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Synergistic Effect of Green Tea, Cinnamon and Ginger Combination on Enhancing Postprandial Blood Glucose

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Abstract: This study was maintained to determine the immediate effect of green tea, cinnamon, ginger and combination of them on postprandial glucose levels. The Glycemic Index (GI) for previous treatments was measured as an indicator for postprandial glucose pattern. Twenty-two healthy volunteers from both genders were enrolled in this study. Mean age was 21.3 years and mean BMI was 24.6 kg m^{-2}. For each herb and combination treatment, a concentration of 2.5% aqueous tea extract was prepared. The GI of green tea, cinnamon and ginger were 79, 63 and 72 respectively. Herbs combination exerted GI of 60, which was the lowest. Combination of these herbs showed the best lowering effect on postprandial glucose levels as compared with each herb alone. A potential synergism from the active ingredients of blended herbs was determined.

Key words: Glycemic index, cinnamon, ginger, green tea

INTRODUCTION

Herbs and spices are commonly used in human consumption. Most of them have been proved to control blood glucose levels (Viuda-Martos *et al*., 2010). The scale that ranks foods by how much they raise blood glucose levels compared to a standard food is called Glycemic Index (GI). The standard food could be glucose or white bread (CDA, 2009). Much evidence suggest that high blood glucose concentrations in the postprandial state are considered as risk factors for the development of chronic metabolic disorders, not only in diabetic patients but also in healthy people (Trinidad *et al*., 2010). This has led to the concept that reducing postprandial blood glucose concentrations should be targeted in the prevention and treatment of chronic diseases (Rizkalla *et al*., 2002; Pi-Sunyer, 2002).

The most popular herbs consumed in Arabic region are green tea, cinnamon and ginger. Numerous researches elucidated the effect of previous herbs on regulating postprandial glucose levels, while others showed no effect. Some studies on tea extract were found that it had significant lowering effect on postprandial glucose (Faqih and Al Nawaiseh, 2006; Bryans *et al*., 2007; Venables *et al*., 2008), whereas others found no remarkable effect (Park *et al*., 2009; Josic *et al*., 2010). Regarding ginger and cinnamon, there effects on reducing the postprandial glucose were reported by many authors (Hlebowicz *et al*., 2007; Ali *et al*., 2008; Hlebowicz *et al*., 2009; Shakib, 2010; Akilen *et al*., 2012), with no ambiguous results as shown in tea extract.

All previous researches determined the GI of single herb without focusing on the effect of combination. Therefore, this study was designed to determine the effect of ginger, cinnamon and green tea as well as combination of these herbs on postprandial glucose levels and GI values using white bread as a reference in healthy adults.

MATERIALS AND METHODS

Subjects: Twenty-two healthy subjects (10 females and 12 males) were recruited in this study with the following inclusion criteria: aged between 20-23 years, normal Body Mass Index (BMI), normal glucose tolerance test, non-smokers and did not take any medications affecting glucose or insulin levels. This research was approved by Ethics Committee in the Faculty of Applied Medical Sciences (Umm Al-Qura University) and volunteer's written consent had been taken before starting the experiment.

Plants used and preparation of herbal tea extract: Three types of commonly used herbs and spices were chosen in this study that purchased from local grocery. They include: ginger root (*Zingiber officinalis*), cinnamon bark (*Cinnamomum zeylanicum*) and green tea leaves (*Camellia sinsesis*). The aqueous tea extract of previous plants was prepared to a concentration of 2.5%, which is the average usual concentration consumed. Also, 2.5% concentration of combination treatment was prepared. For preparing ginger and cinnamon teas 25 g of grated ginger root or grinded cinnamon bark were boiled in 1 L of water, then infused for 10 min followed by filtering and

cooling. Regarding green tea, 25 g of dried green tea leaves infused directly for 10 min then filtered and cooled. To prepare herbal combination, 8.33 g of each grated ginger and grinded cinnamon was mixed and then boiled in 1 L of water. Before infusion, other 8.33 g of dried green tea leaves was added and finally the solution was allowed to filter and cool.

