ORIGINAL ARTICLE

APPLE CIDER VINEGAR AS AN EXCELLENT ANTI-DIABETIC AND ANTI-OBESITY NATURAL BEVERAGE BECAUSE OF ITS DEPRESSION OF POSTPRANDIAL GLYCEMIC RESPONSE

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ABSTRACT

Background: The search of new anti-obesogenic and anti-diabetic treatments based on natural solutions without or with minimal side effects is a challenge. Postprandial glycemic response refers to an elevated blood glucose concentration after a meal. Foods yielding low postprandial glycemic responses should be beneficial for the dietary prevention of metabolic disorders. Postprandial glycaemia has been implicated in the development of chronic metabolic diseases such as obesity, type 2 diabetes mellitus and cardiovascular diseases. **Objective**: The purpose of this study was to estimate the lowering effect of cider vinegar on postprandial hyperglycemia. **Methods**: Seventy-two volunteers were randomly assigned to eat the same hyper caloric breakfast and were asked to drink a solution of cider vinegar (12ml, 2.5% of acidity) at the middle of the meal. The blood glucose concentration was measured before the meal, 150 minutes, and 180 minutes after the meal. The experimentation was repeated two times a day. Throughout the experiment (3 days), regular calorific assessments of the foods consumed were carried out. The comparison of the means between the control and test subgroups and the group function of the BMI is carried out statically by student t-test. Differences are considered significant when $p < 0.05$.. **Results**: In the 20-24 kg/m^2 BMI group, the control subgroup experienced an increase of more than 100% in blood glucose, while the test subgroup decreased by 25% after 150 minutes and maintained at a 23% decrease after 180 minutes. These effects slightly decreased for 25-30 kg/m^2 BMI group, in which cider vinegar reduced postprandial hyperglycemia a little less. **Conclusion**: all anthropometric and glycemic constants are found to be higher in individuals with a higher BMI. These suggest an anti-obesity action.
Keywords: *cider vinegar; BMI; postprandial glycemic response; diabetes.*

1. INTRODUCTION

The epidemic progression of obesity has dramatically increased over the last few decades, becoming an important public health issue across the world due to sedentary lifestyles, excess calories [1], as well as genetic, environmental, and socio-economic conditions [2]. Obesity is defined on the basis of thresholds of body mass index (BMI), it results from an imbalance between energy inputs and expenditure. It is associated with a number of pathologies such as diabetes, cardiovascular disease, and cancer [3]. Several studies have shown the possible relationship between diet and various diseases [4]. Indeed, diets rich in fat have proved to have deleterious effects in humans and animals [5].

Throughout the ages man has been able to rely on nature to meet his basic needs and medical needs. The therapeutic use of the extraordinary plant virtues for the treatment of all human diseases is very old and has evolved with the history of humanity [6]. Currently, and because of their numerous antibacterial, antioxidants, anti-inflammatory and anti-carcinogenic biological activities, a particular interest are directed to bioactive molecules derived from plants [7].

Apple cider vinegar is a type of vinegar made from cider or apple must and has a pale to medium amber color. Vinegar is one of the most widespread products in the world. It has a variety of uses ranging from simple condiment to its use as a remedy since ancient times [8]. Studies carried out so far attribute to vinegar a certain number of therapeutic activities, namely, anti-infectious properties, anti-tumor, antihypertensive, also plays a role in glycemic control [9]. It is also attributed a strong antioxidant activity thanks to the phenolic compounds which form part of its composition [10]. However, little data on its preventive effects are available.

2. Materials and Methods

2.1 Patients and experimental protocol

Seventy-two volunteers (18-32 years of age) were recruited. Their mean ± SD body mass index (BMI) was 24. 87 ± 3.56 kg/m^2. None of the patients was diabetic, nor under medical treatment for gastrointestinal disease. All of the participants gave informed consent, and the study was approved by the Regional Ethics committee.

Subjects were randomly assigned to eat the same hyper caloric breakfast; the test group (38 people) was asked to drink a solution of cider vinegar (12ml, 2.5% of acidity) at the middle of the meal. The control groups (34 people) has drunk the same volume of water. Groups were subdivided in function of people BMI range; 18-24 group and 25-30 group.

