	106
12	271	277	6 (+)	144/81	145/87	94	89
13	414	313	101(-)	122/84	135/95	75	77
14	187	154	33 (-)	154/81	182/100	102	100
15	358	130	228(-)	153/79	156/90	75	90
16	577	337	240 (-)	125/85	120/80	121	120
17	HI (>600)	HI(>600)	No change	125/80	123/71	80	71
18	420	212	208 (-)	160/90	170/92	80	71

After analyzing the data using the Saphiro Wilk test, it is known that the distribution of blood glucose measurement data when normally distributed has a significance value of 0.109. Meanwhile, the significance of blood glucose during the post test was 0.042, indicating that the data were not normally distributed causing abnormal data. Therefore the Wilcoxson non-parametric test was used to compare the two groups of data that were related to diabetes mellitus patients before and after consuming mangosteen peel jelly candy against decreased blood glucose levels. Wilcoxson test results with a confidence level of 95% and an error of 5%, on the results of blood glucose measurements, obtained a Z value of -2.5800 and a significant assumption of 0.010, this value is below α: 0.05. The significance value of the *p-value* is 0.010 <0.05, it can be concluded that there is a significant difference between before and after consuming mangosteen peel jelly candy on the value of blood glucose in diabetes mellitus patients. The distribution of blood glucose values can be seen in Figures 2 and 3.

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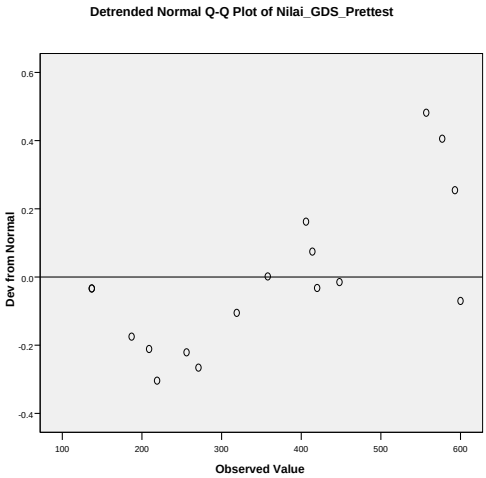

Figure 2. Pre-test blood glucose value

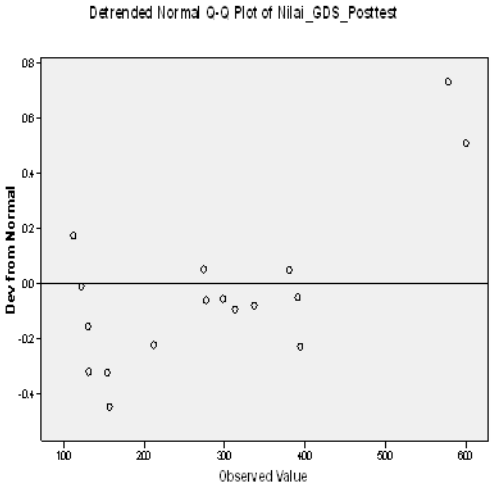

Figure 3. Post-test blood glucose value

DISCUSSION

1 Respondent characteristics

Most of the respondents in this study were Female. Women are more at risk of developing diabetes mellitus. The prevalence of diabetes mellitus nationally by gender found in women 6.4%, higher than in males at 4.9%(6) (Andi Mardhiyah Idris, 2018)Most of the respondents' body mass indexes were in normal values, 4 people were obese and 2 respondents were very thin. The youngest age of the respondents was 40 years old and the oldest was 79 years old. Forty years is the age where people are begin prone to obesity due to the less active in physical activities. Age can affect the risk of diabetes mellitus. The increase of blood glucose levels are closely related to age. The prevalence of type 2 diabetes mellitus increases with age, and results in higher impaired glucose tolerance.(7) At the age of> 30 years, the aging process results in changes in body anatomy, body functions and biochemistry. According to WHO, at the age of a30 years the increase in blood glucose levels can reach 1-2 mg/dL/year when fasting and will increase 5.6-13 mg/dL in 2 hours after meals.(8) (9)

The results of blood glucose measurements for 18 respondents were as follows:

Before consuming the mangosteen jelly candy, the patient's blood sugar was above normal (>200mg/dl) as shown in table 2. After treatment there was a change in blood glucose levels. for blood glucose levels above 600 mg/dl there is no change at all. This means that giving jelly candy is less effective for blood glucose levels above 600 mg/dl and the dose/amount of candy consumed needs to be adjusted.

