VNU Journal of Science, Natural Sciences and Technology 26 (2010) 224-232

Effect of pomelo (*citrus grandis* (l). osbeck) peel extract on lipid-carbohydrate metabolic enzymes and blood lipid, glucose parameters in experimental obese and diabetic mice

Do Ngoc Lien[1,*], Nguyen Thi Thuy Quynh[1], Do Van Phuc[1], Vu Cong Phong[2], Phung Thanh Huong[3]

[1]*Faculty of Biology, College of Science, VNU, 334 Nguyen Trai, Hanoi, Vietnam*

[2]*Pedagogical University of Ha Noi No-2*

[3]*Hanoi University of Pharmacy*

Received 18 January 2010

Abstract. The aim of this study was to assess the effects of Pomelo (*Citrus grandis* (L.) Osbeck) peel extracts (CGE) on activity of lipid-carbohydrate metabolic enzymes such as Carnitine pamitoyl-transferase (CPT), lipase, hexokinase, glucose 6-phosphatase and blood lipid glucose parameters in experimental obese and diabetic mice. The results showed that, in the experimental obese mice treated daily, orally with CGE at dose of 1200 mg/body weight for three weeks, activity of hepatic CPT have been raised from 30.5% (for ethanol extract) to 63.3% (for ethyl acetate extract) compared to the control. Simultaneous increase of blood lipolytic activity was demonstrated in obese mice treated daily by CGE in comparison with the control. In addition, body weight reducing and hypolipidemic effect of the CGE in obese mice were proven clearly. Interestingly, the anti-diabetic effect of CGE in diabetic STZ induced mice was demonstrated. Fasting blood glucose levels in diabetic mice treated orally with CGE (1200 mg/kg.b.w) for three weeks were reduced clearly in comparison with the control (diabetic mice untreated) ($p< 0.001$). Especially, hepatic hexokinase activity in diabetic mice treated with CGE was raised from 14.19% (for ethanol extract) to 55.46% (for ethyl acetate extract) in comparison with the control (untreated diabetic mice). On the contrary, activity of hepatic glucose 6-phosphatase in treated diabetic mice was decreased clearly as compared to untreated diabetic mice ($p<0.05$).

Keywords: Citrus grandis (L.) Obeck, blood glucose and lipid, obese and streptozotocin diabetic mice, hypolipidemic, anti-diabetic effect.

1. Introduction

Obesity is the most common nutritional disorder in the developed country and developing in other countries including Vietnam. It is considered to be a risk factor associated with the development of major human diseases such as cardiovascular disease, diabetes mellitus and cancer.

The anti-obesity and anti-diabetic drugs were developed following the approval process commonly reserved for conventional pharmaceuticals under the guideline of the US Food and Drug Administration (FDA. 2004), such as orlistat, metformin etc [1].

* Corresponding author. Tel.: 84-4-38582179.
E-mail: liendn@vnu.edu.vn

Orlistat, hydrogenated derivative of liptatin derivated from *Streptomyces toxitricini,* is a potent inhibitor of gastric pancreatic lipase and has proved to be moderately effective for treatment of human obesity and, possibly diabetes [2].

Anti-hyperlipidemic and anti-diabetic effect of metformin were showed, but side-effect and its efficacy of remains in debate if its use for a long time. It is has been suggested that herbal remedies from traditional medicinal plants have to be investigated, in the future, for treatment and prevention of obesity and diabetes and other diseases.

The investigation of effects of plant extracts on activity of lipid-carbohydrate metabolic enzymes such as lipase, lipoprotein lipase, carnitine acyl transferases, hexokinase, an important enzyme of carbohydrate degradation and glucose 6-phosphatase, an important enzyme of gluconeogenesis in liver of animals have been interested by scientists for elucidation of anti-obesity and anti-diabetes mechanism of traditional remedies. Inhibition of enzymatic activity of the digestion and absorption of dietary fat such as lipase, lipoprotein lipase and enhancement of carnitine acyl transferases activity and fatty acid oxidation enzymes in fat expenditure in the mitochondria have been also used as target in obesity treatment [2,3].

