Conference Paper

Effectiveness of Jicama Probiotic Yoghurt *(Pachyrhizus erosus)* on Blood Glucose in Diabetic Mice

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Abstract

Background: Diabetes Mellitus (DM) is a degenerative disease population increases every year. DM was ranked sixth as the cause of death. About 1.3 million people died because of diabetes and 4% died before the age of 70 years. DM auto-oxidation causes glucose to increase reactive oxygen compounds. One of the DM management is a complementary therapy using a functional food ingredient, namely, jicama and probiotics. Probiotics and jicama contain active compounds in the form of inulin and BAL and are able to control blood glucose levels. This study aims to determine the effectiveness of jicama probiotic yogurt on blood glucose levels in diabetic mice. **Methods:** This research is a quasi-experimental with pre–post-test control group, using a sample of DDY strain mice according to the criteria. Samples were given treatment probiotic yogurt and jicama probiotic yogurt 2 ml for seven days in the treatment group and one group of non-treated controls. The mean obtained were analyzed by dependent t-test, independent t-test, and one-way ANOVA test. **Result and Conclusion:** The results showed that there was a decrease in blood glucose levels in the probiotic yogurt group amounting to 296.62 mg/dL and jicama probiotic yogurt of 337.57 mg/dL, while the control group increased by 43.57 mg/dL. **Results:** One way ANOVA test showed jicama probiotic yogurt more effectively decreases blood glucose levels than the probiotic yogurt (p = 0.00). Jicama probiotic yogurt can be used as an alternative complementary therapy for patients with diabetes mellitus.

Keywords: diabetes mellitus, blood glucose levels, jicama, probiotics

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1. Introduction

Diabetes mellitus (DM) is a degenerative disease that affects many people around the world. The incidence and prevalence of diabetes mellitus, from various epidemiological studies tend to show an increase from year to year.[1] DM ranked 6th as the cause of death. About 1.3 million people die from diabetes and 4% die before the age of 70.[2]

Diabetes mellitus is characterized by insulin resistance which results in hyperglycemia.[3] The condition of hyperglycemia for a long time will cause glucose autooksidation or glycosylation reaction of non-enzymatic proteins that can increase reactive oxygen compounds (ROS).[4] Increased oxidative stress in the body is characterized by

high results of lipid peroxidation, namely malondialdehyde (MDA) and low activity of antioxidant enzymes, then triggers complications of microvascular and macrovascular diseases.[4]

The use of functional food ingredients and bioactive compounds is an effective strategy for diet planning management and can be used as a complementary treatment for type 2 diabetes mellitus.[5] Functional food ingredients that have been used for type 2 diabetes mellitus patients are inulin in Jicama and probiotics in yoghurt.

The role of Jicama juice in lowering blood glucose levels is known to come from the content of inulin Jicama. Based on a study that has been carried out on prediabetes women, the provision of jicama juice made from 320 grams of Jicama can reduce GDP levels by 6 mg / dL for 21 days.[6]

Jicama is a local food ingredient that has very good functional value, which contains bioactive inulin components with a natural sweetness and has a glycemic index of 51.[7] Inulin has several benefits including; helps absorption of bile salts, increases stool mass and IgA levels, and speeds up food transit time in the intestine and makes satiety last longer. Inulin fiber can also bind carbohydrates, so the body is slow to produce blood glucose.[8, 9] Inulin can modulate peptide gastrointestinal secretions involved in the regulation and metabolism of lipids. This inulin characteristic is very useful for product applications for people with diabetes mellitus or those who are on a low calories diet.[10]

Yogurt is one of the oldest food products that is beneficial for patients with diabetes. Traditionally, probiotics in the form of lactic acid bacteria have been added to yogurt and other fermented products.[11] Probiotics can reduce blood glucose by increasing inflammation and preventing β-cell destruction in animals. The study analyzed the effects of probiotics on glucose metabolism using rats, suggesting a decrease in fasting blood glucose and postprandial blood glucose and a decrease in HbA1C after taking probiotics. Overall, the results showed that consuming probiotics significantly reduced FPG (Fasting glucose) by 15.92 mg / dL and HbA1C by 0.53%.[12]

Previous research on probiotics for Jicama yogurt is only limited to organoleptic tests and nutrient levels. Research on probiotic clinical trials of crooked yogurt has not been carried out. To prevent unexpected effects, the researcher will use experimental animals to see the effect of probiotics on Jicama yogurt on changes in blood glucose levels.