14 respondents experienced a decrease in blood glucose, 3 respondents experienced an increase in blood glucose, and 1 respondent did not experience a change with a very high blood glucose value of 600 mg/dl. Respondent no.7 experienced an increase from 256 mg / dl to 578 mg / dl, with stable blood pressure and pulse

within normal limits. Respondent No.10 also experienced an increase after consuming mangosteen peel candy from 137 mg/dl to 157 mg/dl accompanied by an increase in blood pressure from 182/89 mmHg to 172/98 mmHg. Respondent No.10 has other comorbidities, namely hypertension, while the pulse is within normal limits. Respondent No.12 experienced a slight increase in blood glucose from 271 mg/dl to 277 mg/dl, borderline hypertension of blood pressure 144/81 mmHg to 145/87 mmHg. Respondent No.17 did not experience changes in blood glucose values, it tended to be very high, while blood pressure and pulse were within normal limits.

The cause of an increase in blood glucose can be influenced by several factors including inappropriate calorie needs, duration of illness and other comorbidities such as hypertension, coronary heart disease, stroke and anxiety. Factors that influence fasting blood glucose levels are age (P value = 0.013), hereditary history (P value = 0.025), gender (P value = 0.043), and diet (P value = 0.012).(10)

2 Bioactive Compounds of Mangosteen Peel Extract

Mangosteen peel has various benefits, especially to reduce blood glucose levels. Mangosteen peel contains a substance called xanthones, anthocyanins which have antioxidant and antidiabetic functions so that they are useful for lowering blood glucose levels. Mangosteen peel contains more than 90% xanthones (a mixture of 80-90% α-mangostin and 5-10% gamma mangostin). The action of alpha glucosidase insulin in the digestive tract will be inhibited by α-mangostin so that it can reduce post prandial hyperglycemia.(11)

Anthocyanins are important flavonoids and have several positive responses to the body. Anthocyanins and several flavonoids have several health benefits as anti-carcinogens, anti-inflammatory, antihepatoxic, antibacterial, antiviral, anti-allergenic, anti-thrombotic, and as protection from damage caused by UV radiation and as antioxidants.(12)

Antioxidants. Mangosteen peel extract contains antioxidants in the form of secondary metabolite compounds which are very important for body health. The presence of antioxidant compounds in the body can protect the body from various degenerative diseases. Degenerative diseases can occur due to the antioxidants in the body are unable to neutralize the increased concentration of free radicals. Free radicals are molecules that in their outer orbits have one or more unpaired electrons. Antioxidants in food are found in many vegetables and fruits, one of which is mangosteen. Antioxidants in the mangosteen peel are phenolic, tannins, flavonoids, anthocyanins, and xanthons compounds.(5)

Xanthones are substances that play a role in reducing insulin resistance so that they can normalize blood glucose levels in the body and are able to overcome fatigue caused by unbalanced glucose levels.(11)

3 The Benefits of Mangosteen Peel Extract

In vitro, in vivo, and clinical trials evaluating the pharmacological effects of *Garcinia mangostana* extract or isolate on type 2 diabetes mellitus have shown that mangosteen peel extract can suppress adipogenesis and regulate lipid homeostasis, thereby increasing lipid profiles and preventing type 2 diabetes mellitus. *Garcinia mangostana* also exhibits hypoglycemic properties, including its benefits to lower fasting blood glucose and slightly increase the number and activity of pancreatic β cells. A group treated with mangosteen in a study showed a decrease in the Homeostatic Model Assessment for Insulin Resistance (HOMA-IR), showing an increase in insulin sensitivity, a significant decrease in the high sensitivity CRP (hs-CRP) level. Histopathology showed that the α-mangostin group had less pancreatic β cell damage, healthier hepatocytes and central veins, and less glomerular and tubular epithelial necrosis compared with the diabetes control group. In addition, the antioxidant effect of Garcinia mangostana has been proven can protect against micro and macrovascular damage caused by type 2 diabetes mellitus. Garcinia mangostana extract or isolate has strong potential to prevent and treat type 2 diabetes mellitus.(1)

