Original Articles/นิพนธ์ต้นฉบับ

Comparison between Different Preparations (Fruit Juice, Freeze-Dried Fruit Juice and Seedless Dry Fruit) of Bitter Melon (Momordica Charantia) on Postprandial Plasma Glucose, Insulin and Lipid Levels in Type 2 Diabetics.

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Abstract

Background: Bitter Melon (Momordica Charantia) (MC) has been used as an antidiabetic herb for a long time. However, research evidence has been conflicting.

Objective: This study aimed to compare the effects of different preparations of Momordica charantia (MC) prepared by various processing (fruit juice, freeze-dried fruit juice and seedless dry fruit) on postprandial plasma glucose, insulin, and triglyceride levels in type 2 diabetics.

Method: This was a randomized cross-over study. Twelve type 2 diabetics from Ramathibodi hospital who had been on dietary control with or without oral hypoglycemic agents were randomized to undergo 4 acute tests. The tests consisted of ingestion of MC fruit juice, freeze-dried MC fruit juice, and seedless dry MC fruit before having a 400 kcal standard meal and a control with no MC. There were 1 month washouts between tests. Blood samples were drawn before taking the standard meal (0 min) and at 60, 120 and 240 minutes after the meal.

Results: After ingestion of the MC fruit juice, mean postprandial plasma glucose levels at 60 and 120 minutes (155 $\pm$ 9 and 169 $\pm$ 12 mg/dl) and the area under the glucose curve (AUC) were significantly ($p < 0.037$) lower than the control period (194 $\pm$ 11 and 233 $\pm$ 13 mg/dl) whereas no significant difference was found after ingestion of other MC preparations. All MC preparations tended to produce lower postprandial insulin surges as compared to the control period but there were no significant differences between them. Whereas postprandial TG rose significantly during the control period and after ingestion of other MC preparations, there was no significant rise of postprandial triglyceridemia after MC fruit juice (107 $\pm$ 62 and 116 $\pm$ 65 mg/dl). The only side effects seen were a bowel movement and flatulence occurred in particularly after MC fruit juice.

Conclusions: The results demonstrated that among all MC products, the most efficient preparation for postprandial glycemic and triglyceridemic control was seen in MC fruit juice. No serious adverse events were noted throughout the study.

Key Words: Bitter melon, Momordica charantia, diabetes, postprandial glucose, triglycerides

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Introduction

Plants have been used for years to treat diabetes in many countries; only some have scientific data support.[1] Bitter melon immature fruit, commonly consumed as vegetable, has also been used as anti-diabetic substance. Bitter melon, Momordica charantia (MC) belongs to Cucurbitaceae family, is also called bitter gourd or karela and is found in many tropical countries.[1] It contains several antidiabetic substances such as charantin, saponin, and polypeptide-p.[2] Thai folk medicine has claimed the use of the sun-dried products or oven-dried products to be effective in decreasing plasma glucose, lipids and for weight reduction without obvious clinical evidence.[3] Evidence from animal and human studies have suggested that MC products i.e. MC fruit juice and the MC freeze dried fruit juice have hypoglycemic property,[2,4-8] hypolipidemic property,[9] cataract prevention property[10] as well as blood pressure normalization.[11] However, MC studies are not conclusive, some studies have shown no effect from MC.[3] Hitherto, there have been limited studies in humans especially to compare the effectiveness of various forms of bitter melon from different processing of this plant. This study aimed to compare the effects between various preparations of *Momordica charantia* (i.e. fruit juice, freeze-dried fruit juice and seedless dry fruit) on postprandial glycemia and triglyceridemia in type 2 diabetics.

Materials and methods

We compared within the same dose the various methods of preparation of MC. Previous human study in Thais demonstrated that 40 ml of MC fruit juice significantly decreased plasma glucose levels of type 2 diabetes.[7] Hence, this amount was used as reference. 120 g of fresh MC fruit produced 40 ml of MC fruit juice or 2 g of freeze dried fruit juice or the yield of 8 g MC dry fruit. Six kilograms of unripe MC fruits were purchased from a local market and washed thoroughly with water for 2 minutes. After thoroughly mixed, 2/3 of MC fruits were used to prepare MC fruit juice and MC freeze-dried powder. The remaining one-third was used for preparation of dried-fruit powder.

