EFFECTS OF RED PITAYA FRUIT (*HYLOCEREUS POLYRHIZUS*) CONSUMPTION ON BLOOD GLUCOSE LEVEL AND LIPID PROFILE IN TYPE 2 DIABETIC SUBJECTS

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ABSTRACT. *This study was conducted to determine the effects of red pitaya fruit consumption on blood glucose level, lipid profile, body weight and total body fat in type 2 diabetic subjects. A total of 28 subjects were randomly divided into four groups; Group 1 were given 400g of red pitaya per day, Group 2 were given 600 g of red pitaya per day, Group 3 negative control; were diabetic patients and given a normal diet and Group 4 positive control; were healthy subjects and given a normal diet. Subjects were assigned to a seven week study which consisted of three phases: phase 1: one week, phase 2: 4 weeks of treatment and phase 3: 2 weeks of wash-out. After four weeks of treatment, Group 1 showed a significant increase in HDL-cholesterol level and a significant decrease in blood glucose, LDL-cholesterol and triglyceride level. There was a significant increase in total cholesterol level on the seventh week of the study. Even though there was no significant difference in Group 2, there was still an increasing trend in HDL-cholesterol level and decreasing trend in blood glucose, total cholesterol, triglycerideand LDL-cholesterol levels, with a higher percent of changes than Group 1. No significant differences were seen in body weight and total body fat in any groups.*

KEYWORDS. Blood glucose, red pitaya fruit, type 2 diabetes mellitus, lipid profiles.

INTRODUCTION

Diabetes mellitus is the most common endocrine disorder which is characterized by disruption of carbohydrate, fat and protein metabolism, and electrolyte imbalance (Solomon *et al*., 2002). Diabetes mellitus is one of the chronic diseases threatening 6.4 billion people worldwide. (International Diabetes Federation, 2003).

Today, insulin and oral hypoglycemic agents are the main ways to treat diabetes mellitus and are effective in controlling hyperglycemia, but these kinds of chemically based drugs also have prominent side effects. For instance, tolbutamide which it is believed to have a toxic effect, which cannot be excreted by liver (Berger & Mühlauser, 2001).

The fruits of *Hylocereus* species, which is often called 'the scaly fruit' in Latin America or 'dragon fruit' in Asia, are medium-large berries bearing large green or red scales (Nerd *et al.*, 1999). There are several varieties of pitaya fruit; red pitaya with white flesh (*Hylocereusundatus*), red pitaya with red flesh (*Hylocereuspolyrhizus*) which has been used in this study and another type is yellow pitaya with white flesh (*Hylocereusmegalanthus*).

Red pitaya has high moisture content and is rich in fiber, phophorus, vitamin C and calcium. According to Norhayati (2005), the crude dietary fiber in red pitaya is 10.1g per 100g of edible portion, in addition to the high content of antioxidant vitamins such as vitamin

A, C and E which are 102.13 µg, 540.27 mg and 105.67 µg per 100 g dry weight, respectively.

The aim of this study was to determine the effects of red pitaya fruit consumption on blood glucose level, lipid profile, body weight and total body fat in subjects with type 2 diabetes mellitus.

MATERIALS AND METHODS

Study Subjects

A total of 28 staff of Universiti Putra Malaysia, Serdang (14 males and 14 females), 21 of whom have type 2 diabetes mellitus, aged between 20 and 55 years old, taking oral antidiabetic medication instead of insulin injection, nonpregnant and non-drinkers, were included in the study. The diabetic subjects were recruited based on fasting blood glucose level ≥6.1 mmol/L. The study was supported by the local ethical board and all subjects gave their written consent after being fully informed about the nature of the study.

Study Design

Subjects were randomly divided into four groups; Group 1 received 400g of red pitaya fruit per day, Group 2 received 600g of red pitaya fruit per day, Group 3 was a negative control group (diabetic patients received normal diet) and Group 4 was a positive control group (healthy subjects received normal diet), with seven subjects in each group.

Subjects were assigned to a seven week period of study which consisted of three phases: Phase 1 (one week), Phase 2 (four weeks) and Phase 3 (two weeks). Phase 1 involved the screening session and the collection of basic study data. The treatment was carried out in Phase 2 which lasted four weeks. Phase 3 was a wash-out period when the treatment was completely stopped.

Fasting blood samples and anthropometric measurements were taken four times throughout the study once during Phase 1 in the first week of the study period, twice during Phase 2 (in the third and fifth weeks of the study period) and once during Phase 3 (in the seventh week of the study period).

All diabetic subjects were still taking their oral medication. Since dietary intake and physical activity were not controlled in this study, all the subjects were requested to practice their normal daily lifestyle.

Anthropometric Measurements

Height and body weight of the subjects were measured and Body Mass Index (BMI) computed as body weight/(height^2). Waist-hipratiowas calculated by appropriate formula and total body fat for each subject was measured using OMRON body fat analyzer.

Nutritional Assessment

All enrolled subjects were asked to record their 24-hour dietary intake for 3 days including 2 weekdays and 1 weekend day. Records were then reviewed and analyzed with an appropriate software program, NutritionistPro. National composition food tables were used as reference.

A Food Frequency Questionnaire (FFQ) was completed by each of the subjects on the same day when the first blood samplewas taken. The questionnaires were completed only once throughout the study.

The Food Frequency Questionnaire (FFQ) was then analyzed using a 5-mark scale as follows:

5 = everyday; 4 = 2-3 times per week; 3 = onceper week; 2 = seldom; 1 = never.

The score was calculated using an appropriate score formula (Chee *et al.*,1996) adapted from Reaburn *et al*. (1979) and Zaitun & Terry (1990).

Biochemical Parameters

10 mL of blood were intravenously collected from each subject by qualified medical officers after an overnight fast (10 hr). During the study period, four blood samples were collected in the 1st, 3rd, 5th and 7th week of the study period. The blood samples were analyzed for blood glucose level and lipid profile using *chemical autoanalyzer* (Roche/Hitachi, Germany).

Statistical Analysis

Experimental values were expressed as mean ± standard deviation (SD) using the Microsoft Office Excel 2003. Demographic data, body weight, total body fat and all biochemical parameters were analyzed using the Statistical Package for Social Science for Windows (SPSS for Windows) version 12.0. One-way ANOVA test was performed to compare the means of each group during the different weeks of study and a *P*-value 0.05 was considered statistically significant.

RESULTS AND DISCUSSION

Anthropometric Measurements

Results of the study showed mean body mass index (27.30±5.27 kg/m^2), waist-hip ratio (0.89±0.07) and total body fat (30.61±5.71 %) (See Table 1).

Table 1. Anthropometric measurements of respondents (n=28).

