International Research Journal of Medicine and Medical Sciences
Vol. 8(4), pp. 126-131, December 2020
DOI: 10.30918/IRJMMS.84.20.048
ISSN: 2354-211X
Full Length Research Paper

Effect of black vinegar intake on anthropometric measures, cardiometabolic profiles, and insulin sensitivity among impaired fasting glucose subjects

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Accepted 28 September, 2020

ABSTRACT

This open-label non-controlled study is to evaluate the effects of black vinegar intake for 8 weeks on the anthropometric measures, cardiometabolic profiles, and insulin sensitivity among impaired fasting glucose adults. 32 subjects (14 males and 18 females) were recruited with the mean age of 56.3 (from 25 to 65). Black vinegar 50 ml was diluted to 500 ml with drinking water and was given to all subjects for 8 weeks. At baseline and 8-week, all study subjects received 75 g of oral glucose tolerance test (OGTT) after 10 h of fasting. Venous blood was collected at 0, 30, 60, 90 and 120 min. Plasma glucose and insulin levels were measured using the glucose oxidase method and radioimmunoassay method. Anthropometric variables, blood pressure and blood lipid profiles were measured using standard methods. The Wilcoxon signed-rank test was used to compare the difference between baseline and after eight weeks. After eight weeks, the body weight and BMI decreased from 68.2 ± 14.4 kg to 67.6 ± 14.2 kg and 26.3 ± 4.5 kg/m^2 to 26.0 ± 4.4 kg/m^2, respectively, with statistical significance ($p < 0.05$). Triglyceride level decreased from 152.5 ± 134.7 to 140.6 ± 93.8 mg/dl but without statistical significance. The blood glucose levels at 120 min of OGTT decreased from 178.8 ± 57.0 to 173.7 ± 57.5 mg/dl and the insulin levels at 120 min of OGTT increased from 117.5 ± 74.2 to 126.4 ± 95.9 IU/L but not statistically significant ($p > 0.05$). There is a slight decrease of body weight and BMI, but no significantly change in blood pressure, lipid profiles, and insulin sensitivity after eight weeks of black vinegar intake among impaired fasting glucose adults. However, further large-scale and longer studies are needed to explore the effects of black vinegar on cardiometabolic profiles and insulin sensitivity.

Keywords: Black vinegar, anthropometric measures, lipid profiles, insulin sensitivity, impaired fasting glucose.

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INTRODUCTION

Obesity and type 2 diabetes mellitus are the most important chronic diseases around the world. They are associated with huge medical expenditure and with increasing morbidity and mortality among related cardio-metabolic diseases in developing and developed countries (Rossner, 2020; Saeedi, 2019).

Vinegar was first reported to have anti-glycemic effects since 1988 in animal and human studies (Ebihara and Nakajima, 1988). Vinegar may be associated with improved insulin sensitivity and delayed gastric emptying that accompanied improved glycemic control and reduced body weight (Johnston and Gaas, 2006; Halima et al, 2017; Khezri et al., 2018).

Some studies have demonstrated that vinegar intake has some effects in increasing insulin sensitivity and decreasing blood glucose levels in either healthy adults or diabetes subjects (Johnston and Gaas, 2006; Johnston et al., 2013; Johnston et al., 2004; Johnston et al., 2009). Vinegar intake with meals can reduce fasting blood glucose levels in healthy adults (Johnston et al., 2013). A small cross-over study had shown that the postprandial glucose and insulin levels reduction and vinegar can improve insulin sensitivity in healthy and insulin resistant subjects but not for diabetic patients (Johnston et al., 2004).

But a later study has shown that vinegar can reduce HbA1c level up to 0.16% in diabetes after 12 weeks of regular daily ingestion of vinegar and the positive effects of vinegar intake was found in diabetic subjects (Johnston et al., 2009). In a review study, there is a -0.39% (95% CI -0.18 to -0.59%) reduction in mean HbA1c level after 8 to 12 weeks of vinegar administration. However, the long-term outcomes of vinegar were not statistical significance (Siddiqui et al., 2018).

Whether vinegar is an effective treatment for controlling body weight and improving insulin sensitivity is still controversial (Kohn, 2015). This suggests that the effects of vinegar on weight loss, insulin sensitivity and blood glucose or insulin levels have not been consistent and further studies are needed in different metabolic status subjects.