Therefore, the researchers conducted a study on the Effectiveness of Probiotic Yogurt Progeny on Blood Glucose Levels in Mice Conditioned with Diabetes Mellitus.

2. Methods

This study included experimental research. The research design used was *quasi-experimental with pre-post test control group design*. This research was carried out at the Andalah University Faculty of Pharmacy Immunology Laboratory from June 6-28, 2017.

Subjects were 24 male DDY strain mice which were divided into 3 groups: probiotic yogurt treatment group, probiotic treatment group of yam and yogurt and control group without giving test material. Test material is given as much as 2 mL for 7 days.

Before being given the test material for mice in alloxan induction at a dose of 175 mg / head to get hyperglycemia conditions. After five days the initial blood glucose level is measured. Then, after giving the test material on day 8, blood glucose levels were measured again.

The research subject was taken by using simple random sampling method. The criteria of this research subject were 2 months of age, body weight ± 20 grams, healthy condition and had never received any treatment.

The data used are primary data in the form of initial and final blood glucose levels, initial and final body weight and feed intake measured 3 times during the study. Data analysis using the *one way Anova* test followed by LSD test.

3. Results

3.1. Feed Intake

TABLE 1: Intake of Sample Feed in Control Group and Treatment.

Day	Feed Intake and Test Material		
	Treatment 1 (%)	Treatment 2 (%)	Control (%)
1	68	68	88
4	79	77	80
6	72	73	81
Mean	73.00 ± 5.57	72.67 ± 4.51	83.00 ± 4.36

In table 1 it is known that feed intake in the two treatment groups was less than 80%. This was caused by the use of blunt needle syringes which resulted in irritation of the mouse's throat, thus affecting the feed intake of mice.

Intake of test material in accordance with the prescribed dosage, it is known from the time of giving the product the sample does not spit back the test material. Supplements

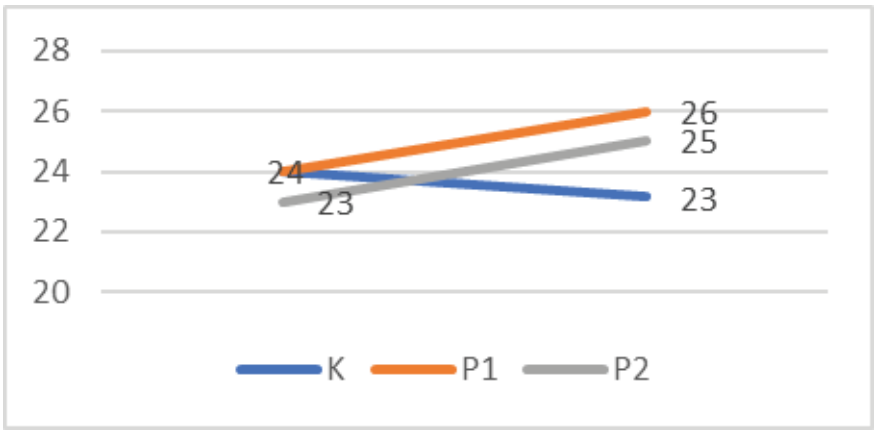

Figure 1: Changes in Weight in Treatment and Control Groups.

were given to the sample using a 1 mL blunt syringe, administered in the morning and evening for 7 days.

