Effect of Crispy Arrowroot Flake on Waist Circumference, Fasting Glucose and Free Fatty Acid in Type 2 Diabetes Patients

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Abstract: In type 2 diabetes mellitus, waist circumference was associated with increase of plasma free fatty acid and improvement in insulin resistance. Crispy arrowroot flake contain high fiber content and has a low glycemic index value which is expected to lower waist circumference through lipolysis. This study was conducted to determine the effect of the crispy arrowroot flake on waist circumference and plasma free fatty acid in type 2 diabetes mellitus. A quasi-experimental study was conducted on 30 type 2 diabetic patients who regularly visited endocrine clinic of RSUP Dr. Sardjito Yogyakarta. The criteria’s participants are age 35-60 years, fasting blood glucose ≥ 126 mg/dL and they aren’t smoking, pregnant, lactating and hypertension. The 7 grams of flake was given 3 times per day for 8 weeks. Waist circumference and blood free fatty acid were measured before and after 8 weeks intervention. Consuming of the flake can reduce waist circumference and increase free fatty acid. Waist circumference was lower in men (85.35±6.76 vs 85.30±6.38, p = 0.453) than in women (84.74±8.92 vs 83.76±7.81, p = 0.176). Free fatty acid was found increase in men (0.29±0.512 vs 0.633±0.26, p = 0.231), whereas no change was observed in women (0.837±0.26 vs 0.834±0.32, p = 0.962). Consumption of the crispy arrowroot flake can reduce waist circumference that is more amount in men than in women type 2 diabetes. Increased of free fatty acid only found in men.

Key words: Crispy arrowroot flake, waist circumference, free fatty acids, type 2 diabetes

INTRODUCTION

Type 2 diabetes mellitus is a metabolic disorder that is characterized by the presence of chronic hyperglycemia due to interference in the metabolism of carbohydrates, fats and proteins in which cause a disturbance in insulin secretion, insulin activity or both (WHO, 1999; ADA, 2005; Mullugeta et al., 2012). Insulin resistance is found in the majority of type 2 diabetes mellitus patients (Reaven, 2005). Bonora et al. (1994) reported that 84% of patients with diabetes mellitus type 2 were insulin resistance. Kumar et al. (2005) reported that 37% type 2 diabetes mellitus patients were insulin resistance.

Insulin resistance is an important factor which trigger lipolysis in adipocyte tissue, cause an increase in blood free fatty acid of type 2 diabetes mellitus patients (Hennes et al., 1996; Barker et al., 1993). Lipolysis is the breakdown of triglyceride intramyocellular that lead to increased free fatty acid and diacylglycerol levels in intracellular due to decreased glucose utilization in skeletal muscle (Lim et al., 2011). Increased lipolysis in type 2 diabetes mellitus is caused by an increase in the activity of the triglyceride lipase enzyme in adipocyte tissue due to chronic hyperglycemia (Krentz, 2003; Schoenborn et al., 2006). Increased activity of the enzyme is affected by fasting or starvation conditions and weakening of insulin activity in adipocyte tissue (Kershaw et al., 2006; Chakrabarti and Kandror, 2011). Centralization of body fat is one of the major caused of insulin resistance (Goedcke et al., 2013), especially excess in visceral adipose tissue (VAT) (Fox et al., 2007; Sandeep et al., 2010; Preis et al. 2010). The plausible mechanism linking insulin resistance and VAT is released of non esterified fatty acid (NEFA) from VAT depots (Frayn, 2000). Based on portal vein hypothesis, free fatty acid, as a product of lipolysis will enter into liver through portal vein and cause increased lipid synthesis, gluconeogenesis and insulin resistance (Patel and Abate, 2013). The excessive amount of free fatty acids may lead to peripheral insulin resistance through inhibition of muscle glucose uptake (Garg, 2004). The waist circumference is a better predictor to measurement intra abdominal adipose tissue (visceral fat) and also a good predictor insulin sensitivity. The waist circumference will provide information about body shape and also reflect both subcutaneous abdominal adipose tissue and intra abdominal adipose tissue volumes (Klein et al., 2007; Wahrenberg et al., 2005). Increased the waist size has been identified as an important risk factor in the development of insulin resistance in obese individuals (Gautier et al., 2010; Gill et al., 2011; Zadeh-Vakili et al., 2011). According to Despres et al. (2008), Frayn (2000), Donohoe (2011)
excessive intra abdominal fat (visceral fat) is as predictor of insulin resistance, thus individuals who have marked increased in visceral fat are at higher risk of insulin resistance. Visceral fat is a metabolically active organ compared to peripheral subcutaneous organ (Nesto, 2005; Donohoe, 2011). The higher rates of lipolysis in visceral fat can be caused by the action of dysregulating lipolysis hormones, insulin and catecholamines. The lipolytic effect of catecholamines are demonstrated clearly, whereas antilipolytic insulin effect is weaker in visceral compared subcutaneous adipose tissue (Wachencheng, 2000). Thus, there are risk of developing to insulin resistance related to visceral fat deposit in the body (Donohoe, 2011).