Since the results of vinegar on weight reduction and improving glycemic control are not consistent especially among the pre-diabetes subjects. The aims of this study are to evaluate the effects of black vinegar on anthropometric measures, cardiometabolic profiles, and insulin sensitivity among the impaired fasting glucose subjects.

MATERIALS AND METHODS

In total, 32 adults (14 males and 18 females) who have impaired fasting glucose were recruited from the out-patient clinic of the Tri-Service General Hospital at Taipei, Taiwan (from Jan. 1st 2018 to Dec. 31st 2018). The criteria for inclusion into this trial were as follows: ages 25 to 65, absence of infection within the previous three weeks, and no history of malignant tumors. The exclusion criteria were pregnancy, current or a history of cerebrovascular accident, myocardial infarction, heart failure, renal failure, hepatic failure, autoimmune disorders, endocrine diseases, or psychiatric conditions, including mood disorders and alcohol abuse. The subjects allergic to vinegar are also excluded.

All study participants consumed black vinegar 50 ml diluted to 500 ml with drinking water throughout the day for eight weeks. The black vinegar is made of fermented brown rice and soybean. Dietary intake and exercise were instructed by trained dietitians and research assistants. The calories were kept as usual intake and exercises were prescribed at least 30 minutes every day.

All participants provided written informed consent and agreed to take black vinegar for eight weeks and have their blood samples taken for this study. The institutional review board of our hospital approved this study (Number: TSGHIRB-2-106-65-010).

Anthropometric measurements

Body weight (BW) was measured to an accuracy of 0.1 kg using a standard beam balance scale for participants in barefoot and wearing light indoor clothing. Body height was recorded to the nearest 0.5 cm using a stadiometer and for body composition analysis a segmental body composition analyzer (TBF-410, Tanita Corp., Tokyo, Japan) was used.

Waist circumference (WC) was measured to the nearest 0.1 cm at the midpoint between the inferior margin of the last rib and the iliac crest of ilium. Hip circumference (HIP) was measured to the widest of the pelvic region. Body mass index (BMI) was calculated using BW (kg) divided by the square of the height (m^2). Waist to hip ratio (WHR) was also calculated using waist circumference (cm) divided by hip circumference (cm) (Beghin et al., 1988).

Blood pressure measurement

Blood pressures were measured after the subjects had rested for five minutes with cuffs of appropriate sizes and under sitting position. The subjects' arms were placed at the same height as the heart. Two measurements were recorded and the mean values of two pressures were used for data analyses.

Specimen collection

After 10-12 hours of fasting overnight, a 10 ml venous blood specimen was collected using venous containers from participants at baseline and after 8-weeks of ingestion of black vinegar while maintaining their usual dietary pattern of the past three days.

Plasma and serum were separated from blood within one hour and stored at −80°C until measurement.

Measurements of lipid profiles

We measured serum total cholesterol (Chol) using an esterase oxidase method (Richmond, 1973), triglyceride using an enzymatic procedure (Stavropoulos and Crouch, 1974) on a Hitachi 7150 auto-analyzer (Hitachi, Tokyo, Japan). High-density lipoprotein (HDL) and low-density lipoprotein (LDL) cholesterol were measured using an enzymatic method (Warnick et al., 1982) with magnesium precipitation using Synchron CX5 analyzer (Beckman Instruments, Palo Alto, California, USA).

We also determined the ratio of total cholesterol to HDL cholesterol (Chol/HDL) as atherogenic index for statistical purposes (Frontini et al., 2007).

Glucose tolerance test

The 75-g oral glucose tolerance test was conducted after 10 hours of fasting at baseline and after eight weeks of black vinegar intake. 15 ml venous blood specimens were obtained by tail bleeding, before and 30, 60, 90 and 120 min after the glucose load to measure glucose and insulin levels.

The plasma glucose concentrations were analyzed immediately after blood sampling and other assays were performed within a 2-week period of the sampling. Plasma glucose concentrations were determined using the glucose oxidase method on a Beckman Glucose Analyzer II (Beckman Instruments, Fullerton, CA) (Kadish et al., 1968). Plasma insulin concentrations were measured using a commercially available immunoradiometric kit (BioSource Europe S.A., Nivelles, Belgium). The intra-assay and inter-assay coefficients of variance for the insulin measurements were 2.2 and 6.5%, respectively.