3.2. Weight

Based on graph 1 it can be seen that the average changes in body weight in each treatment group and control group. The control group during intervention experienced a weight loss of 0.86 grams. Group P1 experienced an increase in weight with an average of 2 grams and group P2 experienced an increase in body weight, but lower than the group P2, with an average increase in weight of 1.57 grams.

3.3. Blood Glucose Levels Before and After Giving Test Materials

Based on statistical tests using *Paired T test*, the results of the treatment of probiotic yogurt and probiotic yogurt for 7 days obtained an overview of blood glucose levels before and after administration of the test material in table 2.

Table 2: Levels of Blood Glucose Before and After GivingTest Material.

Group	Mean ± SD (mg/dL)		Δ (mg/dL)	p value
	Befor	After		
P1	443.00 ± 148.92	146.38 ± 62.00	296.62	0.00*
P2	508.14 ± 117.32	170.57 ± 68.85	337.57	0.00*
K	301.29 ± 96.97	344.86 ± 169.58	-43.57	0.20
* There was a significant difference (p <0.05).				

The results showed that there was a statistically significant decrease in blood glucose levels (p = 0.00). group P1 experienced a decrease in blood glucose levels of 296.62

mg / dL and group P2 at 337.57 mg / dL. The control group experienced anincrease in blood glucose levels (p insignificant= 0.20) of 43.57 mg / dL.

The results of the one way ANOVA test followed by post-hoc analysis with LSD test on the decrease in blood glucose levels before and after the administration of the test material in the treatment group showed no significant difference (p <0.05)

4. Discussion

4.1. Differences in Blood Glucose Levels in Probotics Yogurt Treatment Group

The results of the statistical test found that there were significant differences in the initial and final blood glucose levels in the yogurt probiotic treatment group which was indicated by the value of p <0.05. The mean decrease in blood glucose levels in the control group was 296.62 ± 108.91mg / dL.

Some probiotic strains can regulate blood glucose homeostasis. One of them is that Probiotics can act effectively in regulating the immune system against chronic inflammation caused by pathogenic microbes. Probiotics can prevent type 2 diabetes mellitus by inhibiting inflammatory regulation of IFN- γ and IL-2 or IL-1β or by increasing anti-inflammatory IL-10 produced by animals that have been conditioned by diabetes mellitus.[13] strains *Lactobacillus* can increase serum glucose, inulin, C-peptide, leptin, glyclicate hemoglobin, GLP-1 level, inflammation of IL-6 and TNF-α in adipose tissue and PPAR-γ and GLUT gene 4.[14] Some probiotic strains also provide antioxidant effects, one of which is inhibiting the occurrence of chronic inflammation. Probiotics can alleviate oxidative stress in pancreatic cells which can cause chronic inflammation and apoptosis in β-pancreatic cells,[15] which can prevent damage to pancreatic cells so that they do not cause hyperglycemic effects.

The hypoglycemic effect of probiotics is caused by the presence of lactic acid bacteria in the intestinal epithelium, these lactic acid bacteria will use glucose thereby reducing the absorption of glucose in the intestine. The inhibitor effect of lactic acid causes the production of cytokines which are responsible for pancreatic cell damage.[15]

4.2. Differences in Blood Glucose Levels in the Treatment Group of Probiotics Yoghurt Jicama

Statistical tests showed that there were significant differences in theblood glucose levels initial and finalin the yogurt probiotic treatment group which was indicated by the value of p <0.05. The average decrease in blood glucose levels in the probiotic treatment group of yam bean yogurt with a mean of 337.57 ± 90.01 mg / dL.