Several studies showed that consumption of foods with low glycemic index and high in fiber can lower the waist circumference, improve glycemic control, reduce blood pressure, improve insulin control, prevent the formation of free fatty acids in the blood as a result of lipolysis and prevent dyslipidemia in patients with type 2 diabetes mellitus (Opperman et al., 2004; Radulian et al., 2009; Du et al., 2010; Du et al., 2011; Kiritch and Maryniuk, 2011; Brooking et al., 2012; Kaczmarczyk et al., 2012). The crispy arrowroot flake is food with a low glycemic index values with dietary fiber content of 80%. Therefore, the purpose of this study was to determine the effect of the crispy arrowroot flake on the waist circumference and plasma free fatty acids in patients with type 2 diabetes.

MATERIALS AND METHODS

Research design and subjects: Quasi experimental study was used in this study. We studied 10 men and 20 women with type 2 diabetes who come for routine check up at endocrinology clinic, general hospital Dr. Sardjito, Yogyakarta. The protocol study was approved by medical and health research ethics committee Faculty of Medicine Universitas Gadjah Mada and each patient signed informed consent. The inclusion criteria were, men and women patients who have fasting blood glucose level ≥126 mg/dL and the age between 35-60 years of age. While the exclusion criteria are patients with blood pressure >160 mmHg, smoking, pregnant and breast-feeding.

Protocol of study: Subject who had signed informed consent and agreed to follow this study, then given education from nutritionist, so that they could estimate their daily food consumption of approximately 1500 Kcal of energy. The body weight, height and the waist circumference were measured before and after administration of the crispy arrowroot flake. The body weight was measured using digital scales (Camry) with accuracy of 0.00. The height was measured using microtoise at Frankfurt position. While the waist circumference was measured using a tape measure.

Anthropometric measurement was carried out by trained technicians according to standard procedures.

Blood sampling for measurement of fatty acid level was done after subject fasted at least 8 h. After blood sampling, subjects started consuming the crispy arrowroot flake as much as 21 g/day. The consumption of the crispy arrowroot flake were divided into 3 times, each consumption consist of 7 grams for 8 weeks. Level of subject compliances were measured using questionnaire. If subjects suffered gastrointestinal disorders due to consuming the crispy arrowroot flake, the consumption were stopped and subjects were stated as dropped out. Analysis of the plasma free fatty acids level was performed using enzymatic method (ELISA) kits (Randox, UK).

Statistical analysis: Free fatty acids level and the waist circumference were analyzed using paired t test. Correlation analysis was used to determine relationship between variables. Values were given as means±SE. Differences at p<0.05 were considered significant.

RESULTS

This study was followed by 30 subjects which consist of 10 men and 20 women. Most of subjects were obese. General characteristics of the subject are given in Table 1.