	Mean ± SD
Body Mass Index (kg/m^2)	27.30±5.27
Total body fat (%)	30.61±5.71
Waist-hip ratio	0.89±0.07

Nutritional Assessment

Table 2 shows the mean nutrient intake during the period of treatment collected from the 24-hour dietary records. Since the dietary intake was not controlled in this study, all respondents consumed their normal food. For caloric intake, respondents consumed an average of 2,072.30±638.79 kcal per day.

The mean intake of the major nutrients such as carbohydrate, protein and fat, was 280.12±91.79 g, 88.08±27.91 g and 66.48±24.18 g respectively. Average cholesterol intake per day was estimated to be around 206.78±142.78 mg. For the minor nutrients intake, the mean of vitamin A intake was 7838.72±3208.15IU, vitamin C was 124.25±71.80 mg, calcium was 595.61±164.95 mg and iron was 23.69± 11.22 mg. While for the average dietary fiber intake, respondents consumed 29.89±8.62 g per day.

Caloric intake and distribution of macro and micronutrients were similar for both genders. When compared to the RNI (Recommended Nutrient Intake) value (NCCFN, 2005), respondents' intake of protein and vitamin C were exceeded the recommended, whereas the caloric and calcium intake was lower than recommended.

However, respondents' intake of fat and dietary fiber reached the recommendation of RNI and 'Malaysian Dietary Guidelines' (NCCFN, 1999), respectively. On the other hand, daily iron intake was higher than recommended in males and did not reach the recommended level in females.

Table 2. Average nutrient intake during treatment period determined from 3-day dietary records compared to recommended values (n=28).

	Mean ± SD	Recommended value
Energy (kcal)*	2,072.30±638.79	M (2460) F (2180)
Carbohydrate (g)	280.12±91.79	-
Protein (g)*	88.08±27.91	M (62) F (55)
Fat (g)º	66.48±24.18	M (54-82) F (46-70)
Cholesterol (mg)	206.78±142.78	-
Vitamin A (IU)	7,838.72±3208.15	-
Vitamin C (mg)*	124.25±71.80	M (70) F (70)
Calcium (mg)*	595.61±164.95	M (800) F (800)
Iron (mg)*	23.69±11.22	M (14) F (29)
Dietary fiber (g)⁎	29.89±8.62	M & F (20-30)

*RNI value for age 30-50
º RNI value for age 19-59
⁎ Value from 'Malaysian Dietary Guidelines'
M = male; F= female

Scores determined from Food Frequency Questionnaire are presented in Table 3. The most food consumed was rice, moderately consumed foods (were cabbage, string beans, sweetened condensed milk, anchovy, skinless chicken, white bread, table sugar, hen eggs and 'nasi lemak') and the less consumed foods (were halwa, mutton, cheese, pickled fruits, Chinese cabbage and UHT milk).

Table 3. Food Frequency Questionnaire score (n=28).

	Score
A. Highly consumed food (80-100)	
Rice	98.33
B. Moderately consumed foods (60-79.9)	
Table sugar	73.34
Anchovy	73.33
Cabbage	69.99
Sweetened condensed milk	68.33
Skinless chicken	66.67
String bean	65.01
Hen egg	65.01
White bread	65.00
'Nasilemak'	65.00
C. Less consumed foods (20-59.9)	
Chinese cabbage	31.66
UHT milk	31.66
Mutton	30.00
Cheese	30.00
Pickled fruits	30.00
Halwa	26.67

Effects of Red Pitaya Fruit Consumption on Blood Glucose Level

Figure 1 shows the changes of blood glucose level in each group throughout the study period, while percent of changes of blood glucose level in every group is shown in Figure 2. There was a decreasing trend in blood glucose level in each treatment group (400 g and 600 g).

Mean of blood glucose level for Group 1 differed significantly with percent of changes, 24.02%. Whereas Group 2 still showed a decreasing trend in blood glucose level even though the mean was not statistically significant (34.87%).

In contrast, there was an increase in blood glucose level for Group 1 and Group 2 in the seventh week of study two weeks after the red pitaya treatment was completely stopped, with percentage changes 5.34% and 10.15% respectively. On the other hand, Group 3 showed an insignificant increase of blood glucose level while there was a fluctuation in Group 4.

The positive effect of red pitaya on blood glucose level might be due to the high content of dietary fiber in the fruit, which grosses 10.1 g per 100 g edible portion (Norhayati, 2005). However, the effect of increasing the intake of dietary fiber on glycemic control in patients with type 2 diabetes mellitus remains controversial.

Diverse reports regarding the issue have contributed to the inconsistent results of the role of dietary fiber in controlling glycemic response in diabetic patients. For example, diets that included 15 to 21 g of guar-gum fiber or oat-branconcentrate per day had no effect on glycemic control (Holman *et al.*, 1987) and a previous study by Hollenbeck *et al*. (1986), increasing the fiber content of the diet from 11 to 27 g/1,000 kcal did not lead to improvement in blood glucose level in type 2 diabetes.

In contrast, when increasing the fiber content from 24 to 50 g/day, plasma glucose was seen to improve (Chandalia *et al.*, 2000). Giacco *et al*. (2000) reported the same result where 50 g consumption of dietary fiber per day was effective on blood glucose control in the long term. A study by Jue *et al.* (2003) demonstrated that long-term intake of barley high dietary fiber has beneficial effects for blood glucose control and glucose tolerance in Goto-Kakizaki (GK) rats.

The contradictory reports may result from insufficient amounts of fiber given, in-appropriate treatment periods and low content of soluble fiber. According to Chandalia *et al.* (2000), dietary fiber, predominantly of the soluble type, has been shown to reduce glycemic response and hyperinsulinemia in diabetic patients.

The mechanism of dietary fiber in red pitaya fruit that plays an important role in lowering blood glucose level could be seen when the soluble fibers absorb water, then forming viscous solutions in the digestive tract that slow the rate at which nutrients are absorbed.