The decrease in this group was greater than the probiotic yogurt treatment group. This is due to the addition of pungent juice into yogurt probiotics. Jicama bulbs contain inulin which is able to control blood glucose levels. Inulin is one type of fiber and a source of carboidrate derived from plants. Inulin is a prebiotic which means it can provide good bacteria for digestion in the intestine. Soluble inulin fibers will produce more energy than glucose.[10]

Inulin and oligofructose are able to control blood glucose levels with several mechanisms. First, by slowing the emptying of the stomach, thus slowing glucose into the bloodstream, which results in a decrease in postprandial blood glucose levels. Second, it inhibits the absorption of carbohydrates from food, thus slowing carbohydrate access to digestive enzymes. Third, dissolved dietary fiber such as inulin increases the viscosity of small intestinal fluid and inhibits glucose diffusion. So as to help delay the absorption and digestion of carbohydrates. All of these mechanisms can reduce glucose absorption, and reduce postprandial hyperglycemia.[16]

Probiotics are able to reduce blood glucose levels by increasing the anti-inflammatory IL-10 and preventing the occurrence of β-cell dextrusion. Probiotics are also able to provide an effect as an antioxidant in type 2 diabetes mellitus patients by preventing oxidative stress and endotexmia in β-pancreatic cells that cause insulin resistance.[17]

4.3. Differences in Blood Glucose Levels in the Control Group

The results of the statistical tests found that there was no significant difference in the initial and final blood glucose levels in the control group which was indicated by p> 0.05. The control group experienced an average increase in blood glucose levels of -43.57 ± 81.03 mg / dL.

Increased blood glucose levels in the control group due to the absence of increased intake of lactic acid bacteria and dietary fiber. Low fiber intake and microflora imbalance in the gastroinstestinal can increase blood glucose levels.[6.18]

Intestinal microflora will increase absorption of monosaccharides in the intestine and cause increased production of trigleserides in the liver associated with insulin resistance. Probiotics can correct microflora imbalances in the gastrointestinal by increasing the number of gram-positive bacteria. Bacteria levels *Bifidobaterium* have a significant relationship to improve glucose tolerance and reduce inflammation.[19]

4.4. Effect of Provision of Yogurt Probiotics effect

The results showed a significant relationship ($p < 0.05$) which means that there was a statistically significantof administering probiotics for yogurt in decreasing blood glucose levels in mice that had been conditioned by diabetes mellitus.

Probiotics can reduce blood glucose by increasing inflammation and preventing β-cell de- strusion in animals. The study analyzed the effects of probiotics on glucose metabolism using rats, suggesting a decrease in fasting blood glucose and postprandial blood glucose and a decrease in HbA1C after taking probiotics.[12]

This result is the same as the study conducted by Mohamadshahi et al (2014) which stated a decrease in blood glucose levels in rats given probiotics for 8 weeks.[20] Yogurt probiotics can control blood glucose levels by controlling oxidative damage, increasing the glycazazide bioavailability, delaying glucose absorption and increasing T killer cells to overcome insulin resistance.[12, 21]

The effects of probiotics on glucose metabolism can work through several different mechanisms. First, through oxidative damage and antioxidant ability plays an important role in the pathogenesis of diabetes. Probiotics can reduce the risk of oxidative damage by inhibiting lipid peroxidation and increasing the content of antioxidant glutathione, superoxide dismutase, catalase, and glutathione peroxidase in diabetic rats. Second, probiotics can provide anti-diabetic effects on insulin resistance by increasing T killer (NKT) cells in the liver. Probiotics can overcome increased insulin resistance and inflammation by TNF-expression modulation and reduction of NF-kB bonds. In addition, probiotics can increase glucose metabolism by increasing the glycazazide bioavailability, inhibiting or delaying the absorption of glucose in the intestine and changing autonomic nerve activity.[12, 21]

In addition to acting as a hypoglycemic agent, probiotics can also maintain the body weight of mice at normal status. Probiotics act as antioxidants that can prevent the occurrence of chronic inflammation in the β-pancreatic cells, so as to prevent the occurrence of insulin resistance which acts in breaking down energy from carbohydrate sources.

4.5. The Influence of Probiotic Yogurt Whirl wind effect

Research shows that p <0.05, which means that there was a statistically significantfrom the administration of probiotics for yam yogurt in decreasing blood glucose levels in mice that had been conditioned by diabetes mellitus.