After consuming the crispy arrowroot flake three times a day as much as 7 grams for 8 weeks, we found increased the plasma free fatty acid, while the body weight and the waist circumference were found to be decreased though changes in the three variables were not statistically different (Table 2).

This study showed that the decreased in the body weight in women's group was higher compared to men's group although not significantly different (p = 0.825). Decreased in the waist circumference in men's group was higher compared to women's group although not significantly different (p = 0.463). Before treatment of the crispy arrowroot flake, women's group have higher the plasma free fatty acid level than men's group. However, after

<table>
<thead>
<tr>
<th>Table 1: Characteristics of the subject</th>
<th>Means±SE</th>
</tr>
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<tbody>
<tr>
<td><strong>Variables</strong></td>
<td></td>
</tr>
<tr>
<td>Gender</td>
<td></td>
</tr>
<tr>
<td>Male (n = 10, 33%)</td>
<td></td>
</tr>
<tr>
<td>Female (n = 20, 67%)</td>
<td></td>
</tr>
<tr>
<td>Old (year)</td>
<td>66.0±8.4</td>
</tr>
<tr>
<td><strong>BMI</strong></td>
<td></td>
</tr>
<tr>
<td>Normal (n = 7, 23%)</td>
<td>25.9±3.9</td>
</tr>
<tr>
<td>Overweight (n = 6, 20%)</td>
<td>-</td>
</tr>
<tr>
<td>Obese (n = 17, 57%)</td>
<td>-</td>
</tr>
<tr>
<td><strong>Food Intake</strong></td>
<td></td>
</tr>
<tr>
<td>Energy</td>
<td>1395.0±76.88</td>
</tr>
<tr>
<td>Protein</td>
<td>47.0±4.3</td>
</tr>
<tr>
<td>Lipid</td>
<td>47.0±3.78</td>
</tr>
<tr>
<td>Carbohydrate</td>
<td>194.8±11.02</td>
</tr>
<tr>
<td>Fiber</td>
<td>10.9±0.83</td>
</tr>
</tbody>
</table>
Table 2: Effect of consuming the crispy arrowroot flake for 8 weeks on blood free fatty acids level, the body weight and the waist circumference of type 2 diabetes patients

<table>
<thead>
<tr>
<th>Variables</th>
<th>Pre test</th>
<th>Post test</th>
<th>95% CI</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Free fatty acid</td>
<td>0.76±0.05</td>
<td>0.77±0.06</td>
<td>-0.09-0.11</td>
<td>0.819</td>
</tr>
<tr>
<td>Body weight</td>
<td>62.5±1.25</td>
<td>62.2±1.60</td>
<td>0.50-0.96</td>
<td>0.531</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>94.3±1.35</td>
<td>93.6±1.27</td>
<td>-0.4-2.34</td>
<td>0.139</td>
</tr>
</tbody>
</table>

*Data shown in mean±SE, p<0.05

Table 3: Effect of consumption of the crispy arrowroot flake on the body weight, the waist circumference and plasma free fatty acids in subject based on gender

<table>
<thead>
<tr>
<th>Variables</th>
<th>Women</th>
<th>Men</th>
<th>p</th>
<th>Pre test</th>
<th>Post test</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight</td>
<td>62.3±10.44</td>
<td>66.19±8.45</td>
<td>0.488</td>
<td>61.7±10.11</td>
<td>66.00±8.10</td>
<td>0.825</td>
</tr>
<tr>
<td>Waist circumference</td>
<td>84.7±8.92</td>
<td>85.3±6.78</td>
<td>0.176</td>
<td>83.7±7.81</td>
<td>85.3±6.38</td>
<td>0.463</td>
</tr>
<tr>
<td>Plasma free fatty acids</td>
<td>0.83±0.26</td>
<td>0.63±0.26</td>
<td>0.231</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 4: Correlation and changes between variables after 8 weeks consuming the crispy arrowroot flake (post test)