2.3 Sample analysis

There are three ways to measure blood glucose, corresponding to different physiological states. (i) Fasting blood glucose, the most common test, gives basal blood glucose. It is practiced in the morning before breakfast. Diabetes is reported from 1.26 g/L. (ii) Oral hyperglycemia or glucose tolerance test consists of giving the patient 75 grams of glucose to eat, then wait 2 hours before measuring his blood glucose. Postprandial blood glucose does not exceed 1.40 g / l in healthy subjects. Beyond begins glucose intolerance. (iii) Glycated hemoglobin, or HbA1c. This test represents a global "memory" of blood glucose over the past three months, so it takes into account all conditions, including postprandial glucose. Our protocol combined the first and the second method. The blood glucose samples were analyzed using a glucose oxidase method. The blood concentration of glucose was measured before the meal, 150 minutes, and 180 minutes after the meal, to allow the total postprandial hyperglycemia induction. The experimentation was repeated two times a day. Throughout the experiment (3 days), regular calorific assessments of the foods consumed were carried out.

2.4 Feeding

Subjects were fed with a meal composed as indicated in table below and estimated at 1355 cal. We estimate that the meal greatly exceeds the daily recommendations for a sedentary man. According to the U.S. Department of Health and Human Services 2010 Dietary Guidelines, the typical woman needs about 2,000 calories per day, and the typical man 2,500 calories per day. However, we chose foods with a low to medium glycemic index to test our action. The glycemic index is a ranking criterion for foods containing carbohydrates, based on their effects on blood glucose (glucose level in the blood) for two hours after ingestion. It allows comparing the glycemic power of each food, measured directly during digestion.

Table1: Table presents the individual menu content in portions size and calories per 100g.

	Portions size (calories)	**Calories Per 100g**	**Energy content**
Boiled Carrot (300g)	75	25	Low calorie
Boiled Potatoes (300g)	210	70	Low calorie
White boiled Rice (300g)	420	140	Medium calorie
Roasted beef (100g)	280	280	Medium calorie
Biscuit digestives (50g)	240	480	High calorie
Yogurt natural (50g)	30	60	Low calorie
Orange large (300g)	100	100	Low calorie
Total	**1355 calories**	-	-

2.5 Anthropometric measurements

Anthropometric measurements taken from patients are weight and height to calculate body mass index (weight in kilograms divided by the square of the height in meters, kg/m^2), and the measure of waist circumference to estimate abdominal obesity. The weight in kilograms was measured for shoeless patients and wearing minimal clothing with a trade balance. Height was measured using a device comprising a centimeter tape. The tape was used to measure waist circumference, just below the last rib and on the top of the hip bone.

2.6 Statistical analysis

The results are presented as mean ± SD. The comparison of the means between the control and test subgroups and the group function of the BMI is carried out statically by student t-test. Differences are considered significant when $p < 0.05$.

3. RESULTS

3.1 Patients profile

Weight and height (Mean ±SD) were measured to calculate body mass index; the measure of waist circumference to estimate abdominal obesity was taken. The 72 patients were aged 21.6 ± 2.5 years and were subdivided in two groups. Since we had 33%

of male, we did not consider the gender impact.

Table 2: the table presents the subject characteristics according to BMI class.

	BMI (kg/m²)		**Waist circumference (cm)**	
	Control group	Test group	Control group	Test group
18-24 BMI group	23.89 ± 5.54	24.73 ± 4.37	77.87 ± 13.6	77.48 ± 14
25-30 BMI group	28.47 ± 3.23	30.19 ± 6.11	83.18 ± 21.8	81.15 ± 11.4
	$p<0{,}05$		$p<0{,}05$	

3.2 Postprandial glycemic response

Table3: The table presents the prevalence of Postprandial Hyperglycemia

Characteristics	**Control group (N=34)**	**Test group (N=38)**	**Total**
Normal Postprandial Glycaemia (<1,40g/l)	26	24	50
Postprandial Hyperglycemia (≥1,40g/l)	8	14	22
Total	**34**	**38**	**72**

Approximatively one third of subjects could have an abnormal Postprandial Hyperglycemia.

3.3 Cider vinegar lowering effect of postprandial glycemic response

3.3.1 For the 18-24 BMI group: The mean blood glucose was respectively 0.7±0.17 g/l for the control group and 0.97±0.25 g/l for the test group. 150 minutes after eating, the control group glycaemia was at mean 1.46±0.9 g/l and the test group blood concentration of glucose was 0.72±0.27 g/l. After 180 minutes, the values were respectively 1.72±0.35 g/l and 0.755±0.05 g/l.

3.3.2 For the 25-30 BMI group: The mean blood glucose was respectively 0.8±0.27 g/l for the control group and 1±2.5 g/l for the test group. 150 minutes after eating, the control group glycaemia was at mean 1.4±0.11 g/l and the test group blood concentration of glucose was 0.8±0.24 g/l. After 180 minutes, the values were respectively 1.9±0.75 g/l and 0.7±0.55 g/l.