Preparation of MC fruit juice and powder from freeze dried fruit juice

Seed and fibrous core were removed and edible portion were cut into small pieces and put into an electric juice maker. Half of the extracted juice was poured into individual plastic bottles (40 ml for 1 bottle).[7] and was kept frozen immediately at -20 °C until used. The other half of the juice was kept frozen immediately at -80 °C and was followed by continuous freeze-drying for 72 hr according to Chen Q, 2003,[8] the yield became powder. The powder was weighted and equally packed in capsules and kept in airtight containers at -20 °C until used.

Preparation of seedless dry fruit

MC fruits were cut into small pieces (120 g of MC fresh fruits per individual) and exposed to the sun until dry. The yield was ground into powder with herb grinder. The powder was weighted, equally packed in capsules and kept in room temperature until used.

Composition of the test meal

A standard meal for breakfast, containing 400 kcal and was composed of 55% carbohydrate, 15% protein, and 30% fat.

Demography of the participants

Twelve type 2 diabetics (8 women, 4 men) 30-70 years of age, with a mean HbA1C level of 6.9 ± 0.5 % and mean duration of diabetes of 7.2 ± 4.9 years. Three from 12 subjects were on metformin only, 1 was on sulfonyluria only, 1 was on α-glucosidase inhibitor only, the remaining 5 cases were on

combined drugs. They were recruited from the nutrition clinic of Ramathibodi hospital. The aim and procedure were informed and consent forms were signed. They maintained their oral hypoglycemic medicine, physical activity, dietary intake and their weight during the study.

Study design

This was a randomized control-trial study and had been approved by Ramathibodi Ethical Committee. The randomization was performed by having each participant draw one of four numbered balls from a closed box. Each number corresponded to different treatments (1 = No MC, 2 = freeze dried fruit juice, 3 = dry fruit and 4 = fruit juice). The drawn ball was removed, and the drawing process repeated until each patient had drawn 4 treatments. All subjects underwent 4 meal tests with and without consuming a MC preparation according to the drawn result 30 min before the test meal. All participants had 1 month washout period between treatments. On the test day, after being fasted for 12 hr the participants arrived at the clinical research center of Ramathibodi hospital before 8.00 am without taking any medication, and a cannula was inserted in a forearm vein and kept patent with saline. Subjects consumed one of the MC preparations (equal to 120 g of MC fresh fruit) 30 min prior to the meal. Blood samples were collected at 0, 60, 120 and 240 min to determine the plasma glucose and insulin levels, while the samples at 0 and 240 min for triglyceride level. The incremental area under the curves (AUC) of glucose and insulin over 240 min were calculated accordingly.[12] The values were expressed as mean ± SD. Statistical analyses were performed using the SPSS 16. Repeated measure ANOVA was used to test mean differences within group. ANOVA was used to test mean differences among groups. The level of significance was set at $p < 0.05$ for all statistical tests.

Results

The plasma glucose and insulin levels rose significantly from baseline at 60 and 120 min in all groups (table 1) and the postprandial glucose and insulin peaks in all groups occurred at 120 min. While postprandial plasma glucose elevation was high during the control period, after ingestion of the MC fruit juice the mean postprandial plasma glucose levels at 60 and 120 min (155 ± 9 mg/dl and 169 ± 12 mg/dl) were significantly lower than the control period (194 ± 11 and 233 ± 13 mg/dl). At 240 min, the mean postprandial plasma glucose level in all preparations tended to be higher than their baseline levels, only that of the control period was significantly higher than its baseline level while plasma glucose after the MC fruit juice almost touched the baseline. The peak of mean ± SD of plasma glucose (261 ± 33 mg/dl) in the participants who had diabetes over 5 years occurred at 120 min while this occurred at 60 min (164 ± 28 mg/dl) in the participants who suffered 1-5 years. After taking all MC products the glucose peaks also occurred at 120 min and tended to be lower than during the control period in those who had diabetes more than 5 years. Only after taking the MC fruit juice was the postprandial glucose at 240 min lower than 200 mg/dl. Postprandial insulin surges over 240 min tended to be lower after all MC preparations than during the control period, and there was no significant difference between them. The AUC of glucose and insulin during all MC preparations tended to be smaller than that of control period and AUC of glucose during the MC fruit juice was smallest and was significantly different from the control period (table 2).

Postprandial TG significantly rose during the control period and after ingestion of other MC preparations. However, there was no significant rise of postprandial triglyceridemia after MC fruit juice (107 ± 62 and 116 ± 65 mg/dl) (Table 1).

Table 1 Comparison of plasma glucose, insulin and TG (mean ฑ SD) responses to a meal after various MC preparations.