<table>
<thead>
<tr>
<th>Variables</th>
<th>Coefficient</th>
<th>p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Body weight-waist circumference</td>
<td>0.769</td>
<td>0.000*</td>
</tr>
<tr>
<td>Body weight-free fatty acids</td>
<td>-0.069</td>
<td>0.719</td>
</tr>
<tr>
<td>Waist circumference-free fatty acids</td>
<td>0.131</td>
<td>0.560</td>
</tr>
<tr>
<td>Body weight-waist circumference (delta)</td>
<td>0.440</td>
<td>0.015*</td>
</tr>
<tr>
<td>Body weight-free fatty acids (delta)</td>
<td>0.144</td>
<td>0.448</td>
</tr>
<tr>
<td>Waist circumference-free fatty acids (delta)</td>
<td>-0.013</td>
<td>0.947</td>
</tr>
</tbody>
</table>

*Significant at p<0.05

Consuming the crispy arrowroot flake, the plasma free fatty acid level in men's group was increased but in women's group was relatively stable (Table 3). Spearman correlation test suggested that after consuming the crispy arrowroot flake, the plasma free fatty acids level weakly correlated to the body weight and the waist circumference, while the body weight and the waist circumference are strongly correlated. Furthermore, the result of correlation by considering changes of the body weight, the waist circumference and the plasma free fatty acid level showed that the body weight positively correlated with the plasma free fatty acids level, but this correlation was weak. The waist circumference negatively and weakly correlated to the plasma free fatty acids level, however the body weight positively and strongly correlated to the waist circumference (Table 4).

**DISCUSSION**

Visceral adipose tissue (VAT) may increase metabolic activity, both lipolysis and lipogenesis. Based on portal vein hypothesis, increased the plasma free fatty acid, as a product of lipolysis will enter into liver through portal vein and cause increased in lipid synthesis and gluconeogenesis. Moreover, increased the plasma free fatty acid flux also lead to insulin resistance through decreased insulin-stimulated glucose uptake (primarily in skeletal muscle) (Patel and Abate, 2013; Wajchenberg, 2000; Garg, 2004). According to Lebovitz and Banerjee (2005), VAT is related to insulin resistance in type 2 diabetes. Fox et al. (2007) has reported that higher amount of hepatic free fatty acids produced from VAT lipolysis in women presumed to correlated in fat distribution between women and men. In addition, Fox et al. (2007) also reported that VAT remain more strongly correlated with metabolic risk factor than subcutaneous adipose tissue (SAT).

Body fat distribution is also important risk factor for diseases related to obesity. Excess of abdominal fat can increase risk of cardiometabolic disease, including type 2 diabetes, stroke, hypertension and cardiovascular diseases. The waist circumference usually used as a fat abdominal mass marker, because the waist circumference has a correlation with abdominal fat mass (subcutaneous and intra abdominal) and cardiometabolic disease risk (Ali and Crowther, 2005; Klein et al., 2007). In addition, the waist circumference is a good predictor of insulin sensitivity, both women and men with the waist circumference <100 cm were not included in group of insulin resistance (Wahrenberg et al., 2005).

Gender affects body fat distribution, women commonly have greater percentage of body fat compared to men (Blaak, 2001). In healthy subjects, average range of percentage body fat was 10-15% in men and 20-30% in women (Veilleux and Tchernof, 2012). A greater amount of subcutaneous fat was found in women, whereas a greater amount of visceral fat was found in men (Nedungadi and Clegg, 2009). The cause of differences of body fat distribution is uncertain, though differences in concentration of enzymes, hormones and hormone receptors between women and men play a role (Veila and Kravitz, 2002).