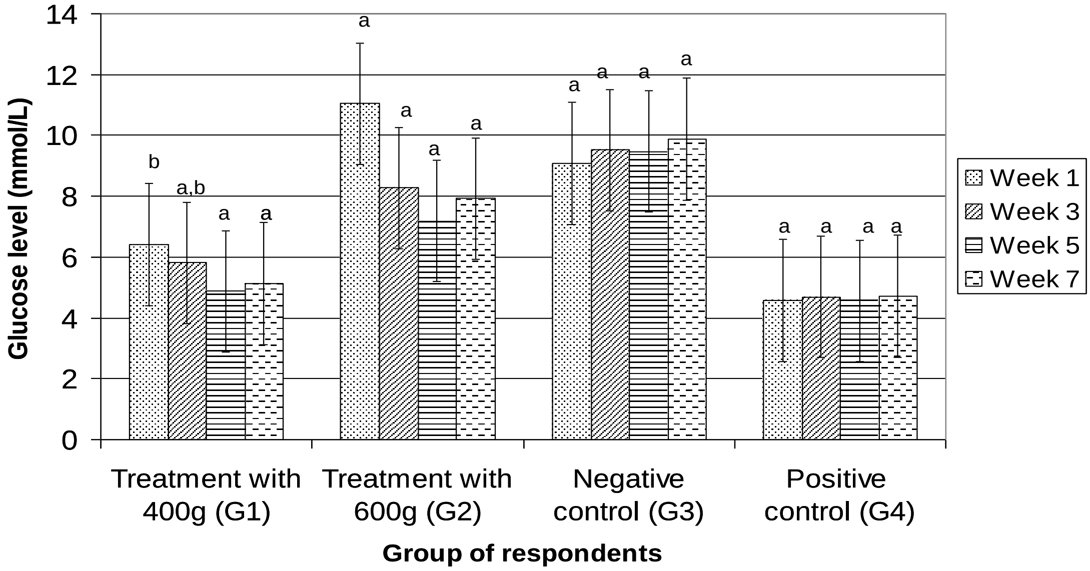
The slowing digestion and partially restricted absorption of the glycemic carbohydrate will thus improve and control the blood glucose by decreasing peak blood glucose levels after eating (Gallaher *et al*, 1999; Venn & Mann, 2004).

Apart from that, high fiber foods such as fruits and some vegetables also play a role in producing a feeling of fullness, promoting satiety and prolonging eating time, and thereby help to control and reduce blood glucose level (Duncan *et al*., 1983).

High antioxidant capacity in red pitaya from Vitamin A, C and E was also associated with the stable blood glucose levels in type 2 diabetic subjects. In a study by Yu *et al.* (2000), GK rats fed with a diet containing α-tocopherol (Vitamin E) showed a significant increment of insulin secretion and a significant decrement of blood glucose levels at 30 and 120 min after glucose loading.

It has been said that nitric oxide inhibits insulin secretion and causes pancreatic beta cell death. Nitric oxide causes beta cell dysfunction in diabetes by influencing the activity of ionic channels (Adeghate & Parvez, 2000). Nitric oxide opens K^+ channels through suppression of phospho-fructo-kinase activity which in turn inhibits glucose-induced insulin release in pancreatic beta cells (Tsumura *et al*., 1994).

Alpha-tocopherol as an antioxidant was able to control blood glucose levels by inhibiting the activity of reactive oxygen species (nitric oxide) in pancreatic beta cells. Burkart *et al.* (1995) showed that preincubation of pancreatic islet cells with α-tocopherol significantly improved their resistance to toxic doses of nitric oxide. In the same time, α-tocopherol works along with other antioxidant agents like Vitamin C, which is also high in red pitaya, to help controlling and improving blood glucose levels in type 2 diabetic patients (Yu *et al.*, 2000).



[a,b]Different letters indicate significant difference ($p<0.05$) between weeks of study for each group

Figure1. Comparison of blood glucose level between treatment and control groups according to weeks of study.

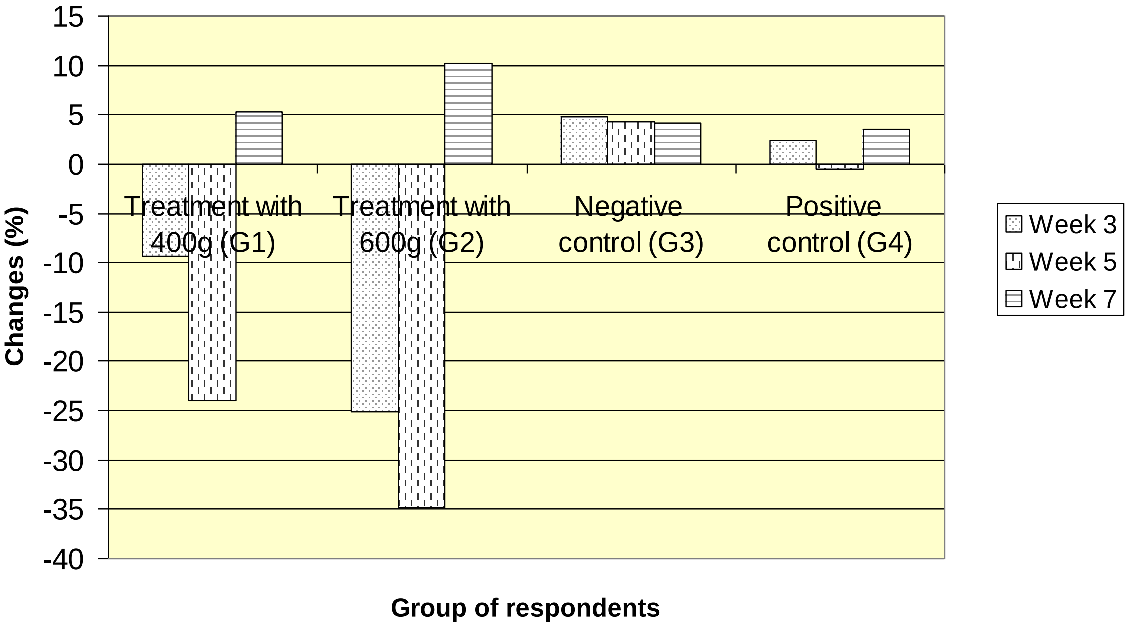


Figure 2. Percent changes in blood glucose level for each group according to weeks of study.

Effects of Red Pitaya Fruit Consumption on Total Cholesterol Level

The difference of total cholesterol level between groups is presented in Figure 3, while Figure 4 shows percent changes of total cholesterol level throughout the study period. Both groups 1 and 2 show the decreasing trend in total cholesterol level after four weeks of treatment. The 600 g treatment group showed the highest percent of decrease in total cholesterol level (31.64%) compared to 400 g treatment group (3.41%).

Although ANOVA test showed the significant different only in total cholesterol level means for Group 1, but high percent of decrease in total cholesterol level in Group 2 indicates that red pitaya fruit has a great potential in decreasing the total cholesterol level among type 2 diabetic subjects.There was an insignificant difference in Group 3 and Group 4, where there was no apparent change in total cholesterol level throughout the study period.

Diabetic patients often present with disruption in lipid metabolism which eventually results in abnormal lipid profiles (Rivellese *et al.*, 2004). This trend can be seen among the respondents particularly in Group 2 who experienced high total cholesterol levels at the beginning of the study.