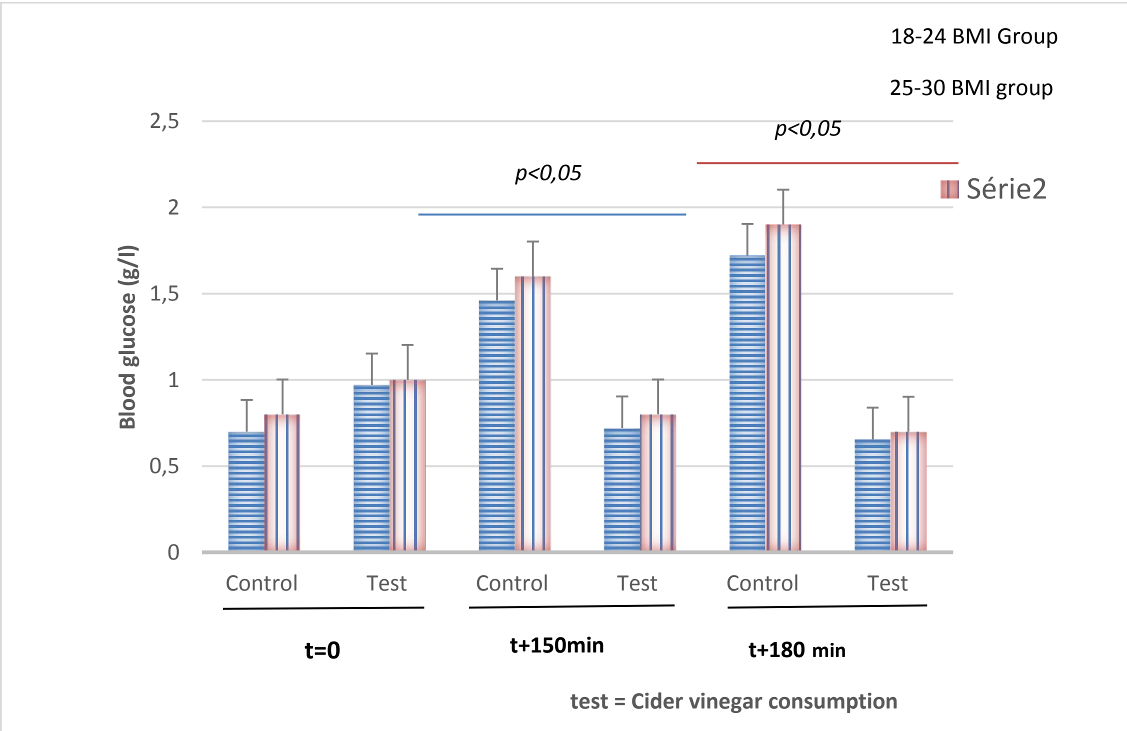

Figure1: The figure presents the effect of cider vinegar on postprandial glycemic response.

4. DISCUSSION

Obesity has reached epidemic proportions in the world, with over 1.6 billion adults being overweight and, at least, 500 million being clinically obese [11]. Obesity, particularly visceral obesity, is a risk factor for several diseases such as type 2 diabetes, cardiovascular complications, hypertension and some types of cancers [12]. Caloric imbalance generally occurs when the balance between energy intake and physical activity is disturbed [13]. However, growing evidence suggests that the calorie imbalance concept may not be sufficient to manage and reverse the obesity epidemic [14]. Based on Estimated Energy Requirements (EER) equations, using reference heights (average) and reference weights (healthy) for each age-gender group, the estimated calorie needs for 20-25 years old moderately active male is 2800 kcal and 2200 kcal for female. Postprandial glycaemia has been implicated in the development of chronic metabolic diseases such as obesity, type 2 diabetes mellitus and cardiovascular diseases [15]. Blood glucose levels measured 2 h after meal, had shown that the largest rises were seen with vegetables (70 ± 5%). followed by breakfast cereals (65 ± 5%), cereals and biscuits (60 ± 3%), fruit (50 ± 5%), dairy products (35 ± 1%), and dried legumes (31 ± 3%). A significant negative relationship was seen between fat ($p < 0.01$) and protein ($p < 0.001$) and postprandial glucose rise but not with fiber or sugar content [16].

Some organs, such as the brain, use glucose continuously and independently of hormonal regulation. Others, such as muscles or adipose tissue, vary their consumption based on physical effort and insulin. But the meals provide the external carbohydrates and trigger hormonal responses, so ultimately determine the nycthemeral glycemic profile. Once evacuated from the stomach, food goes into the intestine where the carbohydrates are digested and absorbed into the bloodstream. At the same time, the liver stops producing endogenous glucose and begins to synthesize glycogen, thus consuming glucose. The muscles also store glucose, or lysate it to produce energy. Adipose tissue can also store glucose in the form of triglycerides. This coordinated reaction of the body is due to a peak of insulin occurring in minutes, followed by a long period of sustained secretion of this hormone, until the return to a normal blood glucose. The secretion of glucagon is blocked. Under these conditions, the blood sugar returns to pre-prandial values in two hours in the healthy person, even as intestinal absorption of carbohydrates continues.