Areas under curve were calculated by the trapezoid rule from the start of the meal to 120 min ($AUC_{0–120}$) (Matsuda and DeFronzo, 1999).

Statistical analysis

We used SPSS ver-22 to conduct all statistical analyses. Continuous variables, anthropometric measures, cardiometabolic profiles and insulin sensitivity were described by sample means and SD. The Wilcoxon signed-rank test was used to compare the difference between baseline and after eight weeks of black vinegar intake for each subject. A two-tailed p value less than 0.05 is considered statistically significant.

RESULTS

Table 1 shows the general characteristics of the study subjects at baseline and after eight weeks of vinegar intake. After eight weeks of vinegar intake, the body weight and BMI decreased from 68.2 ± 14.4 to 67.6 ± 14.2 kg and 26.3 ± 4.5 to 26.0 ± 4.4 kg/m^2, respectively ($p < 0.05$). For lipid profiles, the triglyceride level also reduced from 152.5 ± 134.7 to 140.6 ± 93.8 mg/dl but not statistically significant.

Table 2 compares the difference of insulin sensitivity and metabolic-related profiles between baseline and after eight weeks of vinegar intake. The fasting glucose levels decreased from 106.9 ± 14.7 to 105.0 ± 15.0 mg/dl but not statistically significant ($p > 0.05$). The under curve area of glucose decreased from 448.8 ± 76.6 to 440.1 ± 81.7 (units) but not statistically significant ($p > 0.05$). The AGE level decreased from 7.6 ± 3.9 to 7.1 ± 5.0 but not statistically significant ($p > 0.05$).

Figure 1 shows the change of blood glucose and insulin levels during OGTT at baseline and after eight weeks of vinegar intake. The blood glucose levels at 120 min of OGTT decreased from 178.8 ± 57.0 to 173.7 ± 57.5 mg/dl and the insulin levels at 120 min of OGTT increased from 117.5 ± 74.2 to 126.4 ± 95.9 IU/L but not statistically significant ($p > 0.05$). The AUC-glucose decreased from 448.8 to 440.1 and AUC-insulin increased from 222.8 to 234.9 but not statistically significant ($p > 0.05$).

Table 1. Anthropometric measures and cardiometabolic profiles at baseline and after eight weeks of vinegar intake (with difference), n = 32.

	Baseline		8th week		Difference	P-value
	Mean	SD	Mean	SD	Mean (SD)	
BH (cm)	160.8	8.8				
BW (kg)	68.2	14.4	67.6	14.2	-0.1 (1.6)	0.033*
BMI	26.3	4.5	26.0	4.4	-0.2 (0.6)	0.029*
Waist (cm)	87.5	9.9	87.6	9.0	0.0 (2.1)	0.900
Hip (cm)	99.5	8.6	99.3	8.4	-0.2 (1.5)	0.556
WHR	0.88	0.1	0.88	0.0	0.0 (0.3)	0.631
SBP (mmHg)	131.3	14.0	133.8	12.7	2.4 (11.6)	0.250
DBP (mmHg)	81.3	9.6	82.1	8.4	0.8 (8.6)	0.611
HR (BPM)	72.9	9.1	74.0	7.8	1.1 (8.1)	0.438
Chol (mg/dl)	175.8	30.0	181.7	32.9	5.8 (17.0)	0.062
HDL (mg/dl)	49.3	9.5	50.9	10.1	1.6 (5.6)	0.116
LDL (mg/dl)	88.6	22.7	90.6	22.1	2.0 (15.0)	0.078
TG (mg/dl)	152.5	134.7	140.6	93.8	-11.9 (60.5)	0.274
Chol/HDL	3.7	1.2	3.7	1.1	0.0 (0.6)	0.865

Data are expressed as mean ± SD.
BH, body height; BW, body weight; BMI, body mass index; Waist, waist circumference; Hip, hip circumference; WHR, waist-to-hip ratio; SBP, systolic blood pressure; DBP, diastolic blood pressure; HR, heart rate; Chol, total cholesterol; HDL, high-density lipoprotein cholesterol; LDL, low-density lipoprotein cholesterol; TG, triglyceride.
* $p < 0.05$, using the Wilcoxon signed-rank test to compare the difference between baseline and after eight weeks of vinegar intake.