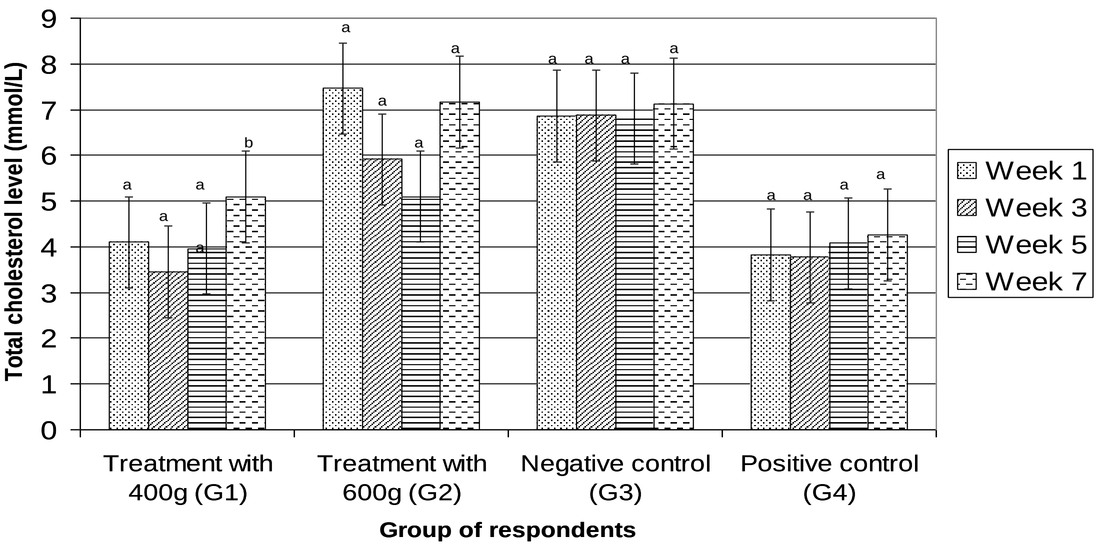
However after an intensive four week treatment with red pitaya, total cholesterol level of treatment groups decreased, which might result from an increasing intake of dietary fiber as well as the high concentration of antioxidant vitamins in red pitaya fruit.

Dietary fibre, particularly soluble type, is capable of trapping cholesterol and bile acids in the small intestine (Smolin & Grosvenor, 2003). The gel matrix formed by soluble fibres that are eventually excreted in the feces may entrap some of the bile acids released from the gallbladder.

This physical entrapment appears to be more pronounced in the terminal ileum where bile acids are usually reabsorbed. Thus, the liver then has to use cholesterol from the blood to synthesize new bile acids which may result in reducing blood cholesterol levels (Watts *et al.*, 1996).

This was shown by a study conducted by Hannan *et al.* (2003), where the hypolipidemic action of soluble dietary fiber fraction in *Trigonella foenum graecum* demonstrated positive effects on lipid profiles in type 2 diabetic rats.

Apart from dietary fiber, high tocotrienol (vitamin E) content in red pitaya attributed to the decrement of blood cholesterol levels. Tocotrienol regulates cholesterol production in mammalian cells by inhibiting 3-hydroxy-3-methylglutaryl-coenzyme A (HMG-CoA) reductase activity, thus decreasing liver cholesterol levelsand plasma total cholesterol and LDL cholesterolconcentrations (Parker *et al.*, 1993).



[a,b]Different lettersindicate significant difference ($p<0.05$) between weeks of study for each group

Figure 3. Comparison of total cholesterol level between treatment and control groups according to weeks of study.

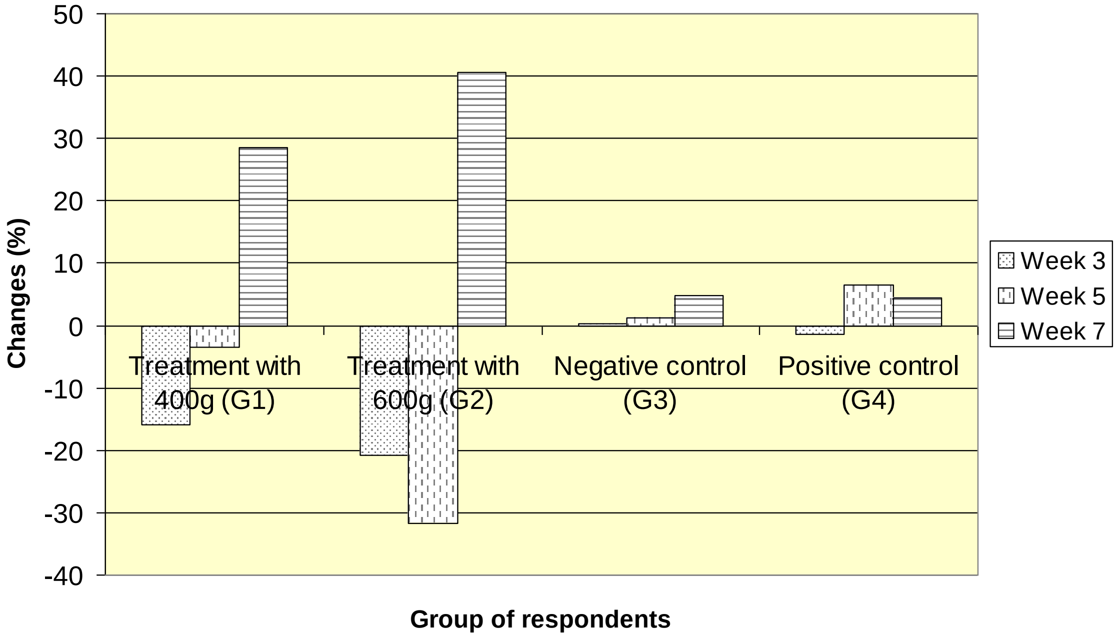


Figure 4. Percent of changes in total cholesterol level for each group according to weeks of study as compared tothe baseline data (Week 1).

