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*Full Length Research Paper*

# The effect of white vinegar on some blood biochemical factors in type 2 diabetic patients

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**Type 2 diabetes is one of the most prevalent endocrine disorders worldwide. Traditionally, herbal plants and their derivatives are used to lessen complications of type 2 diabetes. The hypoglycemic and hypolipidemic properties have been reported for vinegar, but some cases of discrepant effects were also observed. In the current study, the impact of apple vinegar on some hematological and blood biochemical factors in type 2 diabetic patients was investigated. In this trial study, sixty patients with type 2 diabetes were divided into two groups. The first group took 15 ml of vinegar with their middle meal for one month. The second group received water as placebo. At the beginning and end of the study, blood samples were collected and biochemical factors including fasting blood sugar (FBS), glycated hemoglobin (HbA1c), triglycerides (TG), total cholesterol, low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein-cholesterol (HDL-C), urea, creatinine (Cr), uric acid, aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP) and complete blood count (CBC) were evaluated. Findings showed that FBS (P=0.006), HbA1c (P=0.002), MCV (P=0.0001) and mean cell hemoglobin (MCH; P=0.002) decreased where platelets (PLT) (P=0.005) increased significantly in first group. There was no significant difference in the studied parameters in placebo group. Based on the results of this study, it can be concluded that vinegar is a hypoglycemic agent that can be applied for treatment of type 2 diabetes.**

**Key words:** Vinegar, acetic acid, type 2 diabetes, fasting blood sugar (FBS), glycated hemoglobin (HbA1c).

## INTRODUCTION

Diabetes Mellitus (DM) is a globally growing health problem and has been considered as one of the five major causes of morbidity and mortality in many societies (Gispen and Biessels, 2000). According to the recent collected information worldwide, over 171 million individuals suffer from diabetes in 2000 and the number is expected to reach 366 million by 2030 (Wild et al., 2004).

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Possible leading mechanisms for diabetes establishment are impaired insulin secretion, insulin resistance and over-production of hepatic glucose (fasting hyperglycemia) (Dailey, 2004). Insulin resistance not only plays pivotal role in diabetes complications, but also involved in atherosclerosis, hypertension and dyslipidemia (Adeli et al., 2001). DM usually causes several organ damage related disorders including retinopathy, cataract, neuropathy, atherosclerosis, nephropathy, embryopathy and wound healing retardation (Diabetes Control and Complications Trial Research Group, 1994).

Although, to date, insulin and other hypoglycemia reagents

are considered as the only medication for treatment of type 2 diabetes, but this agents have undesirable side effects. Epidemiological studies showed that application of plants and their derivatives improve chronic disease symptoms such as cardiovascular disease, cancer and diabetes (Yang et al., 2004). One of the plant derivatives is vinegar. Apple vinegar as one of the apple products contains a variety of flavonoids such as gallic acid, catechin, caffeic acid and ferulic acid (Natera et al., 2003).

Vinegar is a merged format of French words “vin aigre”, meaning “sour wine”, and can be made from almost any fermentable carbohydrate source, including dates, sorghum, apple, grapes, etc. Acetic acid, the volatile organic acid that identifies the product as vinegar consist of about 3 to 9% of vinegar content and is responsible for the tart flavor and pungent, biting odor of vinegars (Ren et al., 1997). The antiglycemic properties of vinegar were firstly reported by Ebihara and Nakajima (1988). In animal studies, it has been revealed that a diet containing acetic acid or vinegar at concentrations found in traditional diets has varying effects from enhancement of glycogen repletion (Fushimi et al., 2001), prevention of hypertension (Kondo et al., 2001) to stimulation of calcium (Ca) absorption (Kishi et al., 1999).

In a study, it was shown that white vinegar reduced both postprandial blood glucose and insulin levels. It also increased and prolonged satiety in healthy subjects (Ostman et al., 2005). The hypoglycemic impacts of acetic acid have been shown to be mediated by enhanced glycogen repletion in liver and skeletal muscles (Fushimi et al., 2001) and in the suppression of disaccharidase activity in human intestinal cells (Ogawa et al., 2000). In insulin resistant subjects, apple cider vinegar indicated to improve postprandial insulin sensitivity (Johnston et al., 2004).