Study protocol: This study was randomized crossover design. About 50 g white bread was used as control. Subjects came on different days to complete the control and each herbal treatment separately after an overnight fasting for 10 h at least. Control treatment was done first for all subjects by consuming 50 g white bread and 200 mL of water. Then same participants drank 200 mL of 2.5% concentration of each treatment in separate occasions, with the same time 50 g white bread. After ingestion the meals within 10 min, blood samples were taken at 0, 30, 60, 90 and 120 min. Blood samples were collected and centrifuged immediately after complete clotting at 5000 rpm for 6 min. Serums were used for glucose analysis using human biochemical analyzer (Siemens Dimension RXL, German) available in Faculty of Applied Medical Sciences (Umm Al-Qura University). To ensure best GI results, the control and tested herbs were fed in three times at separate occasions.

The Area Under the Curve (AUC) for each treatment was calculated geometrically according to the equations reported by Brouns *et al.* (2005). GI was calculated as percentage of AUC of the white bread and herb or combination divided by AUC of the white bread (control). Foster-Powell *et al.* (2002) classified foods according to their GI into 3 categories: high GI when calculated GI is between 70-100, moderate GI as GI around 50-70 and lower than 50 a food can be considered as low GI.

Statistical analysis: Statistical analysis was performed by using SAS software (Statistic Analysis System) version 9.1. Least Significant Differences (LSD) test was attained for comparison between means. Means were considered statistically significant when p-value less than 0.05.

RESULTS

The characteristics of participants are mentioned in the Table 1. Table 1 shows that the mean age (year) of the whole samples was 21.3, and the mean BMI was 24.6 kg m^{-2}. The average fasting blood glucose (mg dL^{-1}) was 78.6±7.5 as well as subjects had normal glucose tolerance test as shown from the results of control blood glucose response (Table 2). Therefore, no diabetic, prediabetic or insulin resistant subjects were included in this study.

Table 1: Characteristics of sample study

Parameter	Male (n = 12)	Female (n = 10)	Total (n = 22)
Age (year)	22.00±0.800	20.5±0.60	21.30±1.040
Height (m)	1.72±0.030	1.6±0.04	1.65± 0.060
Weight (kg)	70.80±1.700	63.3±2.80	67.10±4.500
BMI (kg m^{-2})	24.40±2.700	24.7±3.40	24.60±6.700
Fasting blood glucose (mg dL^{-1})	80.40±7.100	76.8±5.20	78.60±7.500

Results are considered as Mean±SD, BMI: Body Mass Index

Table 2 shows the average serum glucose concentrations, AUC and GI of herbal teas and combination treatment. The glycemic indices for green tea, cinnamon and ginger were 79 (high), 63 (moderate) and 72 (high), respectively. Herbs combination exerted GI of 60 (moderate), which was the lowest as compared with other treatments. Previous results showed significantly ($p \leq 0.05$) lower GI than the control.

Figures 1-4 and present the pattern of mean serum glucose response to white bread as affected by green tea, cinnamon, ginger and combination treatment, respectively. Figure 1-4 demonstrate that after consuming any herb or combination of them, postprandial glucose

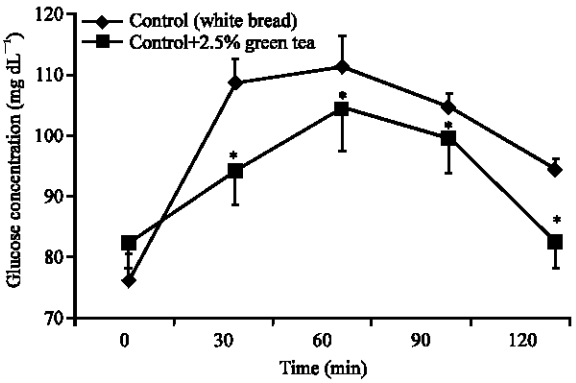

Fig. 1: Mean serum glucose response to white bread as affected by green tea. *Denotes significant differences in serum glucose changes at p<0.05

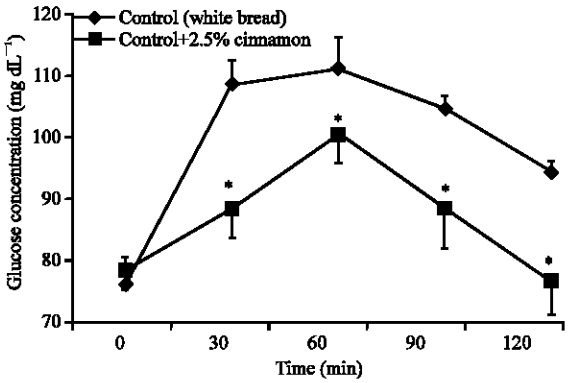

Fig. 2: Mean serum glucose response to white bread affected by cinnamon. *Denotes significant differences in serum glucose changes at p<0.05