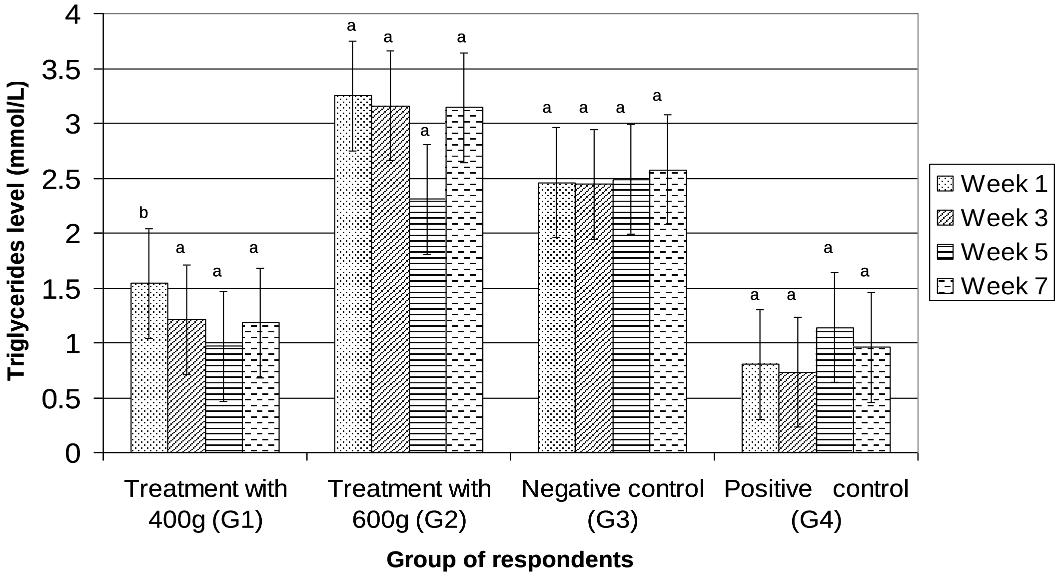
Effects of Red Pitaya Fruit Consumption on Triglycerides Level

ANOVA test presented in Figure 5 indicates that there was a significant decrease in triglyceride level of Group 1. The 400 g treatment group showed a higher percent of changes in triglyceride level (37.14%) than the 600 g treatment group (28.89%) (Figure 6).

Although there was no significant difference in Group 2, there was still a decreasing trend in triglycerides level with high percent of changes. This means that red pitaya has the potential to reduce and control triglyceride levels in type 2 diabetic patients. In contrast, after the two week treatment was discontinued, triglyceride levels were seen to increase in both treatment groups with percent of changes 21.65% and 36%, respectively.

For Group 3 and Group 4 there showed no evident changes in triglycerides level throughout the period of study. There was a gradual increase in Group 3 from the third week of study onwards, while Group 4 showed more fluctuating trend.

Glycemic control can lead to marked reductions in triglyceride levels (John *et al.*, 2001). Excessive glucose promotes hepatic lipogenesis, and thus can increase lipid content and promote dyslipidemia. Therefore, a decrease in triglyceride levels among type 2 diabetic patients after the treatment of red pitaya can be correlated with good glycemic control and decreasing trend in blood glucose level.



[a,b]Different lettersindicate significant difference ($p<0.05$) between weeks of study for each group.

Figure 5. Comparison of triglycerides level between treatment and control groups according to weeks of study.

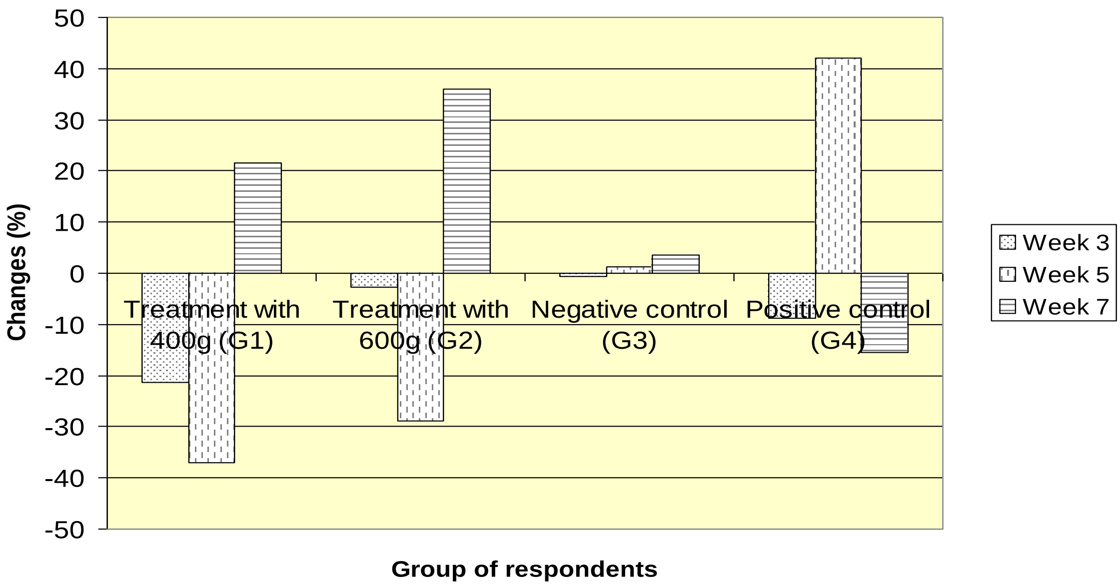


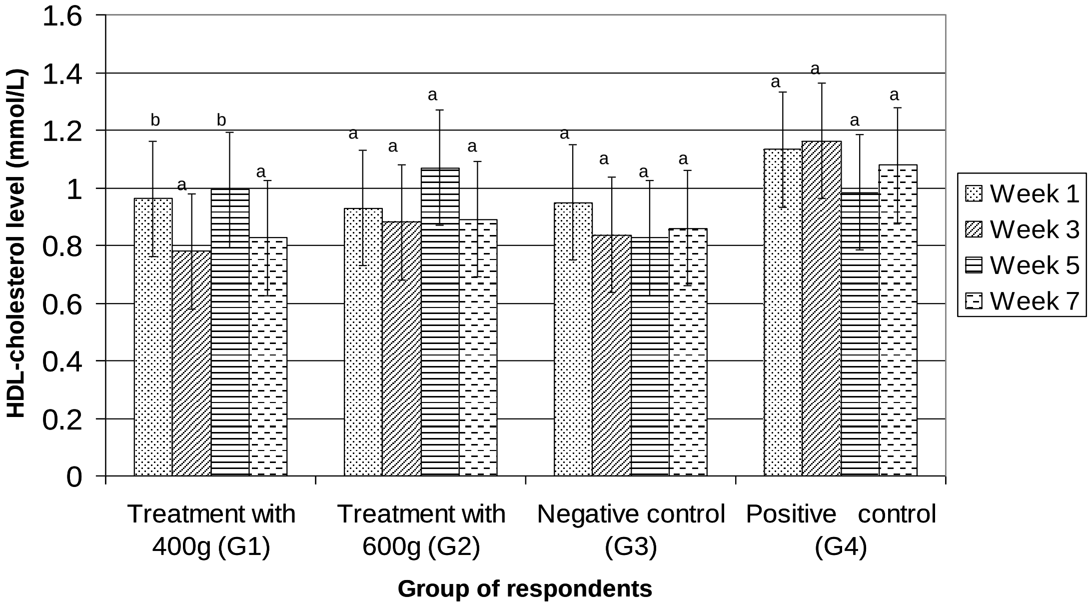
Figure 6. Percent of changes in triglyceride levels for each group according to weeks of study as compared to the baseline data (Week 1).