In another rat model, acetic acid reduced triglycerides (TG) level in hyperlipidemic rats (Fushimi et al., 2006), in parallel risk of cardiovascular disease (Iso et al., 2001). Due to the high cost of drug remedy and their unwanted side effects, finding of some natural components for treatment of diabetes and its complications is considered.

Actually, simple, inexpensive diet strategies to help blood glucose are greatly needed to delay the progression of diabetes. Accumulating evidence indicates that a single dose of apple vinegar may attenuate postprandial glycaemia. Since postprandial glycaemia is a strong predictor of hemoglobin A1C, particularly in well controlled diabetic patients (Carol et al., 2009).

Apple vinegar is remarkably more regarded for its beneficial effects. Therefore, in the present study, the impacts of oral apple vinegar consumption on some hematological and blood biochemical factors in type 2 diabetic patients were investigated.

## MATERIALS AND METHODS

The present study was a double-blind trial study done in 2011. Duration of treatments was one month. Type 2 diabetic patients, aging 30 to 60 years possessing the entrancing criterion (fasting blood sugar (FBS) more than 126 mg/dl, did not have any digestional, hepatic, renal, cardiovascular, asthma disease and using anti-diabetic drugs (Glibenclamide 1 daily)) were entered into the study. Also, exclusion criteria (vinegar intolerance, digestional disorder and using other drugs) were also imposed for choosing patients.

All of the enrolled patients either placebo or vinegar receiving group filled out written consent form which was designed specifically for this study. Patients with type 2 diabetes were divided into two groups. In each group, 30 persons including 15 males and 15 females were matched for body mass index (BMI).

The first group received 15 ml vinegar with middle meal for one month, without mixing with food or salad. Furthermore, they did not change their lifestyle during the study. In the second group, patients received water as placebo.

At the beginning and end of the study, blood samples were collected and hematological and blood biochemical factors including: FBS, glycated hemoglobin (HbA1c), TG, total cholesterol, low-density lipoprotein-cholesterol (LDL-C), high-density lipoprotein-cholesterol (HDL-C), urea, creatinine (Cr), uric acid, aspartate transaminase (AST), alanine transaminase (ALT), alkaline phosphatase (ALP) and hematological parameters including white blood cell (WBC), red blood cell (RBC), mean cell volume (MCV), mean cell hemoglobin (MCH), mean corpuscular hemoglobin concentration (MCHC), hematocrit (HCT) and platelets (PLT) were evaluated.

### Statistical analysis

Data were expressed as mean±standard deviation of mean. Collected data were analyzed using one way analysis of variance (ANOVA) in Statistical Package for Social Sciences (SPSS) software and paired T-test. Probability level of $<0.05$ indicates significant difference.

## RESULTS

The findings of this study indicate that FBS (P=0.006) and HbA1c (P=0.002) reduced significantly in the first group, while TG, total cholesterol, LDL-C, HDL-C, urea, Cr, uric acid, AST, ALT, ALP did not show significant differences. In placebo group, there was no significant difference in the studied factors (Table 1). It was also observed that the MCV (P=0.0001) and MCH (P=0.002) significantly reduced, while PLT (P=0.005) increased significantly in the first group and WBC, RBC, hemoglobin, HCT and MCHC did not change significantly. In placebo group, no significant differences were observed in the hematological parameters (Table 2).

## DISCUSSION

The related results for biochemical factors and hematological parameters in the first (vinegar treated) and second (water treated) groups are completely illustrated in Tables 1 and 2, respectively.