Preparation"	0 min"	60 min"	p-value [a]"	120 min"	p-value [a]"	240 min"	p-value [a] "
Plasma glucose (mg/dl)							
Control	103 ± 3.9	194 ± 10.8	0.000	233 ± 12.8	0.000	153 ± 12.2	0.008
Freeze dried	102 ± 3.6	169 ± 8.9	0.000	192 ± 16.8	0.001	122 ± 8.3	0.134
Dry fruit	101 ± 3.3	171 ± 8.9	0.000	186 ± 13.9	0.000	137 ± 11.4	0.038
Fruit juice"	101 ± 3.4"	155 ± 9.3[*]	0.000	169 ± 11.7[**]	0.000	117 ± 7.7	0.387
Plasma insulin (µU/ml)							
Control	5.43 ± 0.9	26.57 ±4.9	0.004	45.03 ± 9.2	0.005	24.93 ± 3.3	0.000
Freeze dried	6.73 ± 0.9	25.11 ±4.7	0.015	36.78 ± 5.9	0.002	27.56 ± 4.6	0.002
Dry fruit	7.25 ± 1.2	24.90 ±3.0	0.001	38.45 ± 3.1	0.000	20.63 ± 2.4	0.001
Fruit juice"	6.90 ± 1.1	27.03 ±4.9	0.005	34.23 ± 4.6	0.000	16.74 ± 3.2	0.017
Plasma TG (mg/dl)							
Control	115 ± 44.4	-	-	-	-	148 ± 54.2	0.000
Freeze dried	104 ± 57.2	-	-	-	-	120 ± 58.3	0.023
Dry fruit	107 ± 49.5	-	-	-	-	131 ± 58.1	0.011
Fruit juice"	107 ± 62.3	-	-	-	-	116 ± 65.0	0.711

[a] Significantly different from baseline, [*] Significantly different from control at p = 0.037, [**] Significantly different from control at p = 0.015

Table 2 Areas (mean ± SD) under the postprandial glucose and insulin curve (AUC) responding to various MC preparation consumption.

MC preparation	AUC glucose (mg.h/dl)	p-value*	AUC insulin(μU/ml.min)	p-value*
1. Control	20172 ± 7014	-	5916 ± 1093	-
2. Freeze dried	13400 ± 7298	0.087	5058 ± 863	1.000
3. Dry fruit	14042 ± 6812	1.000	4670 ± 400	1.000
4. Fruit juice	10442 ± 4568	0.004	4068 ± 579	0.605

* Significantly different from control

Eight out of 12 subjects during taking the fruit juice preparation, 1 subject during the freeze-dried preparation and 2 subjects during the sun-dried preparation reported of having a bowel movement. Flatulence occurred only with the fruit juice preparation. There was no serious side effect during and after the study periods.

Discussion

Our result agrees with others[2,4-8] that all MC products showed hypoglycemic effect as can be seen from their ability to keep the maximum postprandial glucose levels to less than 200 mg/dl while during the control period it was over 200 mg/dl and stayed at significantly higher than baseline over 4 hours. Hypoglycemic effect of MC comes from multiple mechanisms created by various compounds as charantin, saponin and polypeptide-p.[2,13-16] Saponin, charantin, flavonoids and other charantosides in the MC fruit had been demonstrated in animal studies to contain α-glucosidase inhibitory activity[4,17,18] approaching 22 % while acarbose exhibited 50% inhibition.[18] Eight from twelve subjects reported having a bowel movement and five had flatulence during taking the MC fruit juice which was similar to the prominent side effect of patient taking α-glucosidase inhibitor[19] whereas only a few incidence of bowel movement was present with other preparations. In addition to the α-glucosidase inhibitory effect MC fruit juice has been reported to decrease intestinal glucose absorption, by reducing the Na^+ and K^+ dependent absorption of glucose by the brush border membrane vesicles of the jejunum in diabetic rat.[20] Previous animal model also demonstrated that MC supplementation promoted the activity of insulin by increasing the number of glucose transporter (GLUT4) at cell surface, thereby promoting glucose uptake into peripheral tissues,[21] subsequently plasma glucose declines. However, this process should not be responsible for the reduction of glucose in this acute study. According to Kumar R, et al. at least 24 hours was needed to increase the glucose transporters in the in vitro study.[22] Furthermore, it has been shown in vitro and animal study that MC promotes insulin release[14] but we could not demonstrate this effect. MC may have a weaker insulin stimulation than glucose since glucose is a strong stimulator of insulin secretion in postprandial state.[23] Moreover, α-Glucosidase inhibiting effect of MC slowed down glucose absorption and, therefore, lowered the insulin release.[24] In the present study only MC fruit juice showed significant decrement of postprandial plasma glucose than the control period. This agrees with the animal study showing that MC fruit juice was more potent in