Pomelo (*Citrus grandis* (L.) Osbeck) belonging to the family Rutaceae, is a fruitful plant found widely in Vietnam with many different cultivars. Its peels being major by-product in the processing of Citrus juice become waste and cause environmental pollutions. The previous studies showed that, polemo peels are abundant of bioactive compounds such as flavonoid, pectin, naringenin, hesperidin, naringin, kaemferol and its derivates ... [4].

The present study was carried out to assess anti-obesity, anti-diabetic effects and the expression of activity of some lipid-carbohydrate metabolic enzymes in experimental obese and diabetic mice. The aim of this study is to elucidate some biochemical mechanism of traditional anti-obesity and anti-diabetes remedy.

2. Materials and methods

2.1. Plant material and preparation of plant extract

The Pomelos were collected from Hanoi during the months of August-September, 2009. The plant materials were classified by Botany Department at Vietnam National University, Hanoi.

Pomelo peels were dried at 50^0C grinded into powder and extracted 3 times with ethanol with continuously stirring. The mixture was filtered with Whatman No.1 filter paper and the filtrate was centrifuged at 6.000 rpm at room temperature (25^0C). The supernatant was concentrated *in vacuum* by means of rotary evaporator at 40^0 C to obtain concentrates. This concentrate was dissolved in distilled water and fractionated in turn via n- hexane, chloroform, ethyl acetate solvents. The extracting portions were concentrated to obtain concentrates. All the concentrates were stored at 4^0C until use [5, 6].

2.2. Animals and diets

Male Swiss strain mice weighing 14-16g at four weeks of age (NIHE) were used in this study. Animals were housed at 25 ± 2^0C with 12h light/dark cycle. Mice were divided into two groups with different diets. One was fed normal standard pellet diet (ND) supplied by

National Institute of Hygiene Epidemiology (NIHE). Another was fed high-fat died (HFD). HFD was prepared by mixing the normal chow (NIHE) with high lipid and cholesterol diet according to National Institute of Nutrition (NIN) and Srinivasan et al [5]. Animals had free access to diet and water (*ad libitum)* in 6 weeks.

2.3. Determination of hypolipidemic and body weight reducing effect of pomelo peel extracts in obese mice

After 6 weeks care, mice from each group were divided into different lots (6 mice/ lot). Each lot of mice was treated daily with 1200mg/kg concentrate of ethanol, n-hexan, chloroform, ethyl acetate and 500mg/kg metformin respectively for three weeks. The mice fed ND are untreated as the control. Body weight of mice was determined weekly and on the final day of the experience, blood of all mice was collected for analysis. Blood lipid parameters, including total cholesterol (TC), triglyceride (TC), HDL-c, LDL-c, and was assayed using Biochemical automatically analyzer AU640, Japan.

2.4. Evaluation of hypoglycemic effect of CGE in STZ induced diabetic mice

On the final day of 6 weeks care, fasting blood glucose levels of mice fed ND and fed HFD were determined, then obese mice were given single i.p injection of Streptozotocin (STZ) at dose 120mg/kg (STZ was freshly in 0.1M citrate buffer pH 4.5) and blood glucose was monitored after 72h. Only mice with fasting blood glucose levels >18mmol/l in tandem with expressed blood insulin were considered to be type 2 diabetes. Blood insulin concentration of mice was determined by ELISA kit technique (Mercodia, Sweden). For studying hypoglycemic effect of pomelo peel extracts, diabetic mice were divided into different lots administrated daily with 1200mg/kg concentrate of ethanol, n-hexan, chloroform, ethyl acetat extracts and 500mg/kg metformin respectively for three weeks. Fasting blood glucose levels were determined weekly by Technique (USA) One Touch Ultra in all the experience.