This study used 2 mL of probiotic yogurt which was given for 7 days with an average decrease in blood glucose levels of 337.57 mg / dL. The results of previous studies conducted by Helmi, et al (2011) with the treatment of giving bengkuag juice to white minutes at a dose of 30 ml / kg for 21 days showed that there was a decrease in blood glucose levels in the sample of 230 mg / dL.[22] Statistically a significant effect on the supply of yam juice to the sample blood glucose level was measured with p <0.05. From the results above, it can be seen that the probiotic crooked yogurt can lower blood glucose levels in the sample with an average reduction of 337.57 mg / dL compared to the study of 30 ml / kg body weight of bengkuang juice on average a decrease in blood glucose levels of only 230 mg / dL.

Jicama (*Pachyrhizus erosus*) is a type of leguminous plant whose tuber is rich in water content (about 80-90%) and nutrients such as carbohydrates, vitamin C, vitamin B_1, minerals calcium, phosphorus, potassium and inulin. Inulin is a group of fructants with soluble fiber properties. Inulin has an effect on increasing the work of the intestinal villi and improving blood parameters, especially cholesterol and glucose in the blood. Inulin is a form of soluble food fiber that cannot be digested by digestive enzymes.[23]

Inulin is broken down by bacterial enzymes. Bifidobacteria bacteria are able to digest inulin. Inulin can increase bifidobacteria in the intestine which can help the immune system and help absorption of vitamins.[24]

Inulin has a role in controlling blood glucose levels through two mechanisms. The first mechanism is to slow gastric emptying and inhibit glucose absorption in the small intestine. Inulin can reduce glucose levels after meals, during fasting and can also improve insulin profiles. Inulin and fiber in yam can increase food viscosity in digestion. Increased viscosity in the digestive tract is considered as the main factor that influences glucose absorption rate. The second mechanism is fermented inulin in the large intestine to produce *Short Chain Fatty Acid* (SCFA). Inulin does not interact with digestive enzymes and remains intact until it reaches the large intestine. The concentration and amount of SCFA in the *caecum* and colon were higher when subtracting this fermentation was dietary fiber.[25]

Besides the inulin content, lactic acid bacteria also play a role in decreasing blood glucose levels. The hypoglycemic effect of probiotics is caused by the presence of lactic

acid bacteria in the intestinal epithelium, these lactic acid bacteria will use glucose thereby reducing the absorption of glucose in the intestine. Lactic acid bacteria are able to control oxidative damage, increase the glycazazide bioavailability, inhibit the production of cytokine hormones which are responsible for pancreatic cell damage, and can increase the activity of T killer cells to overcome insulin resistance.[12,21,15*bengku*]

4.6. Effectiveness of Probiotics for Yogurt Bengkuang Provision

The results showed that probioticyogurt was more effective in reducing blood glucose levels in mice. The jasmine yogurt probiotic, in addition to containing lactic acid bacteria, also contains inulin which is able to control blood glucose levels. Inulin is known as natural insulin, insulin can act as a hypoglycemic agent.[16]

Inulin is a carbohydrate made from residues of fructosyl β (1,2), most of which end up with glucose residues. Modification of this chemical reaction makes short chain oligomers, called fructooligosaccharides.[26] Fructosyl β (1,2) causes inulin resistance to digestive enzymes, such as α-glucoside and α-amylase.[16] Inulin has physiological benefits against soluble fiber, which can increase blood glucose levels. Soluble fiber contains polysaccharides that are resistant to hydrolysis by digestive enzymes.[23, 27] Water soluble fiber can delay glucose uptake in the small intestinal epithelium and reduce glucose uptake by resisting the convective effect of intestinal contractions, thereby controlling postprandial glucose levels.[16]

Besides acting as an inulin hypoglycemic agent it also acts as a prebiotic. Prebiotic compounds are nutrients that are suitable for probiotic bacteria, but are not favored by pathogenic bacteria. Inulin will be fermented by lactic acid bacteria, which is used as an energy source for multiplication and cell metabolism.