In this study, it was observed that vinegar significantly reduced FBS and HbA1c in type 2 diabetic patients. Acetic acid is the active ingredient of vinegar and several

**Table 1.** Illustrated biochemical parameters in vinegar treated and placebo type 2 diabetic patients (results shown as mean±SD).

| Factor | Group | | | |
|---|---|---|---|---|
| | Vinegar treated | | Placebo treated | |
| | Pre-treatment | Post- treatment | Pre-treatment | Post- treatment |
| FBS (mg/dl) | 174.67±63.52 | 156.23±60.04* | 198.7±28.18 | 203.23±28.5 |
| HbA1c (%) | 7.56±3.01 | 7.03±2.97** | 8.75±0.92 | 8.64±1.41 |
| Cholesterol (mg/dl) | 201.029±32.84 | 197.47±34.92 | 218.575±54.51 | 216.787±48.84 |
| TG (mg/dl) | 211.05±121.22 | 213.79±92.92 | 232.87±136.53 | 219.48±146.322 |
| LDL-C (mg/dl) | 111.97±26.39 | 115.52±22.54 | 127.6±35.86 | 124.12±31.46 |
| HDL-C (mg/dl) | 45.47±10.14 | 47.2±1.95 | 46.21±2.61 | 46.69±3.34 |
| AST (IU/L) | 22.61±6.27 | 22.67±5.77 | 20.84±6.69 | 22.21±7.51 |
| ALT (IU/L) | 17.117±8.07 | 17.235±7.93 | 17.54±8.07 | 16.9±7.49 |
| ALP (IU/L) | 256.23±64.53 | 249.5±65.01 | 250.15±58.35 | 242.27±57.64 |
| Blood urea | 31.41±8.46 | 30.50±8.12 | 36.96±23.57 | 36.36±22.25 |
| Creatinine | 0.885±0.157 | 0.885±0.145 | 1.009±0.601 | 1.036±0.659 |
| Uric acid | 5.15±1.55 | 5.19±1.65 | 5.42±1.26 | 5.45±1.49 |

Number of individuals=30; *P=0.006; **P=0.002; SD: Standard deviation.

**Table 2.** Illustrated hematological parameters in vinegar treated and placebo type 2 diabetic patients (results shown as mean±SD), Number of individuals=30.

| Factor | Group | | | |
|---|---|---|---|---|
| | Vinegar treated | | Placebo treated | |
| | Pre-treatment | Post-treatment | Pre-treatment | Post-treatment |
| WBC (n/ml) | 9023.07±1519.02 | 8715.38±1917.64 | 8051±1490 | 8740±2221.86 |
| RBC (mil/ml) | 5.311±0.573 | 5.409±0.534 | 5.5±0.33 | 5.56±0.48 |
| Hemoglobin(g/dl) | 14.71±2.44 | 14.33±2.96 | 15.01±1.6 | 15.57±1.64 |
| HCT (%) | 46.27±3.846 | 45.82±3.802 | 46.82±4.11 | 47.34±3.58 |
| MCV (fl) | 88.07±7.101 | 85.41±5.748*** | 85.57±3.21 | 84.15±14.5 |
| MCH (pg) | 28.78±2.9 | 27.61±2.27** | 28.32±1.41 | 28.21±1.24 |
| MCHC (%) | 32.73±1.59 | 32.32±0.797 | 32.3±0.698 | 32.18±0.811 |
| PLT (n/ml) | 266076±49795.5 | 308307±78586.9* | 267760±68606±52 | 2684400±69731.62 |

Number of individuals=30; *P=0.005; **P=0.002; ***P=0.0001; SD: Standard deviation.

mechanisms have been suggested to explain anti-glycemic effects of vinegar. Acetic acid may control these factors via different manners like slowing down of gastric emptying (Liljeberg and Fjorck, 1998), inhibition of disaccharides activity in the small intestine, blocking the complete digestion of starch molecules (Ogawa et al., 2000) and also promotion of glucose uptake by muscle performance (Fushimi et al., 2001).

In another study performed on human subjects, the use of a starchy meal with vinegar was reported to cause suppression of postprandial increments in serum glucose and insulin by a delayed gastric emptying rate (Kondo et al., 2001). Therefore, continuous acetic acid consumption may lead to chronically decreased serum insulin level.