In recent study, consuming the crispy arrowroot flake three times a day for 8 weeks can reduce the body weight and the waist circumference although not
statistically different ($p_{BV} = 0.521$ and $p_{VC} = 0.134$). This reduction may be caused by fiber content in the crispy arrowroot flake that is about 80%. Reducing the body weight in women more than in men, the average of the weight reduction in all subjects were 0.51%, whereas in women were 1.03% and in men were 0.29%. Although it was not statistically different, however, according to Williamson et al. (2000), Fujikata (2010), The Look Ahead Research Group (2010) and Wing et al. (2011), reduction of the body weight in the diabetes mellitus patients who are overweight or obesity as much as 0.4-5% may decrease 0.5% HbA1c level, systolic and diastolic blood pressure (both about 5 mmHg), triglycerides level 40 mg/dl and reduce mortality. The reduction of the body weight also increase HDL level about 5 mg/dl.

The differences in the body weight reduction between women and men, in this study is accordance with Romaguera et al. (2011) who reported that increase in fiber consumption may reduce the body weight significantly in women but not in men. Du et al. (2010) also reported that fiber consumption in women are more beneficial in the weight reduction compared to men. The weight reduction in men are more influenced by physical activity, whereas in women physical activity had no effect (Mozafarian et al., 2011). Increased in dietary fiber consumption has been known to slow down digestion and maintain stability of glucose level, give longer satiety effect and also lower energy intake (Chandalia et al., 2000; Isaksson et al., 2009).

Consuming the crispy arrowroot flake may reduce the waist circumference as much as 0.96% but not statistically different. The average reduction of the waist circumference in men (1.22%) is more higher than in women (1.18%). This finding is accordance with Evans et al. (2012) who reported that men is more effective decreasing abdominal fat mass than women. Another study has shown that men tend to loss abdominal fat mass than women, while in women tend to loss femoral fat mass (Mauriege et al., 1999; Janssen et al., 2002). Weyers et al. (2002) reported that men will loss their fat mass 2.7 more times than women. Volek et al. (2004) and Evans et al. (2012) also reported that men tend to loss abdominal fat than women, when got low-carbohydrate and low-lipid diet or high-protein diet. This difference is related to energy metabolism and steroid hormone between women and men (Wu and O’Sullivan, 2011; Karastergiou et al., 2012).

In this study, we found that the body weight positively and significantly correlated with the waist circumference ($p = 0.000$). This result indicate that reduction of the body weight will be followed by reduction of the waist circumference (Brenner et al., 2010). Miyatake et al. (2007a) reported that reduction of the body weight as much as 3 kg will be followed by decreased the waist circumference as much as 3.45 cm in men and 2.83 cm in women. The decreased the waist circumference as much as 3 cm in men with obesity has been known to reduce the blood pressure and triglycerides level, and also increase HDL level in subject with central obesity (Miyatake et al., 2007 b).

After consuming the crispy arrowroot flake, level of the plasma free fatty acid was found increased as much as 1.32% though not statistically different. Increased the plasma free fatty acid level only observed in men (23.53%), while in women the plasma free fatty acid level were relatively similar before and after consuming the crispy arrowroot flake (Table 3). Increased the plasma free fatty acid level in men is caused by oxidation of triglycerides, which occur more frequent in men than in women. Santosa et al. (2008) has reported that oxidation of triglyceride occur more frequent in obese men than in women after treatment for the body weight reduction though it’s not statistically different. Moreover, this study found that the body weight and the waist circumference were negatively correlated with the plasma free fatty acids level. These result are consistent with the findings of Nestel and Whyte (1968), Mittendorfer et al. (2009) and McQuaid et al. (2011), who reported that negatively correlation between the blood free fatty acid level with body fat mass. This result indicated that reduction of the body weight and the waist circumference, or the body fat mass will increase the blood fatty acid level.

Conclusion: We conclude that type 2 diabetes mellitus patients who consume the crispy arrowroot flake can reduce the waist circumference more amount in men than in women. The plasma free fatty acid was found increased in men, whereas no change in women.

REFERENCES