4.Blood glucose controlling with mangosteen peel extract

Controlling blood glucose levels is one of the important activities in the management of diabetes mellitus. There is a relationship between adherence to taking anti-diabetic drugs with blood glucose levels in diabetes mellitus patients. In a previous study, Nanda (2018) showed that 46.2% of residents were adherent and 53.8% were non-adherent in taking anti-diabetic drugs. Patients with regulated blood glucose showed that 92.3% were adherent and 7.7% were non-adherent in taking anti-diabetic drugs. There is a relationship between adherence to taking anti-diabetic drugs with regulation of blood glucose levels in diabetes mellitus patients with a value of p = 0.015. This shows that respondents who do not adhere to anti-diabetic drugs are 14 times more risky to experience bad changes in blood glucose levels than patients who are adherent to taking anti-diabetic drugs.. Patients with uncontrolled blood glucose levels were more likely to not adhere to taking anti-diabetic drugs, while patients with controlled blood glucose levels were mostly adherent enough to take anti-diabetic drugs.(4) Diabetes patients have to understand the factors affect controlling blood glucose levels, that one of which is adherence to taking anti-diabetic drugs.

Diabetes mellitus treatment aims to maintain blood glucose levels within a normal range. Hypoglycemic drugs can restore the blood glucose levels within the normal range. Xanthones found in mangosteen peel are bioactive compounds classified as polyketides. This compound is expected to have an antidiabetic effect, which can reduce blood glucose levels from hyperglycemic conditions. The

production of jelly candy aims to make it easier for diabetes mellitus patients to consume mangosteen peel. In addition to having a very beneficial nutritional content, the mangosteen peel also produces a purplish red color which is useful as a natural dye in jelly candy. Commercial jelly candy generally has an attractive color and is usually made with the addition of a dye. The process of jelly producing refers to Salamah et al (2006).(5)

The difference in the producing process with previous research is that water and keragenan were heated first to a boil reaching a temperature of 100 °C, then the temperature was lowered to 70-80 °C, then the mangosteen peel extract and complementary ingredients were added slowly and stirred for ±10 minutes until thickened. The jelly candy was then poured into a mold and left for 1 hour at room temperature. After that it was put in the refrigerator for 24 hours and left for 1 hour at room temperature. The next process is drying by aerating for three days and the candy was ready for consumption.

Mangosteen peel contains anthocyanins which produce a purplish red color. The selection of mangosteen peel as a processed food is not only seen from its nutritional composition, but the color of the mangosteen peel is also one of the attractions for processed food. Jelly candy production carried out at 80 ° C for 22 minutes did not cause discoloration of the jelly candy. The long cooking process will affect the color of the jelly candy.(5)

The use of chemical drugs to treat diabetes mellitus has the risk of having side effects that are quite dangerous for body functions. Symptoms emerged from these side effects are dizziness, cold sweat, anxiety, confusion, difficulty speaking and even unconsciousness. People today prefer to use herbal medicine due to it has many advantages including easy to get, affordable prices, and the most important reason it doesn't cause harmful side effects to the body.(11)

5.The Supporting studies of mangosteen peel extract in experimental animals and humans