glucose reduction than the powder form.[25] A few reasons may be responsible for the weaker potency and lesser side effects of other MC preparations. It is thought that part of the hypoglycemic chemicals may be lost through the freeze-drying process during sublimation of ice from the frozen MC fruit juice.[26] The process causes sugar hydrolysis and leads to structural change.[27] Sun drying process of the MC fruit, causes browning reactions and discoloration of the fruit, can deteriorate the carbohydrate[28] present in the MC fruit, and leads to loss of α-glucosidase inhibitory activity.[29] Heating temperature from sun drying process was not responsible for loss of hypoglycemic activity because the temperature used in the sun-dry process ranged between 38 °C - 42 °C while most hypoglycemic chemicals of MC fruit (saponin, charantin and polypeptide-p) decomposed at over 100 °C.[30-32] Moreover, ultraviolet (UV) exposure during the sun drying process generates free radicals which causes peroxidation of membrane lipid and leads to breakdown of their structure and function,[33] could inactivate the insulin-like peptide-p (p-insulin),[34] steroidal structure of MC, charantin as well as saponin.[35]

After taking MC, the participants suffering from shorter duration of diabetes (1-5 years) had lower postprandial plasma glucose than the participants with longer diabetic duration. This is in accord with the animal study demonstrating that antihyperglycemic activity of MC was more effective in the milder degree of hyperglycemia.[16] In addition, our findings also demonstrated that only the MC fruit juice helped to keep postprandial glycemia under 200 mg/dl over 4 hours even in more serious patients suffering from a longer period of diabetes. Our findings may provide a new hope for those diabetics who had very weak pancreatic endocrine function.

Our finding revealed that while postprandial triglyceridemia elevated in other MC preparations, postprandial triglyceridemia after the MC fruit juice did not rise which is in accord with previous animal study.[36] The mechanism is unclear. However, this is an important finding since postprandial hypertriglyceridemia has been shown to be a prominent cardiovascular risk.[37] The prevention of postprandial hypertriglyceridemia by the MC fruit juice can be explained partly by the α-glucosidase inhibitory action which retarded the glucose availability for hepatic very-low-density lipoprotein production[38] and by increased insulin[14, 21] and lipoprotein lipase activity, therefore, promoted very-low-density lipoprotein catabolism.[39] However, further studies with more subjects on longer duration of the MC fruit juice consumption are needed.

The results confirmed the hypoglycemic effect of MC products and demonstrated that the most efficient preparation for postprandial glycemic and triglyceridemic control was seen in the MC fruit juice. No serious adverse events were noted throughout the study. However, long-term studies are needed to strengthen these findings.

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Original Articles/นิพนธ์ต้นฉบับ

ผลของการบริโภคมะระขี้นกในรูปแบบต่างๆ (น้ำมะระขี้นก ผงมะระขี้นกทำแห้งแบบเยือกแข็งจากน้ำและจากผลมะระขี้นกตากแห้ง) ที่มีต่อการเปลี่ยนแปลงแบบเฉียบพลันของระดับน้ำตาล อินสุลิน และไขมันในกระแสเลือดหลังอาหาร ของผู้ป่วยเบาหวานชนิดที่สอง

รุ่งรัตน์ ไชยวัฒนาสราญสุข, วท.ม (โภชนศาสตร์).[1], ปริย พรรณเชษฐ์, พบ.[2], สุรัตน์ โคมินทร์, พบ.[2]

[1] โครงการร่วมคณะแพทยศาสตร์โรงพยาบาลรามาธิบดีและสถาบันโภชนาการมหิดล, [2] หน่วยโภชนวิทยาและชีวเคมีทางการแพทย์ ภาควิชาอายุรศาสตร์ คณะแพทยศาสตร์โรงพยาบาลรามาธิบดี มหาวิทยาลัยมหิดล กรุงเทพฯ 10400

บทคัดย่อ

บทนำ: มะระขี้นกได้ถูกนำมาใช้ในการรักษาโรคเบาหวานมาเป็นเวลานานแต่งานวิจัยต่างๆยังหาข้อสรุปไม่ได้