Depending on the meal, the body thus passes successively by three states: (i) the post-meal state, which follows a meal, corresponds to the phase of digestion and absorption of dietary carbohydrates. It lasts about 4 hours. The blood glucose, which rises initially, returns to the pre-prandial values in 2 hours in the healthy subject; (ii) the pre-prandial state, or post absorptive state. The body uses its reserves in glucose, the blood glucose is low; (iii) the state of fasting, which starts 10-12 hours after the last food intake. This is the moment of the minimum blood glucose. A subject taking three daily meals therefore spends about 12 hours a day in a post-meal state, and only two or three - the last of the night - in a fasting state.

In people with postprandial hyperglycemia, glycemic "excursions" are more frequent, long and intense. In particular, after meals: in total, postprandial hyperglycemia periods can be 12 to 15 hours per day in a patient with Type 2 Diabetes, instead of 6 hours in an unaffected person. The cause of the problem is the resistance of the body (liver and muscles in particular) to insulin, as well as a lower secretion of this hormone. Glucagon production can also be increased. As a result, the liver does not stop producing glucose after meals. To this endogenous production, which is clearly higher than in a healthy person, is added the exogenous glucose, because the muscles store it less well. Overall, there is more glucose in the blood for longer [17,18, 19, 20].

Apple cider vinegar had been use as reported by the Old Testament and Hippocrates in combination with honey against infection. Factually, vinegar has been produced and sold for over 5000 years [21]. Vinegar is produced by the conversion of ethyl alcohol to acetic acid by *Acetobacter*. Different methods of production exist [22]. Apple cider vinegar contains organic acids, flavonoids, polyphenols, vitamins and minerals and is produced from cider that has undergone acetous bioconversion and has relatively low acidity (5% acetic acid) [23]. Apple cider vinegar has been hailed as a supplement aiding weight loss, hyperlipidemia, hypercholesterinemia, nutritional support, antioxidant defense and lowering blood pressure. Organic acids can reduce harmful intestinal bacteria [24, 25, 26]. The postprandial glycemic response can be reduced by natural foods. It has been shown that inclusion of oat β-glycan into breakfast cereals could reduce the postprandial glycemic response by up to 50 %. At low levels (below 5 %) this appeared to be dose responsive [27].

We highlight that apple cider vinegar has a hypoglycemic effect as it significantly decreased ($p<0.05$) postprandial blood glucose 150 minutes after meal. Researchers suggest that its use may influence satiety and glycemic control in healthy adults [28, 29], as well as in insulin-dependent subjects, by slowing down gastric emptying, resulting in lower postprandial blood glucose levels [30]. This decrease is maintained, but less significantly after 180 minutes.

In our study, we also studied the anthropometric parameters (BMI and abdominal circumference); their increase seems to induce the blood glucose increase. Especially in the group whose BMI is between 25-30 kg/m^2, the attenuating action of cider vinegar is lessened. Similar results have been demonstrated by the work of Novelli *et al.* [30].

The great novelty of our study is that it provides information on resistance to anti-obesity treatment when BMI increases. This reminds strangely the loss of sensitivity to fatty acids observed in the obese [31] or the existence of a genetic polymorphism in obese people [32]. Our results are confirmed by previous work on mice. It has been revealed that apple cider vinegar has considerable reducing effect on blood glucose levels in diabetic mice [33]. Although the full mechanism of this effect is unclear, one of probable mechanism could be the effect of apple cider vinegar α-amylase. Reduction of α-amylase in liver cells can suppress the conversion of carbohydrates (polysaccharides) into smaller saccharide units such as glucose leading to a reduction in blood glucose levels. Whether apple cider vinegar has any effect on insulin action in peripheral tissues, such as skeletal muscles and adipocytes any other probable mechanisms are unclear that can be further studied. More work is needed to determine the exact nature of the active ingredients.

5. CONCLUSION

These findings demonstrate that drinking a cup of apple cider vinegar at the middle of the meal induced a reduction of postprandial glucose concentration. The benefits of dinking apple cider vinegar are based on natural medicines. The blood sugar level varies during the nycthemeron, mainly under the influence of meals. Postprandial hyperglycemia is difficult to be identified with the usual tests, but still a first step in a progression towards diabetes. It is also strongly correlated with cardiovascular risk. The first answer is dietary, before moving to the medical care.

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