Effects of Red Pitaya Fruit Consumption on HDL-Cholesterol Level

Both treatment groups showed an increase in HDL-cholesterol level. ANOVA test for HDL-cholesterol presented in Figure 7 shows that only means for Group 1 differed significantly. Even though there was no significant difference in Group 2, but there was still an increasing trend in HDL-cholesterol level with higher percent of changes than in Group 1.

The 600 g treatment group showed the highest percent of changes in HDL-cholesterol level (14.95%), while the percent of changes in HDL-cholesterol level for Group 1 was 3.22% (Figure 8). On the other hand, this trend was reversed on the seventh week of study for both treatment groups where HDL-cholesterol levels were seen to decrease by 16.8% (Group 1) and 16.74% (Group 2). Conversely, different trends were seen in both control groups where there was a drop in HDL- cholesterol level till the fifth week in Group 3 and a fluctuating trend in Group 4.

According to Wilson (1990) most of the drugs that decrease total cholesterol level also decrease HDL-cholesterol level. However a contrasting outcome has resulted from this study where red pitaya treatment not only caused a decreasing trend in total cholesterol and triglyceride levels, but at the same time increased HDL-cholesterol level among type 2 diabetic subjects. This could give another extra credit to red pitaya fruit as a healthier and safer way of controlling glycemic level and lipid profiles in type 2 diabetic patients.



[a,b]Different lettersindicate significant difference (p<0.05) between weeks of study for each group.

Figure 7. Comparison of HDL-cholesterol level between treatment and control groups according to weeks of study.

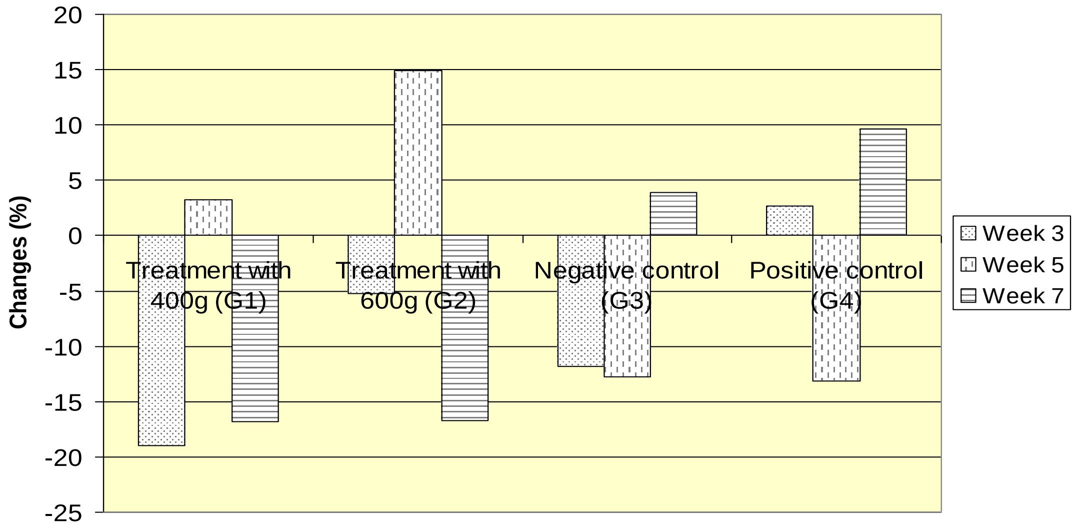


Figure 8. Percent of changes in HDL-cholesterol level for each group according to weeks of study as compared to the baseline data (Week 1).

Effects of Red Pitaya Fruit Consumption on LDL-Cholesterol Level

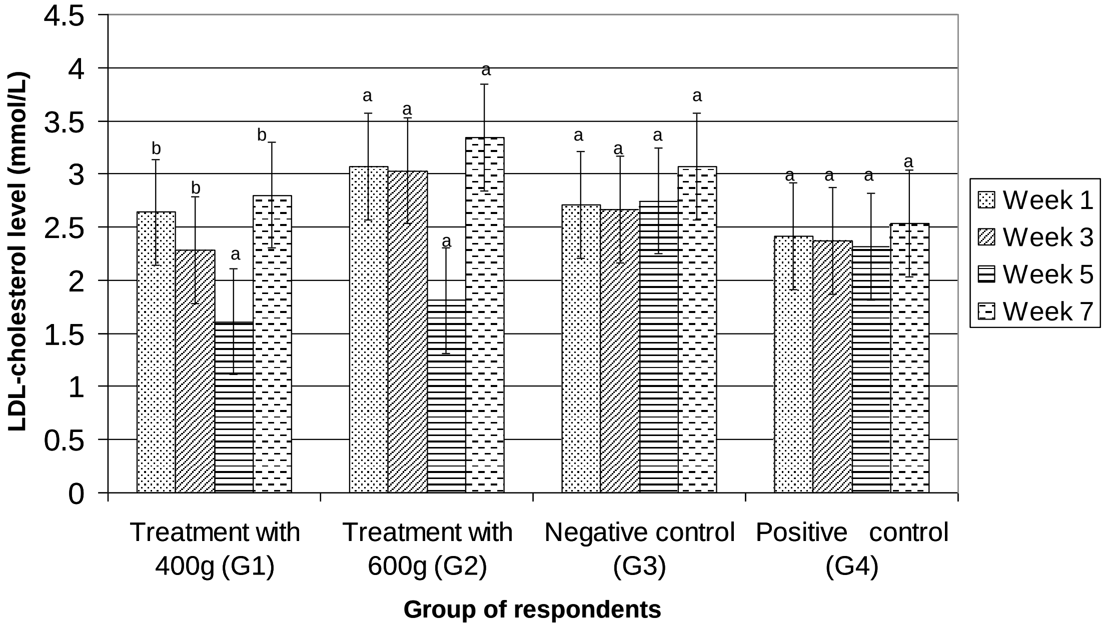
As presented in Figure 9, ANOVA test for LDL-cholesterol level showed that only means for Group 1 differed significantly. Although there was insignificant difference in Group 2, there was still a decreasing trend in LDL-cholesterol level with slightly higher percent of changes than Group 1.