Table 2. Blood glucose, insulin and metabolic-related characteristics at baseline and after eight weeks of vinegar intake (with difference), n = 32.

	Baseline		8th week		Difference	P-value
	Mean	SD	Mean	SD	Mean (SD)	
Glucose-0 (mg/dl)	106.9	14.7	105.0	15.0	-1.9 (8.5)	0.217
Glucose-30	185.5	23.8	182.7	26.3	-2.7 (22.6)	0.505
Glucose-60	214.1	35.4	216.0	41.2	1.9 (24.0)	0.657
Glucose-90	207.8	46.2	201.5	47.5	-6.3 (24.7)	0.164

Table 2. Continues.

Glucose-120	178.8	57.0	173.4	57.5	-5.4 (32.1)	0.351
AUC-glucose (mg/dl*h)	448.8	76.6	440.1	81.7	-8.7 (34.9)	0.176
Insulin-0 (IU/L)	14.9	6.9	15.6	8.1	0.8 (4.2)	0.305
Insulin-30	68.9	44.7	67.3	50.8	-1.6 (36.1)	0.807
Insulin-60	118.0	101.1	134.6	110.1	16.6 (56.4)	0.105
Insulin-90	135.9	96.9	144.4	112.6	8.5 (87.0)	0.501
Insulin-120	117.5	74.2	126.4	95.9	8.9 (73.7)	0.250
AUC-insulin (IU/L*h)	222.8	135.3	234.9	163.3	12.1 (81.3)	0.412
HbA1c (%)	6.3	0.5	6.2	0.5	-0.1 (0.2)	0.140
Pro-insulin (pM/L)	3.4	2.0	3.3	1.9	-0.1 (1.3)	0.769
AGEs (ug/ml)	7.6	3.9	7.1	5.0	-0.5 (3.2)	0.370

Data are expressed as mean ± SD.
AUC, area under the curve of OGTT; AGEs, advanced glycation end-products.
* $p < 0.05$, using the Wilcoxon signed-rank test to compare the difference between baseline and after eight weeks of vinegar intake.