Lactic acid bacteria are able to control blood glucose levels by using glucose so as to reduce the absorption of glucose in the intestine. The inhibitor effect of lactic acid causes the production of cytokines which are responsible for pancreatic cell damage.[15]

Probiotics of Bengkuang yogurt are more effective in lowering blood glucose levels than giving probiotics of yogurt. This is due to the fact that probiotics of yam yogurt in addition to containing lactic acid bacteria also contain inulin. The content of lactic and inulin acid bacteria in the probiotic of crooked yogurt can play a role in increasing insulin sensitivity and decreasing the inflammatory response and oxidative stress in β-pancreatic cells thus preventing insulin resistance. Probiotics of Javanese yogurt can control blood glucose levels, so it can be used as an alternative complementary therapy for patients with diabetes mellitus.

5. Conclusions and Suggestion

5.1. Conclusion

In total cholesterol levels the treatment group of yogurt probiotics decreased an average of 196.62 mg / dL, the treatment group of yogurt probiotics experienced an average decrease of 337.57 mg / dL while the control group experienced an average increase of 43.57 mg / dL.

Administration of probiotics for yam yogurt is more effective for lowering blood glucose levels than administering probiotics for yogurt. This is because probiotic yam yogurt contains active substances that act as hypoglycemia agents, namely lactic and inulin acid bacteria.

5.2. Suggestion

Probiotics of Javanese yogurt have benefits to control blood glucose levels for patients with diabetes mellitus. It is expected that yogurt producers can process jicama into a probiotic bengkuang yoghurt, so that yam has a higher selling value and can be consumed by patients with diabetes mellitus.

For further research, it is expected to continue this research by conducting clinical trials in patients with diabetes mellitus and analyzing the content of active compounds in probiotics, yam yogurt.

References

[1] Joan Webster-Gandy, Madden, A. & Holdsworth, N. *Gizi dan Dietetik*. (EGC, 2014).

[2] Mann, J. & Truswell, A. S. *Buku Ajar Ilmu Gizi Edisi 4*. (EGC, 2014).

[3] Ndraha, S. Diabetes Melitus Tipe 2 Dan Tatalaksana Terkini. *Medicinus* **27,** 9–16 (2014).

[4] Iliadis, S. & Papageorgiou, G. Oxidative Stress, Preeclampsia and Cardiovascular Disease. 130–135 (2012).

[5] Boaz, M., Leibovitz, E., Dayan, Y. B. & Wainstein, J. Functional Foods in The Treatment of Type 2 Diabetes: Olive Leaf Extract, Turmeric and Fenugreek, A Qualitative Review. **1,** 472–481 (2011).

[6] Yasmina, A. R. & Probosari, E. Perbedaan Kadar Glukosa Darah Puasa Sebelum dan Setelah Pemberian Sari Jicama (Pachyrrhizuserosus) Pada Wanit Prediabetes.

J. Nutr. Coll. **3,** 440–446 (2014).

[7] Regards, W. Glycemic Index (GI) Food Chart. 1–15

[8] Kasmiyetti. Pengaruh Pemberian Jicama Terhadap Kadar Glukosa Darah Sewaktu Pasien Diabetes Melitus Tipe 2 di Puskesmas Nanggalo Padang Tahun 2015. *Poltekkes Kemenkes Padang* (2015).

[9] Kaminskas, A. *et al.* Quality Of Yoghurt Enriched by Inulin and Its Influence On Human Metabolic Syndrome. **64,** (2013).

[10] Arasj, F., Nurhamidah & Oenzil, F. Pengaruh pemberian pati Jicama terhadap penurunan kadar gula darah tikus putih diabetes. 1–6 (2006).