2.5. Determination of blood and liver enzymatic activity of mice

Activity of blood lipase was determined by automatic analyzer AU640, Japan. Hepatic CPT Activity was determined by technique of Markwell et al [6]. Hexokinase (HK) activity was determined using a spectrophotometric assay as described by Darrow and Colowick in where the formation of glucose 6-phosphate at 37°C was coupled to its oxidation by glucose-6-phosphate dehydrogenase and NAD^+ [7-9]. Hepatic glucose-6-phosphatase activity was determined based on hydrolytic reaction of glucose-6-phosphate to produce inorganic phosphorus (P_i). Produced P_i was quantified according to the method described by Taussky [10]. The protein concentration was measured by the method of Bradford using bovine serum albumin as the standard [11].

2.6. Statistic analysis

All values are expressed as the mean ± S.D. The results were analyzed for statistical significance by one-way ANOVA test using SPSS software. Changes were considered significant if the P-value was less than 0.05 or 0.01.

3. Results and discussion

3.1. Body weight and blood biochemical parameters with different nutrition diets

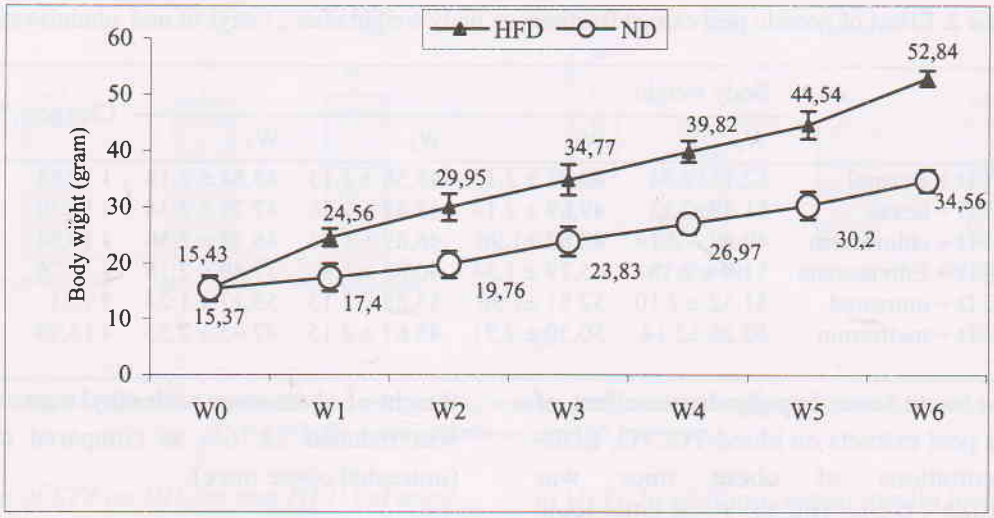


Fig. 1. Body weight gain of mice groups with ND and HFD after 6 weeks care ($p < 0.05$).

Table 1. Blood biochemical parameters of mice groups fed with ND and HFD diet

Parameters	ND group	HFD group	Changes, times
Total Cholesterol (TC). mmol.l^{-1}	3.17 ± 0.1	5.93± 0.41	↑1.9
Triglyceride (TG).mmol.l^{-1}	1.18 ± 0.17	6.03 ± 0.19	↑5.1
LDL-c mmol^{-1}	0.92 ± 0.12	2.08 ± 0.1	↑2.3
Free fatty acid (FFA) mmol.l^{-1}	0.81 ± 0.1	1.37 ± 0.1	↑1.7
Glucose mmol.l^{-1}	5.47 ± 0.35	9.61 ± 0.37	↑1.8
Serum Insulin (SI) ng.ml^{-1}	0.60 ± 0.01	1.56 ± 0.17	↑2.6
HDL-c mmol.l^{-1}	1.72 ± 0.1	1.09 ± 0.08	↓1.6
Lipase U.l^{-1}	90.2 ± 13.06	41.2 ± 7.73	↓2.2

(↑): increase, (↓) decrease

The obtained results show that the body weights of HFD-fed mice were increased approximately 1.8 times compared to the ND-fed mice (Fig.1). There is great difference in blood biochemical parameters between these groups. Particularly, blood TC, TG, LDL-c, glucose and insulin of fed HFD groups were increased respectively 1.9, 5.1, 2.3, 1.8, and 2.6 times compared to fed ND mice. While, concentration of HDL-c and enzymatic activity of lipase decreases respectively 1.6 times and 2.2 times as compared to ND fed mice (table 1). These results have affirmed that the experimentally obese mice suffer from lipid-carbohydrate metabolism disorder.