Maris Kurniawati previously conducted a study on a group of mice which were given mangosteen peel juice therapy. The results showed that this group of mice could reach normal blood glucose levels, which was indicated by the condition of the β cells of Langerhans islands experiencing sel repairing. This proves that the mangosteen peel juice has the potential for good pharmacological effects. The pharmacological potential of mangosteen peel juice is due to the content of xanthone compounds that act as antioxidants. The antioxidant content of xanthones in the mangosteen peel can inhibit the formation of Reactive Oxygen Species (ROS) which induces cytokines to increase cell apoptosis. The inhibition of the AGEs formation and reduced production of ROS can prevent insulin migration that is facilitated by neutrophils, so that it can inhibit β-pancreatic cell inflammation (insulitis).(13)

Xanthones have an anti-inflammatory effect so they can stop

autoimmune reactions attacking inflammatory cells (mononuclear lymphocytes) and increase cell resistance so that they are able to carry out the healing process due to infection. These conditions support tissue repair and the formation of new β cells.(13) The conclusion is that giving mangosteen peel juice to streptozotocin-induced mice can reduce blood glucose levels of mice and repair the histological condition of the rat pancreas. The group received mangosteen peel juice had blood glucose levels of 104.7±10.9 mg/dL which was almost the same as the average blood glucose levels in the control group of 108.5±19.5 mg/dL. Whereas in the group of sick rats, the average blood glucose level remained high at 163.8±16.2 mg/dL.(13)

Husein et al (2019) conducted a study on the antioxidant potential of mangosteen peel against HbA1C levels in fasting blood glucose levels in diabetic rats. The study was divided into three groups, namely the control group, the metformin HCL group and the mangosteen peel group. The intervention was carried out for 5 days and the results showed that there was a significant decrease in HbA1C levels and fasting blood glucose in the rats in the mangosteen skin group.(14)

A study by Handayani et al (2020) on the effect of adding mangosteen peel extract to endothelial damage in 49 patients with type 2 diabetes mellitus showed a relationship between decreased fasting blood glucose levels and hbA1c in the intervention group compared to the control group.(15) The addition of α mangostin (200 mg/kg/day) for eight weeks has decreased MAP, plasma HbA1C, serum insulin, cholesterol, triglyceride, and HOMA-IR.(16) Concumtion Mangoesteen peel extract 26 week in female leads to glucose homeostasis, lowering insulin level, BMI and potential inhibiting lipid and effect on weight loss.(3)

Research by Laili et al (2020) on 36 diabetes mellitus patients was conducted in a quasy experiment. The study was divided into 2 groups, namely intervention and control. The intervention group was given a mangosteen peel drink (Garcinia Mangostana) as much as 25-50 grams (2 small mangosteen peels). Mangosteen peel (Garcinia Mangostana) was washed first, after that it was boiled in 3 cups of water, until it becomes 1 cup of water, boiled mangosteen peel (Garcinia Mangostana) was drunk 1 cup per day. The average value of blood glucose in the intervention group was 260.33 mg/dL (pre test) to 251.83 mg/dL (post test). This shows that there is a decrease in the average value of blood glucose. The average value of blood glucose in the control group was 264.28 mg/dL (pretest) to 262.44 mg/dL (post test). There was a significant difference between the treatment and control groups with a *p-value* of 0.001. This means that there is an effect of giving mangosteen peel on blood glucose levels, while the control group has a value of p = 0.166. So it can be concluded that Garcinia Mangostana is effective in reducing blood glucose levels in people with diabetes mellitus.(11) Daily consumtion of

mangoesteen to diabetic rats 200 mg/kg include diet 8 weeks can effect to hypoglycemic and insulin effect also reduction tryglyseride and cholesterol

This research can be used as a reference basis for research on the potential of mangosteen peel extract jelly candy to reduce blood glucose levels in diabetes mellitus patients. There are deficiencies in this study, including the number of respondents is relatively small and other confounding factors such as calories have not been studied directly.

CONCLUSIONS

The results of this study indicated that there was a significant change in the value of blood glucose in diabetes mellitus patients who consumed mangosteen peel jelly candy with a p value of 0.010 (<0.05). Mangosteen peel extract in the form of jelly candy has made patients more interested and excited about consuming blood glucose controllers. The form of jelly candy has made it easier for diabetes mellitus patients to carry it everywhere.

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