[11] Apostolidis, E., Kwon, Y.-I. & Shetty, K. Potential of Select Yogurts for Diabetes and Hypertension Management. *J. Food Biochem.* **30,** 699–717 (2006).

[12] Zhang, Q., Wu, Y. & Fei, X. Science Direct Effect of Probiotics on Glucose Metabolism in Patients with Type 2 Diabetes Mellitus: A Meta-analysis of Randomized Controlled Trials. *Medicina (B. Aires).* **52,** 28–34 (2016).

[13] Matsuzaki, T., Jicamaazaki, R., Hashimoto, S. & Yokokura, T. Antidiabetic Effects of an Oral Administration Lactobacillus casei in aNon-Insulin-Dependent Mellitus (NIDDM) Model using KK-AY Mice of Diabetes. *Endocr. J.* **44,** 357–365 (1997).

[14] Hsieh, F. *et al.* Oral administration of Lactobacillus reuteri GMNL-263 improves insulin resistance and ameliorates hepatic steatosis in high fructose-fed rats. *Nutr. Metablism* **10,** 1–14 (2013).

[15] Harisa, G. I., Taha, E. I., Khalil, A. F. & Salem, M. M. Oral Administration of Lactobacillus acidophilus restores nitric oxide level in diabetic rats. *Aust. J. Basic Appl. Sci.* (2009).

[16] Park, C. J. & Han, J. Hypoglycemic Effect of Jicama (Pachyrhizus erosus) Extract on Streptozotocin-Induced Diabetic Mice. **20,** 88–93 (2015).

[17] Zhang, Y. & Zhang, H. Microbiota associated with type 2 diabetes and its related complications. *Food Sci. Hum. Wellness* **2,** 167–172 (2013).

[18] Larsen, N. *et al.* Gut Microbiota in Human Adults with Type 2 Diabetes Differs from Non-Diabetic Adults. *PLoS One* **5,** (2010).

[19] Cani, P. D., Bibiloni, R., Knauf, C., Neyrinck, A. M. & Delzenne, N. M. Changes in Gut Microbiota Control Metabolic Diet – Induced Obesity and Diabetes in Mice. **57,** (2008).

[20] Mohamadshahi, M., Veissi, M., Haidari, F., Shahbazian, H. & Kaydani, G. Effects of probiotic yogurt consumption on inflammatory biomarkers in patients with type 2 diabetes. *BioImpats* **4,** 83–88 (2014).

[21] Lenoir-wijnkoop, I. *et al.* An Economic Model For The Use of Yoghurt in Type 2 Diabetes Risk Reduction in The UK. *BMC Nutr.* 1–9 (2016). doi:10.1186/s40795-016-0115-1

[22] Arifin, H., C, A. M. & Ahmad, A. Pengaruh Air Perasan Jicama Terhadap Kadar Gula Darah Mencit Putih Jantan Diabetes. *J. Sains dan Teknol. Farm.* **16,** 128–137 (2011).

[23] Cherbut, C. Inulin and Oligofructose in The Dietary Fibre Concept. *Br. J. Nutr.* 159–162 (2002). doi:10.1079/BJN2002532

[24] Diza, Y. H., Wahyuningsih, T. & Ningsih, Ti. P. *Penelitian Peningkatan Mutu Minuman Probiotik Jicama*. (2013).

[25] Khairina, A. & Yuanita, L. Pengaruh Variasi Lama Penyimpanan Umbi Jicama (Pachirhyzus erozus) Terhadap Kadar Glukosa Darah Rattus norvegicus. *UNESA J. Chem.* **4,** 31–36 (2015).

[26] Yun, J. W. Fructooligosaccharides-Occurrence, Preparation, and Application. *Enzyme Microb. Technol.* **229,** 107–117 (1996).

[27] Conceic, A. *et al.* Inulin-Type Fructans: A Review on Different Aspects of Biochemical and Pharmaceutical Technology. *Carbohidrate Polym.* **101,** 368–378 (2014).