Several investigations examined the fact that whether delayed gastric emptying aid the hypoglycemic effects of vinegar (Liljeberg and Fjorck, 1998). Using non-invasive ultrasonography, Brighenti et al. (1995) did not observe any difference in gastric emptying rates in healthy subjects consuming bread (50 g carbohydrate) in association with acetic acid (that is, vinegar) versus sodium acetate (that is, vinegar neutralized by the addition of sodium bicarbonate); however, post-meal glycaemia was noted by the acetic acid treatment (1995).

Johnston et al. (2004) reported that vinegar could significantly improve insulin sensitivity in insulin resistant patients. There are some evidences that showed vinegar consumption can reduce postprandial glycaemia (Ostman et al., 2005). In agreement with our findings, Johnston et al. (2009) showed that regular vinegar intake by type 2 diabetic patients in a period of 12-weeks reduced HbA1c to 0.16% of its baseline as compared to a related control group.

Despite of these hypoglycemic effects, vinegar has

hypolipidemic effects as well. Although, such an effect was not observed for vinegar and cholesterol, TG, LDL-C and HDL-C levels did not change significantly in our studied patients.

More recent investigations showed that a daily diet containing vinegar induced intestinal calcium absorption (Kishi et al., 1999). Hypokalemia in parallel with hyperreninemia and osteoporosis was evidenced in a 28-year-old lady who had consumed approximately 250 ml apple cider vinegar daily for 6 years (Lhotta et al., 1998). Fushimi et al. (2006) showed that vinegar consumption with diet containing 1% cholesterol for 19 days significantly reduced TG and total cholesterol (Fushimi et al., 2006).

Several investigations revealed that vinegar positively affected lipid profile in diabetic rats, but not FBS and HbA1c (Shishehbor et al., 2007) while 10 ml/day intake of apple vinegar decreased LDL-C and cholesterol in rabbit model (Setorki et al., 2010).

The association between hepatic enzymes and some metabolic syndromes confirmed increased proportion of AST to ALT leading to atherosclerosis (Setorki et al., 2010). In this study, no significant differences were observed in ALT, AST and ALP activity in diabetic patients consuming vinegar. But the activity of liver AST and ALP in the animals treated with the vinegar decreased and elevated, respectively (Mohamed et al., 2001). No significant differences were found neither in the activity of hepatic ALT nor in hepatic acid phosphatase (ACP). Treated groups also showed statistically significant increases in both mean liver and spleen weight. Kidney weight did not show significant change. High dose of cider vinegar also induced histopathological alterations in liver, stomach and duodenum (Mohamed et al., 2001).

Current findings displayed no significant changes in the number of WBC, RBC count and its related indices such as MCHC and Hb, while MCH and MCV were reduced and the numbers of platelets were increased. In Mohammad et al. (2001), the study Hb, total RBC counts and total WBC counts were above the normal in all treated groups.

As mentioned earlier, vinegar reduced glucose level significantly as included in some previous findings and could be related to the effects of some flavonoids that are found in vinegar. Flavonoids are antioxidant components that can reduce glucose absorption and modulate the activity and expression of rate limiting enzymes involved carbohydrate metabolism (Cazarolli et al., 2008). Some studies confirmed the inhibitory effects of acetic acid on some enzymes in carbohydrates metabolism (Ogawa et al., 2000).

Considering the therapy of lipidemic disorders in diabetes, intake of vinegar affects lipid profile in diabetic patients was investigated. Evidences showed that the prevalence of type 2 diabetes is increasing globally. Simple, applicable and inexpensive diet strategies are greatly needed to help and manage blood glucose in type 2 diabetes patients for either delay or control of the progression of complications (Fushimi et al., 2001). Vinegar which is used traditionally as a folk medicine is believed to have several beneficial effects including hypoglycemic and hypolipidemic (Fushimi et al., 2001).

It is clear that these findings are consistent with previous studies in some extent and about some factor, there are contradictory results.

## Conclusion

Conclusively, based on the previous reports and current results, it can be concluded that vinegar is useful as a therapeutic target in diabetes, but more studies are needed to explore both its advantages and disadvantages as a tool for controlling type 2 diabetes and other metabolic disorders like hyperlipidemia.

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