3.2. Effect of orally treated with C. grandis peel extract fractions on obese mice

In order to treat the obese mice, we have designed the experimental schema for daily repeated oral administration (for three weeks) of CGE fractions (1200mg/kg b.w). Obtained results show that anti-obesity effect of CGE was proved clearly to reduce body weight of HFD-fed mice. Namely body weight of HFD-fed mice administrated with ethyl acetate extract fraction was reduced clearly (32.04%) than untreated obese mice. Whereas body weight of untreated HFD lot raised normally (7.51%) (Table 2).

Table 2. Effect of pomelo peel extract fractions on body weight after 21 days of oral administration

	Body weight				Chargers, %
	W_0	W_1	W_2	W_3	
HFD + Ethanol	52.15±2.34	48.23 ± 2.13	45.58 ± 2.13	43.84 ± 2.14	↓20.53
HFD + hexan	51.49±2,13	49.69 ± 2.14	48.42 ± 1.56	47.78 ± 2.34	↓13.39
HFD + chloroform	49.58 ± 2.14	48.02 ±1.98	46.89 ± 1.44	46.32 ± 2.56	↓16.04
HFD + Ethylacetate	51.9 ± 2.18	45.79 ± 1.34	40.88 ± 1.82	37.49 ± 2.15	↓32.76
HFD + untreated	51.32 ± 2.10	52.81 ±1.36	53.82 ± 2.13	55.17 ± 1.24	↑7.51
HFD + metformin	52.26 ±2.14	50.39 ± 2.21	48.67 ± 2.15	47.45 ± 2.33	↓13.99

At the same time, hypolipidemic effect of *C.grandis* peel extracts on blood TC, TG, LDL-c concentrations of obese mice was demonstrated clearly (fig.2). Especially body weight of obese mice with ethyl acetate fraction was reduced 32.76% as compared to control (untreated obese mice).

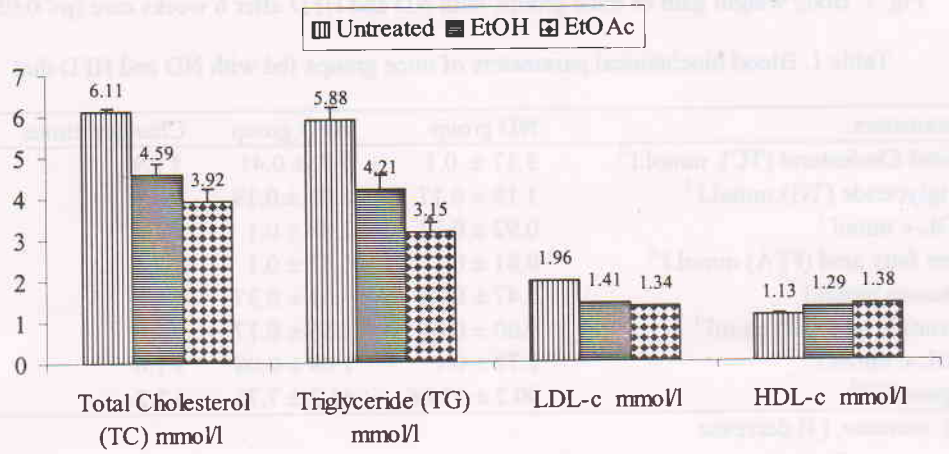
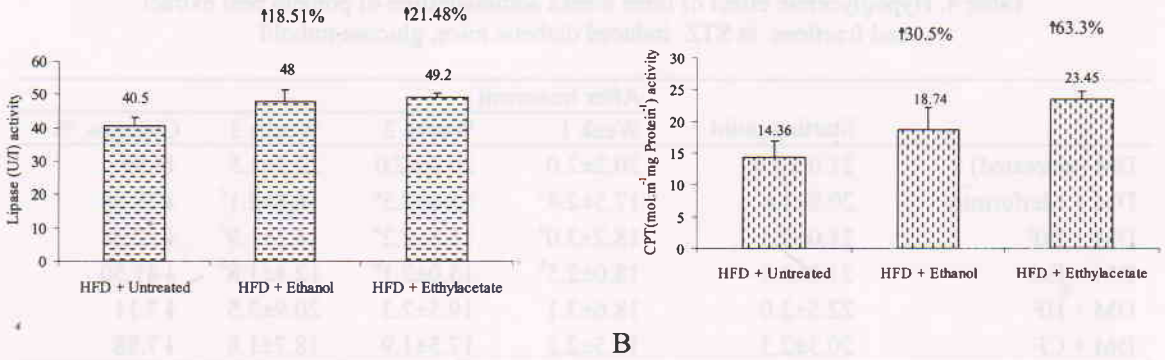