The 600 g treatment group showed the highest percent of changes in LDL-cholesterol level with 41.04%, while the percent of changes for Group 1 was 39.02% (see Figure 10). By the end of wash-out week, the decreasing trend was reversed for both treatment groups with percent of increase 73.91% in Group 1 and 84.53% in Group 2.

In spite of this, both positive and negative control groups showed no apparent changes during the study period. There were ups and downs in LDL-cholesterol level with insignificant differences in Group 3 and Group 4.

It has been suggested that higher soluble fiber intakes of 10-25 g/day are recommended for a more effective lowering of LDL-cholesterol and a consequent reduction in the risk of heart disease (NCEP, 2002). According to Jenkins *et al* (2000), consumption of 5 to 10 g of viscous fiber daily can reduce LDL-cholesterol by approximately 5%.

In this study, treatment with 400 g and 600 g red pitaya is almost equal to the consumption of 40.4 g and 60.6 g fiber/day, respectively (10.1g fiber per 100g edible portion), and the reduction in LDL-cholesterol level for Group 1 was nearly double the approximate reduction. Thus, it was clearly proven that the effect of fiber in red pitaya was effective in controlling and reducing LDL-cholesterol among type 2 diabetic patients.



[a,b]Different lettersindicate significant difference ($p<0.05$) between weeks of study for each group.

Figure 9. Comparison of LDL-cholesterol level between treatment and control groups according to weeks of study.

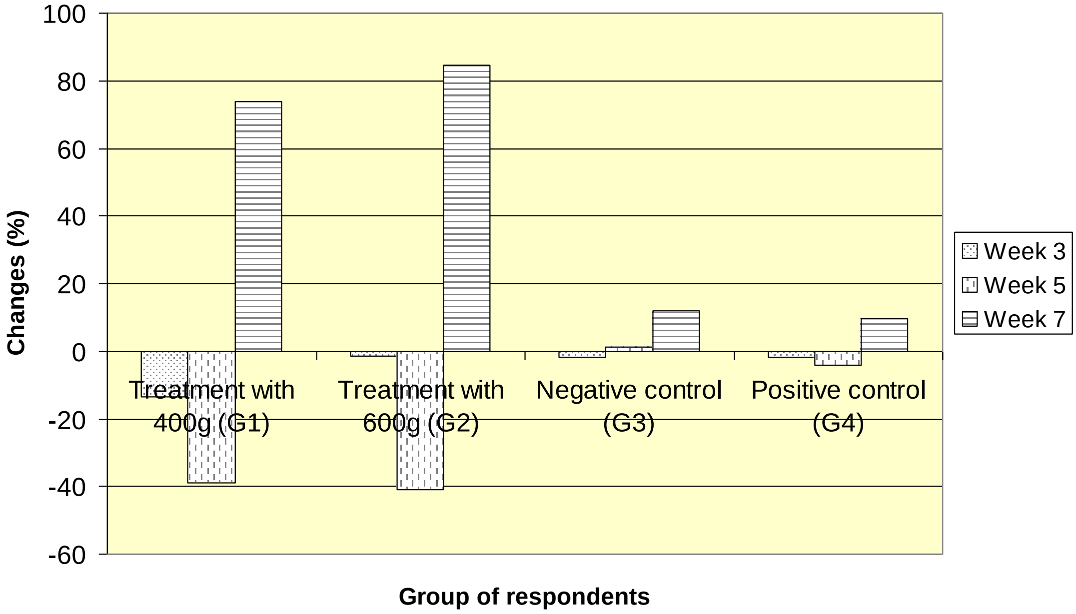
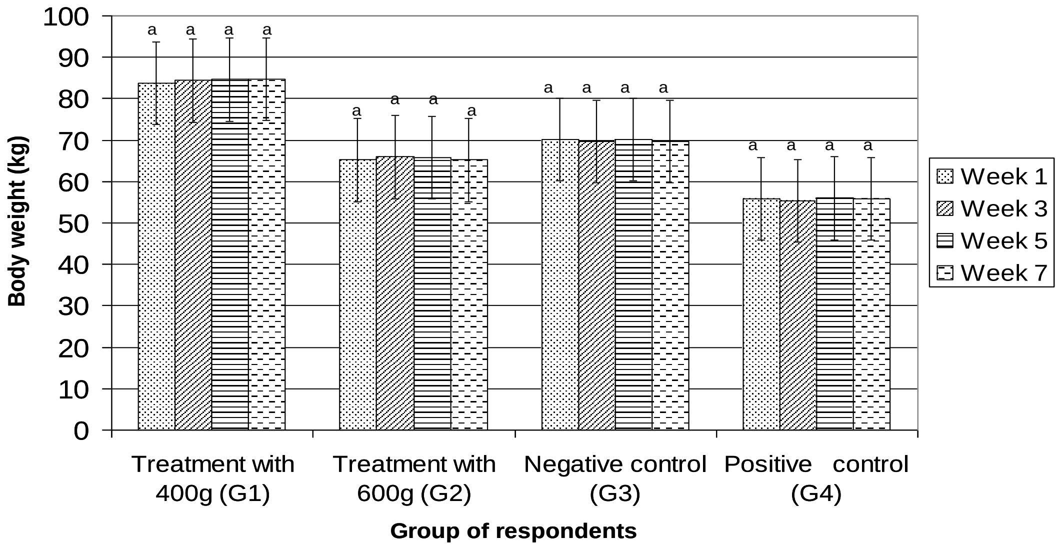


Figure 10. Percent of changes in LDL-cholesterol level for each group according to weeks of study.

Effects of Red Pitaya Fruit Consumption on Body Weight

As shown in Figure 11, ANOVA test indicated that mean body weight for each group did not differ significantly during the study. Percent change in body weight for Group 1 was only 1.1%, while for Group 2 was 0.92% (see Figure 12). There were no evident changes in body weight, which indicated that there was no significant relationship between the consumption of red pitaya fruit with body weight in type 2 diabetic patients.



[a,b]Different lettersindicate significant difference ($p<0.05$) between weeks of study for each group.

Figure 11. Comparison of body weight between treatment and control groups according to weeks of study.