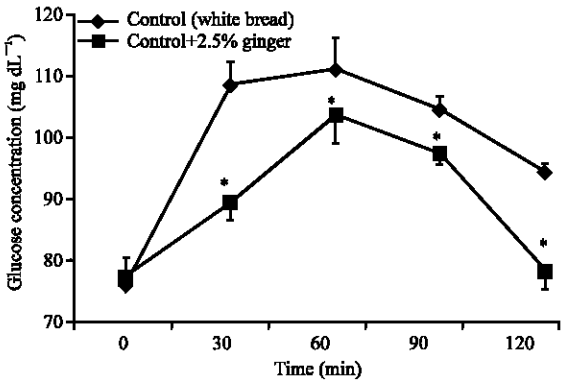

Fig. 3: Mean serum glucose response to white bread affected by ginger. *Denotes significant differences in serum glucose changes at $p<0.05$

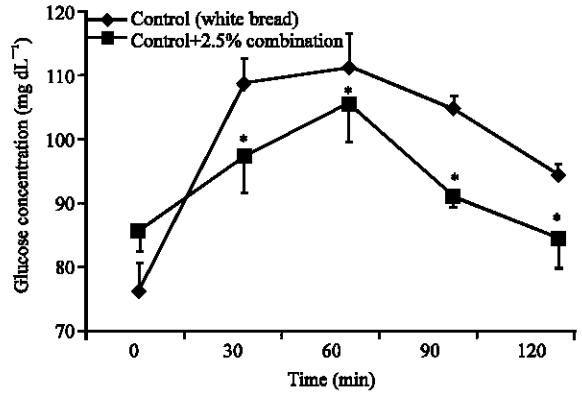

Fig. 4: Mean serum glucose response to white bread affected by combination of herbs. *Denotes significant differences in serum glucose changes at $p<0.05$

concentrations decreased significantly ($p\leq0.05$) in all tested times. Peak Increment (PI) can be calculated for each curve by subtracting the highest level of postprandial serum glucose from the fasting concentration. PI is a good indicator for the efficacy of any treatment on postprandial serum glucose (Lunetta *et al*., 1995). Average PI (mg dL^{-1}) values for green tea, cinnamon, ginger and combination treatments were 21.9±7.2, 22±7.9, 26.2±6.8 and 20±7.3, respectively, while for control treatment was 34.9±5.9. Combination treatment was also showed the lowest PI value as compared with others.

DISCUSSION

This study is the first that demonstrated the effect of combination of herbs on postprandial glucose concentrations. As shown from previous results, studied herbs had hypoglycemic effect. This effect was noticeably improved by combination treatment. Hypoglycemic effect from each herb was related to their active ingredients. Green tea has flavanols polyphenol called catechins (Da Silva Pinto, 2013), which can considerably decrease the postprandial blood glucose levels in human (Tsuneki *et al*., 2004; Venables *et al*., 2008). Epigallocatechin gallate (ECGC) is the most effective catechin in green tea extract (Auger *et al*., 2004). In addition, long term intervention and epidemiological studies demonstrated that tea catechins reduced the risk and prevalence of type 2 diabetes (Odegaard *et al*., 2008; Jing *et al*., 2009; Panagiotakos *et al*., 2009). Josic *et al*. (2010) listed some mechanisms associated with reducing blood glucose levels by green tea, those are; suppressing glucose absorption in small intestine, increasing the basal and insulin-stimulated uptake by adipocytes, ameliorating insulin resistance by increased expression of glucose transporter in adipocytes and suppressing gluconeogenesis in hepatoma cells. The GI of green tea in this study was 79 and postprandial glucose levels decreased significantly in all times. Park *et al*. (2009) were partially in line with study results to the effect that green tea lower significantly glucose levels at the first 60 min, but after that glucose concentrations increased. Josic *et al*. (2010) were in agreement with the previous result and reported that studies on the immediate effects of green tea on glucose levels were not fully concluded and could be related to variations in the bio availability and metabolism of catechins in humans. In addition, De Bock *et al*. (2012) declared that tea polyphenols have variations between subjects that might be explained by heterogeneity in enzymatic activity and gut flora in humans.