Fig. 2. Effect of repeated oral administration (for three weeks) of C.grandis peel extract fractions on lipidemic parameter.

Namely, blood cholesterol, triglyceride and LDL-c levels of lot of mice fed HFD were decreased clearly (fig. 2).

3.3. Effect of C. grandis peel extracts fractions on enzymatic activities of lipase and CPT in obese mice.

Obtained results showed that blood lipolytic activity in obese mice treated with ethanol and ethyl acetate fractions were increased clearly from 18.51% to 21.48% respectively in comparison with the control (untreated obese mice) (Fig.3. A). Especially, CPT, an enzyme enhancing lipid degradation has expressed raising activity in obese mice treated with CGE. The results showed that hepatic CPT activity in treated obese mice were increased from 30.5% (for ethanol fraction) to 63.3% (for ethyl acetate fraction) in comparison with the control (untreated obese mice mice) ($0.01<p$) (Fig.3. B). In addition, the increase of CPT activity in mice treated with ethyl acetate fraction was raised more than that treated with ethanol fraction ($p<0.01$). (Fig.3. B)



A B

Fig.3. Effect of *C. grandis* peel extract fractions on enzymatic activities of lipase (A) and CPT(B) in treated obese mice (↑ Increases).

3.4. Effect of STZ on ND-fed and HFD fed mice

Injection of STZ (120 mg/kg) into obese mice significantly increased blood glucose concentration ($p < 0.001$), with recorded values being over 4 times greater than fed ND mice ($p<0.01$). However, blood glucose concentration in fed ND mice injected with STZ (120 mg kg^{-1}) increased slightly (about 1.5 times, $p > 0.05$) as compared to buffer injected ND fed mice untreated with STZ and equivalent to HFD. In addition, serum insulin level in HFD mice significantly increase (2.7 times) in comparison with ND fed mice (Table 3). It is clear that, obese mice injected with STZ at dose (120mg/kg w.b) suffer from type 2 diabetic disease expressed insulin mutinously insulin resistance. Therefore, the carbohydrate metabolic disorder and insulin resistance were proved in the STZ induced diabetic mice

Table 3. Blood glucose and insulin concentration after 5 days of buffer or STZ injection

Biochemical estimation	ND	ND + STZ	HFD	HFD + STZ
Blood glucose (mmol/l)				
Initial	4.85 ± 0.64	5.87 ± 1.15	8.76 ± 1.07	9.15 ± 1.13
After 5 days of injection	5.42 ± 0.72	8.36 ± 1.08	8.43 ± 1.04	23.25 ± 4.14
Serum insulin (ng/ml)	0.63 ± 0.03	0.59 ± 0.05	1.71 ± 0.1	0.98 ± 0,08

ND: normal diet fed mice injected with citrate buffer (control), ND +STZ: normal diet fed mice injected with STZ (120 mg/kg).
HFD: high fat diet fed mice injected with citrate buffer (control), HFD + STZ: high fat diet fed mice injected with STZ (120mg/kg)
All values were expressed as mean ± S.D. Value are statistically significant at * $p < 0.01$ and ** $p < 0.001$.