วัตถุประสงค์: เพื่อเปรียบเทียบผลของการกินมะระขี้นกรูปแบบต่างๆ (น้ำมะระขี้นก ผงมะระขี้นกทำแห้งแบบเยือกแข็งจากน้ำ และจากผลมะระขี้นกตากแห้ง) ที่มีต่อการเปลี่ยนแปลงแบบเฉียบพลันของระดับน้ำตาล อินสุลิน และไขมันไตรกลีเซอไรด์ในกระแสเลือดหลังอาหารของผู้ป่วยเบาหวานชนิดที่สอง

วิธีการวิจัย: การศึกษาครั้งนี้เป็นการศึกษาแบบไขว้ โดยการสุ่มผู้ป่วยเบาหวานชนิดที่ 2 เข้าร่วมโครงการ 12 คนซึ่งเป็นผู้ป่วยที่มีการควบคุมอาหารทั้งที่ได้รับและไม่ได้รับยาลดระดับน้ำตาลในกระแสเลือดเพื่อเปรียบเทียบผลของการกินมะระขี้นกรูปแบบต่างๆ (น้ำมะระขี้นก ผงมะระขี้นกทำแห้งแบบเยือกแข็งจากน้ำ และจากผลมะระขี้นกตากแห้ง) ที่มีต่อการเปลี่ยนแปลงแบบเฉียบพลันของระดับน้ำตาล อินซุลิน และไขมันไตรกลีเซอไรด์ในกระแสเลือดหลังอาหาร ของผู้ป่วยเบาหวานชนิดที่สอง ได้ทำการทดสอบดูผลระยะสั้น 4 การทดสอบคือได้รับน้ำมะระขี้นกคั้นสด, ได้รับผงมะระขี้นกทำแห้งแบบเยือกแข็งจากน้ำมะระ และได้รับมะระขี้นกจากผลตากแห้ง ก่อนได้รับอาหารมาตรฐานที่มีพลังงาน 400 kcal และการทดสอบที่ไม่ได้รับมะระขี้นก โดยมีระยะพักระหว่างแต่ละชนิดการทดสอบ 1 เดือน มีการเจาะเลือดก่อนได้รับอาหารมาตรฐาน (0 นาที) และ 60, 120 และ 240 นาทีหลังอาหาร

ผลการศึกษา: หลังจากได้รับน้ำมะระคั้นสด ระดับน้ำตาลในกระแสเลือดที่เวลา 60 และ 120 นาที (155 $\pm$ 9 และ 169 $\pm$ 12 mg/dl) และพื้นที่ใต้กราฟของระดับน้ำตาลในเลือดหลังรับประทานอาหารลดลงอย่างมีนัยสำคัญทางสถิติ (ค่า $p < 0.037$) เมื่อเปรียบเทียบกับน้ำตาลระยะควบคุม (194 $\pm$ 11 และ 233 $\pm$ 13 mg/dl) ในขณะที่ไม่ได้รับน้ำมะระที่ช่วงเวลาเดียวกัน มะระขี้นกทุกรูปแบบมีแนวโน้มลดการเพิ่มขึ้นของระดับอินซุลินหลังอาหารเมื่อเปรียบเทียบกับระยะควบคุมอย่างไม่มีนัยสำคัญทางสถิติ ในขณะที่ระดับไตรกลีเซอไรด์หลังอาหารเพิ่มขึ้นในระยะควบคุมและหลังบริโภคมะระขี้นกผลิตภัณฑ์อื่น การบริโภคน้ำมะระขี้นกสามารถทำให้ระดับไตรกลีเซอไรด์หลังอาหารไม่เพิ่มขึ้น (107 $\pm$ 62 และ 116 $\pm$ 65 mg/dl) ในระยะที่ได้รับน้ำมะระขี้นกมีการถ่ายอุจาระประมาณ 1 ครั้ง และมีลมในช่องท้องเกิดขึ้นโดยไม่มีผลข้างเคียงอื่น

สรุปผลการศึกษา: ในระหว่างผลิตภัณฑ์จากมะระขี้นก น้ำมะระขี้นกคั้นสดมีประสิทธิภาพในการควบคุมระดับน้ำตาลและไตรกลีเซอไรด์หลังอาหารดีที่สุด ไม่มีผลข้างเคียงที่ร้ายแรงตลอดทั้งการศึกษาครั้งนี้

คำสำคัญ: มะระขี้นก, เบาหวาน, น้ำตาลหลังอาหาร, ไตรกลีเซอไรด์หลังอาหาร

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