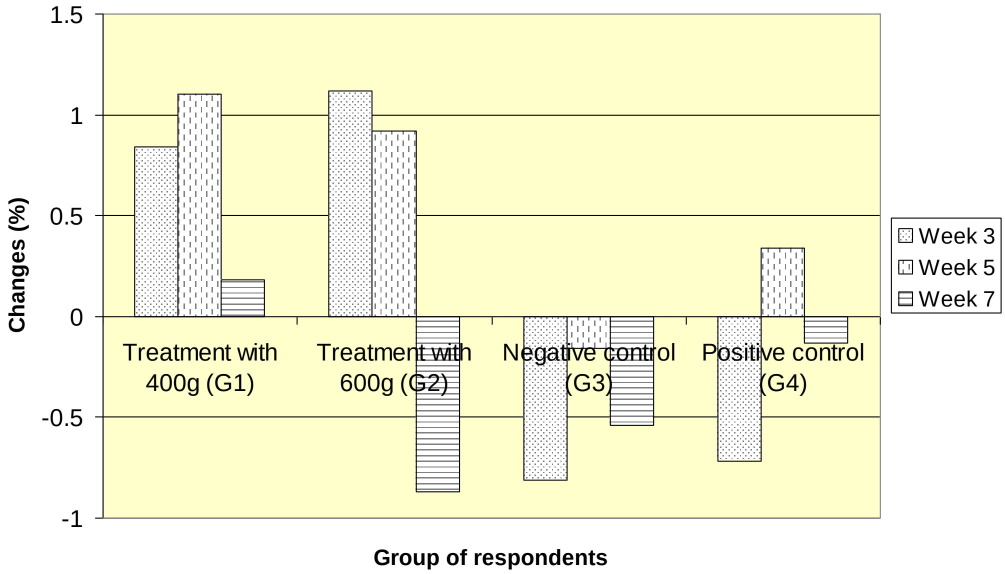
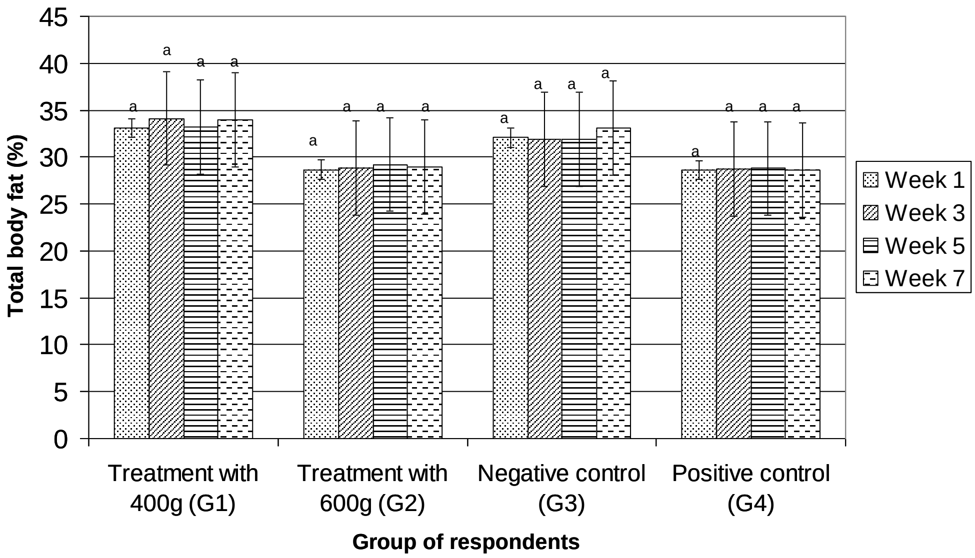


Figure 12. Percent of changes in body weight for each group according to weeks of study as compared to the baseline data (Week 1).

Effects of Red Pitaya Fruit Consumption on Total Body Fat

Figure 13 shows that no significant difference was seen for total body fat in each group throughout the study period. As presented in Figure 14, percent of changes in total body fat for Group 1 was 0.24%, while Group 2 was 1.88%, which indicated that red pitaya fruit treatment had no effect on total body fat among type 2 diabetic patients. Both control groups also had the same trend where there were no apparent changes in total body fat during the study period.

Dietary fiber may cause malabsorption of fat (Kay & Truswell, 1977), however in our study there was no change in body weight and total body fat after the treatment with high-fiber fruit. This might suggest that the relationship between high dietary fibers with the degree of reduction in the absorption of fat was insignificant for this study.



[a,b]Different lettersindicate significant difference (p<0.05) between weeks of study for each group.

Figure 13. Comparison of total body fat between treatment and control groups according to weeks of study.

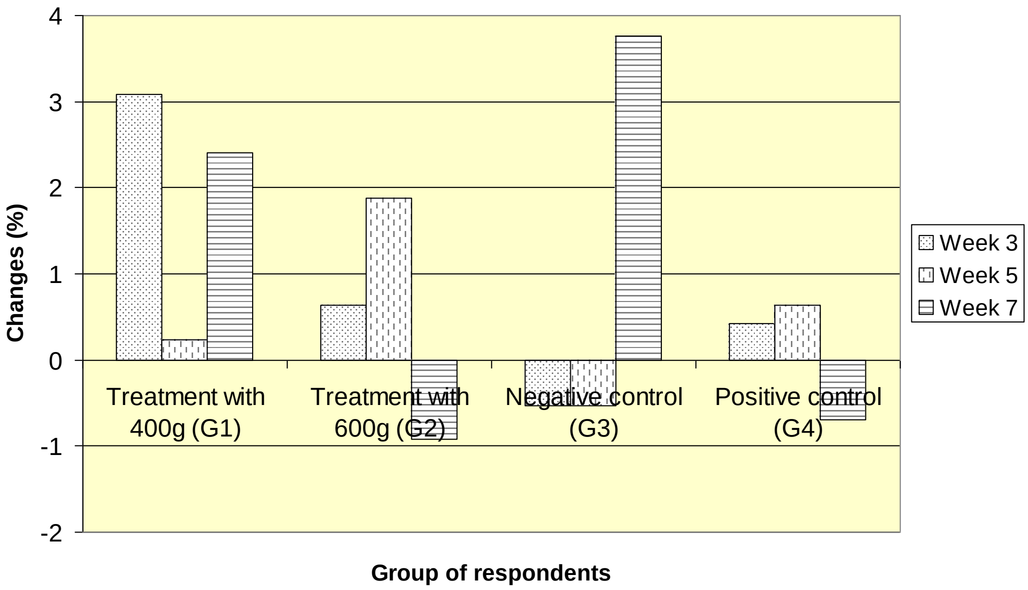


Figure 14. Percent of changes in total body fat for each group according to weeks of study.

CONCLUSION

As a conclusion, the findings indicated that red pitaya fruit consumption has great potential and is beneficial in controlling the blood glucose level and lipid profiles in type 2 diabetic subjects, with both amounts showing the different effect in each variable. The 400 g amount was more effective in lowering triglyceride levels with higher percent of changes (37.14%) compared to the 600 g amount (28.89%). While the 600 g amount was more effective in decreasing the blood glucose (34.87%), total cholesterol (31.64%) and LDL-cholesterol levels (41.04%) and increasing the HDL-cholesterol level (14.95%). While for the body weight and total body fat, there were no significant differences for both parameters.

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