3.5. Hypoglycemic effect of pomelo extracts fractions on type 2 diabetic mice

The treatment of diabetic mice with ethanol, ethyl acetate fractions (1200 mg/kg w.b) and metformin 500mg/kg w.b for three weeks have reduced significaly their blood glucose levels 32.38%, 41.50% and 28.84% respectively ($p<0.001$). Interestingly, blood glucose level in diabetic mice treated with ethyl acetate fraction was reduced strongly more than that treated with anti-diabetic metformin ($p<0.05$) (Table 4).

Table 4. Hypoglycemic effect of three weeks administration of pomelo peel extract and fractions in STZ induced diabetic mice, glucose mmol/l

	Starting point	After treatment			
		Week 1	Weeks 2	Weeks 3	Changes, %
DM (untreated)	21.0 ±2.4	20.2±2.0	20.2 ±2.0	22.1±1.5	↑4.93
DM + Metformin	20.8±1.6	17.5±2.4^{c}	15.8±2.5^{c}	14.8±2.1^{c}	↓28.84
DM + EtF	21.0±2.4	18.2±3.0^{a}	15.8±2.2^{a}	14.2±1.9^{a}	↓32.38
DM + EaF	21.2±3.0	18.0±2.5^{b}	15.0±2.1^{b}	12.4±1.8^{b}	↓41.50
DM + HF	22.5±2.0	18.6±3.1	19.5±2.3	20.9±3.5	↓7.11
DM + CF	20.3±2.3	18.5±2.2	17.5±1.9	18.7±1.8	↓7.88

EtF: ethanol fraction, EaF: ethyl acetate fraction, HF: n-hexan fraction, CF: chloroform fraction. All values were expressed as mean ± S.D. Value are statistically significant at ^{a} $p<0.05$, ^{b} $p < 0.01$ and ^{c} $p < 0.001$. Value in parenthesis indicates the percentage lowering of blood glucose in comparison to the before treatment. (↑: increase, ↓: decrease).

While, blood glucose level of diabetic mice treated with n-hexane, chloroform fractions were reduced only slightly.

3.6. Effect of CGE on activities of Hexokinase and glucose-6-phosphatase in diabetic mice

The results showed that, after three weeks of treatment with ethanol and ethyl acetate fractions, hepatic hexokinase activity in treated CGE diabetic mice was increased from 14.9% (for ethanol fraction) to 55.46% (for ethyl acetate fraction) in comparison with untreated diabetic mice ($p<0.001$). However, hexokinase activity in normal non-diabetic mice was bigger about two times in comparison with treated or untreated diabetic mice (Fig.4A) Therefore, it is necessary to treat for long time with CGE to restore hexokinase activity. On the contrary, there was a significant reduction in hepatic glucose-6-phosphatase activity in type 2 diabetic mice treated with CGE as compared to the untreated diabetic group. Namely, hepatic glucose-6-phosphatase activity in type 2 diabetic mice treated with CGE was decreased from 38.71% (for ethanol fraction) to 47.85% (for ethyl acetate fraction) ($p < 0.05$) (Fig. 4B). Seeing that, glucose 6-phosphatase, an important enzyme is necessary for gluconeogenesis pathway in the liver [3, 12]. Anti-diabetic effect of CGE was indicated clearly by inhibition of glucose 6-phosphatase activity in this study (Fig 4B).