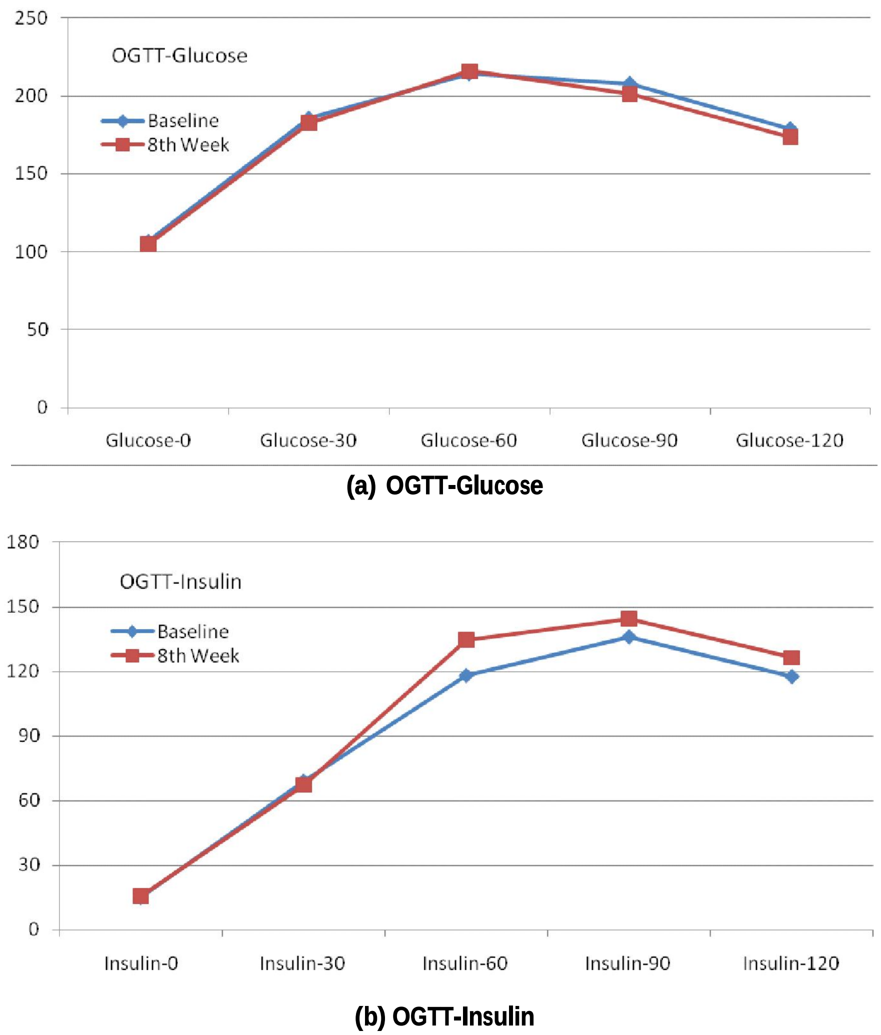

Figure 1. Mean blood glucose and insulin levels during oral glucose tolerance test at baseline and after eight weeks of vinegar intake, n = 32.

DISCUSSION

Vinegar is the product of acetic acid and is reported to have anti-glycemic effects in either animal or human studies (Johnston and Gaas, 2006). The mechanisms of vinegar are based on improved insulin sensitivity and delayed gastric emptying accompanied with improved glycemic control and reduced body weight (Halima et al, 2017; Khezri et al., 2018; Siddiqui et al., 2018; Shishehbor et al., 2017; Chen et al., 2016; Petsiou et al., 2014).

In this study, we found that body weight and BMI slightly decreases after eight weeks vinegar intake. However, there is no significantly change in blood pressure, lipid profiles and insulin sensitivity after eight weeks of black vinegar intake among adults impaired fasting glucose status. It may be due to the short study period or those subjects are in impaired glucose tolerance but not in diabetic status.

A systemic review and meta-analysis study show that the consumption of vinegar can decrease postprandial glucose and insulin level (Shishehbor et al., 2017). Samad et al. (2016) reviewed the therapeutic effects of vinegar and shown that daily consumption of vinegar is associated with improvement of chronic disease status such as high blood pressure, hyperlipidemia and obesity. More interestingly, different types of vinegar, such as persimmon or tomato vinegar, is associated with anti-obesity and anti-diabetic effects.

In our study, the results of body weight and BMI reduction were similar to that of the Halima et al. (2017) study and Seo et al. (2015) study, which showed that apple cider intake, could reduce body weight and BMI significantly. Furthermore, the Khezri et al. (2018) study have shown that the intake of apple cider vinegar and restricted calorie diet for 12 weeks among overweight and obese subjects significantly reduced body weight, BMI, and visceral adiposity index when compared with restricted calorie diet subjects. However, there is no reduction of lipid profiles in our results, which is not consistent with the results of these studies.

Johnston et al. (2013) showed that fasting glucose level was reduced after 750 mg acetic acid intake per day for 12 weeks, whereas our results indicate that there is no change in fasting glucose and insulin levels. This may be due to insufficient vinegar intake in our study. Larger dosage of vinegar intake may be conducted in the future.

Our results showed that the change of glucose and insulin response and under area curve of OGTT before and after black vinegar intake for eight weeks is not statistically significant. It is not consistent with the results of the Johnston et al. (2004) study, which indicated that vinegar intake can improve insulin sensitivity for insulin resistant or type 2 diabetes subjects. These inconsistent results may be due to the short duration of study period or the study population with minor cardio-metabolic abnormalities. Further studies and larger sample size may be needed to explore the possible mechanism of vinegar on insulin and glucose metabolism.

Conclusion

The body weight and BMI slightly decreased after 8-week of black vinegar. However, there are no changes on cardiometabolic profiles and insulin sensitivity for 8-week black vinegar intake. This needed further larger scale and longer studies to confirm the effects of weight reduction on black vinegar.

ACKNOWLEDGEMENTS

This research was funded and with generous donation of products by the Fukuyama Kurozu (Black Vinegar) Co., Ltd. Japan. We thank Mrs. Wang SJ for her technical assistance.

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Citation: Chu NF, Lee CH, Shieh CH, Lu CH, Hung YJ, 2020. Effect of black vinegar intake on anthropometric measures, cardiometabolic profiles, and insulin sensitivity among impaired fasting glucose subjects**.** Int Res J Med Med Sci, 8(4): 126-131.