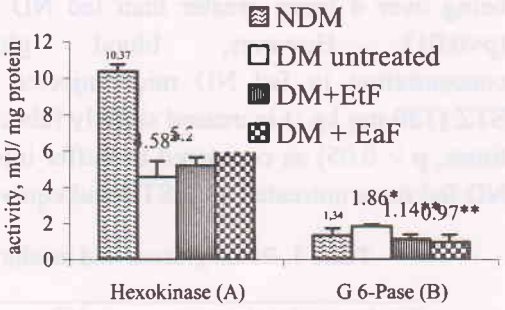


Fig. 4. Effect of ethanol fraction and ethyl acetate fraction of Citrus grandis (L.) Osbeck peel on hepatic hexokinase and glucose-6-phosphatase activity in STZ-induced diabetic mice.

NDM: non-diabetic, DM: diabetic, EtF: ethanol fraction, EaF: ethyl acetate fraction, Data are expressed as means ± S.E.M, n=6. * and ** indicate the significant levels of difference in glycogen level, hexokinase and glucose-6-phosphatase as compared to non-diabetic and untreated diabetic mice, respectively (* $p < 0.05$, ** $p<0.01$).

Conclusion

1. Body weight reducing, anti-obesity and anti diabetic effects of CGE were proven in

experimental obese and type 2 diabetic mice treated orally, daily for three weeks at the dose of 1200mg/kg b.w of dry CGE fractions.

2. Activity of lipid degrading enzymes such as lipase, CPT in obese mice treated with CGE, was demonstrated to be increased from 18.51% to 21.48%(for lipase) and from 30.50% to 63.30% (for CPT) in comparison with untreated obese mice.

3. Activity of glucose degradation of hexokinase in CGE treated diabetic mice was increased strongly from 14.9% (for ethanol fraction) to 55.46% (for ethyl acetate fraction) in comparison with untreated diabetic mice ($p<0.001$). On the contrary, activity of hepatic glucose 6- phosphatase of glucoseneogenesis in type 2 diabetic mice treated with CGE was proved to be decreased clearly from 38.71% (for ethanol fraction) to 47.85% (for ethyl acetate fraction) as compared to untreated diabetic mice.

Acknowledgements

Authors are thankful to support of the project QGTD. 08.06. of Vietnam National University, Hanoi.

References

[1] D.A. Moreno, N. lic, A. Pouler I. Raskin, Effect of Arachis hypogaea nutshell extract on lipid metabolic enzymes and obesity parameters. *Life sciences* 78 (2006) 2797- 2803.

[2] Ide T. Effect of dietary α-linolenic acid on the activity and gene expression of hepatic fatty acid oxidation enzymes. *Biofactors* 13 (2000) 9-14.

[3] J. M. Berg, J. L. Tymoczko, L. Stryer, Glycolysis and Gluconeogenesis. *In. biochemistry W.H freeman and Company, New York* (2001) 425-464.

[4] Y.C. Wang, Y.C. Chuang, H. W. Hsu, The flavonoid, carotenoid and pectin content in peels of citrus cultivated in Taiwan, *Food Chemistry*, 106 (2008) 277-284.

[5] K. Srinivasan , B. Viswanad , L. Asrat , C.L. Kaul , P. Ramarao Combination of high-fat diet-fed and low – done streptozotocin-treated rat A model for type 2 diabetes and pharmacological sceening, *Pharmacological Reseach* 52 (2005) 313-320.

[6] M. A. K. Markwell, E. J. Macgroarty,L.L. Bieber, N. E. Tolbert, The sub cellular distribution of carnitine acyl tranferrases in mammlian liver and Kidney. *J.Biochem.* 248 (1973) 3426-3432.

[7] S. Bhavana, S. K. Satapathi, P. Roy Hypoglycemic and Hypolipidemic effect of *Aegle marmelos* L. leaf extract on Streptozotocin induced diabetic mice. *International Journal of Pharmacology* 3 (6) (2007) 444-452.

[8] H. U. Bergmeyer, K. Gawehn, and M. Grassl, *Methods of Enzymatic Analysis* (Bergmeyer, H.U. ed.), Second Edition, Vol.1 (1974) 434-435.

[9] U.I. Jung, M. K. Lee, K. S. Jeong, M. S. Choi The hypoglycemic effects of hesperidin and naringin are partly mediated by hepatic glucose-regulating enzymes in C57BL/KsJ-db/db mice, *Journal of Nutrition,* 134 (2004) 2499-2503.

[10] H.H. Taussky, E. Shorr, A microcolorimetric method for the determination of inorganic phosphorus, *The Journal of Biological Chemistry* 202 (1952) 675 – 685.

[11] M. A. Bradford. Rapid and Sensitive Method for the quantification of microgram quantities of Protein Utilizing the Principle of Protein-Dye Binding, *Anal. Biochem.* 72 (1976) 248-254.

[12] N.Z. Banquer, D. Gupta, J. Raju, Regulation of metabolic pathways in liver and kidney during experimental diabetes effects of anti-diabetic compounds. *Indian Journal Clinical Biochemistry*, 13 (1998) 63-68.

Tác dụng của dịch chiết cùi bưởi (*Citrus grandis* (L.) Obeck) đến một số enzyme trao đổi lipid-saccarit và các chỉ số lipid, glucose máu trên chuột béo phì và đái tháo đường thực nghiệm

Đỗ Ngọc Liên[1], Nguyễn Thị Thuý Quỳnh[1], Đỗ Văn Phúc[1], Vũ Công Phong[2], Phùng Thanh Hương[3]

[1]*Trường Đại học Khoa học Tự nhiên, Đại học Quốc gia Hà Nội*

[2]*Trường Đại học Sư Phạm Hà Nội 2*

[3]*Trường Đại Học Dược Hà Nội*

Mục đích của nghiên cứu này là đánh giá tác dụng của dịch chiết cùi bưởi (*Citrus grandis* (L.) Obeck) (CGE) lên một số enzyme trao đổi lipid- saccharid như carnitine panmitoyl-transferase (CPT), lipase, hexokinase, glucose 6-phosphatase và một số chỉ số lipid và đường glucose huyết của chuột béo phì và đái tháo đường thực nghiệm. Các kết quả nghiên cứu cho thấy rằng: ở chuột béo phì thực nghiệm được xử lý hằng ngày bằng đường uống với dịch chiết cùi bưởi ở liều lượng 1200 mg/kg thể trọng trong ba tuần, hoạt động của enzyme CPT ở gan tăng lên từ 30,5% (đối với dịch chiết ethanol) đến 63.3% (đối với dịch chiết ethyl acetate) so với đối chứng (chuột béo phì không được uống dịch chiết cùi bưởi). Hoạt động lipase của máu cũng được nhận thấy tăng lên đồng thời ở chuột béo phì khi được xử lý hằng ngày với dịch chiết cùi bưởi từ 18,51% đến 24,48% so với đối chứng. Thêm vào đó, tác động làm giảm trọng lượng và mỡ máu cuả dịch chiết cùi bưởi cũng được chứng minh rõ ràng ở chuột béo phì thực nghiệm. Điều đáng chú ý là dịch chiết cùi bưởi còn có tác dụng chống đái tháo đường ở chuột gây đái tháo đường thực nghiệm. Cụ thể là nồng độ đường huyết lúc đói của chuột đái tháo đường khi được điều trị 3 tuần bằng 1200mg/kg cao dịch chiết cùi bưởi đã giảm xuống rõ ràng từ 32,5% (uống cao cồn tổng số) đến 42,4% (uống cao ethyl acetat) so với đối chứng ($P<0.01$). Đặc biệt là hoạt động hexokinase ở gan chuột đái tháo đường khi xử lý với dịch chiết cùi bưởi đã tăng lên từ 14,19% (đối với cao cồn tổng số) đến 55,46% (đối với cao ethyl acetat) so với đối chứng. Trái lại, hoạt động glucose 6-phosphatase ở gan chuột đái tháo đường được xử lý với dịch chiết cùi bưởi giảm xuống rõ so với chuột đái tháo đường không xử lý dịch chiết cùi bưởi ($p<0.05$).

Từ khóa: Citrus grandis (L.) Obeck ,glucose và lipid máu, chuột béo phì, chuột đái tháo đường, STZ.