Cinnamon tea alone showed the lowest GI as compared with single herbs. This could be related to that cinnamon extract contains biologically active substances with insulin-mimetic properties (Soliman *et al*., 2012). Essential oils in cinnamon have many functional ingredients and the primary one is cinnamaldehyde, which possess hypoglycemic activity (Subash Babu *et al*., 2007). Furthermore, a water-soluble polyphenol type-A polymer isolated from cinnamon has been shown to enhance insulin activity (Anderson *et al*., 2004). Many authors reported that cinnamon reduced postprandial glucose levels in human by delaying gastric emptying (Hlebowicz *et al*., 2007, 2009; Akilen *et al*., 2012), decreasing glucose absorption (Kim *et al*., 2006), increasing the insulin sensitivity and glucose uptake in adipocytes (Jarvill-Taylor *et al*., 2001), as well as regulating glucose transporter and insulin-signaling gene expression in adipocytes (Cao *et al*., 2010).

Table 2: Average serum glucose concentrations, AUC and GI for herbs and combination treatment

	Serum Glucose Concentration (mg dL^{-1})							
Treatment	0 min	30 min	60 min	90 min	120 min	AUC (mg. min dL^{-1})	GI %	Classification
Bread	76.2±4.4	108.6±3.9	111.1±5.2	104.6±2.1	94.4±1.7	3750.7^{a}±425.2	100^{a}	High
Bread+2.5% Green Tea	82.4±4.2	94.1±5.4	104.3±6.9	99.6±5.8	82.5±4.5	2966.8^{b}±283.5	79^{b}±6	
Bread	76.2±4.4	108.6±3.9	111.1±5.2	104.6±2.1	94.4±1.7	3750.7^{a}±425.2	100^{a}	Moderate
Bread+2.5% Cinnamon	78.5±2.9	88.4±4.8	100.5±4.5	88.6±6.8	76.8±5.5	2366.7^{b}±317.1	63^{b}±7	
Bread	76.2±4.4	108.6±3.9	111.1±5.2	104.6±2.1	94.4±1.7	3750.7^{a}±425.2	100^{a}	High
Bread+2.5% Ginger	77.5±6.5	89.5±2.8	103.7±4.4	97.5±1.7	78.5±2.9	2700.5^{b}±243.2	72^{b}±5	
Bread	76.2±4.4	108.6±3.9	111.1±5.2	104.6±2.1	94.4±1.7	3750.7^{a}±425.2	100^{a}	Moderate
Bread+2.5% Combination	85.5±3.1	97.3±5.6	105.5±6.0	91.1±1.6	84.5±4.7	2253.9^{b}±357.5	60^{b}±5	

Results are considered as Mean±SD. Means in the same column with different subscripts are significantly ($p<0.05$) different according to LSD Abbreviations; AUC: Area Under the Curve; GI: Glycemic Index Classification to high, moderate or low GI was determined according to Foster-Powell *et al.* (2002)

Cinnamon is believed to be superior in treating diabetes (Khan *et al*., 2003; Mang *et al*., 2006; Crawford , 2009; Akilen *et al*., 2010, 2012). Cinnamon tea had moderate GI (Table 2) with value of 63. Faqih and Al Nawaiseh, (2006) were in agreement with study result who concluded that GI of 4 g cinnamon/cup was 54, which also considered moderate GI according to Foster-Powell *et al.* (2002). Vanschoonbeek *et al.* (2006) reported that after ingestion of 5 g cinnamon, postprandial blood glucose concentrations, insulin sensitivity and an oral-glucose-tolerance test were improved in healthy subjects. Although Hlebowicz *et al.* (2007) found that 6 g cinnamon mixed with 300 g rice pudding decreased postprandial blood glucose concentrations significantly, 1 and 3 g cinnamon didn't show similar effect Hlebowicz *et al*., (2009), which means that low cinnamon concentration used in a meal will not exert remarkable postprandial blood glucose reduction.

Regarding ginger, studies the immediate effects of ginger on blood glucose are not common as green tea and cinnamon. This possibly related to high pungent taste of raw ginger tea and its taste is not acceptable for volunteers. The pungency of fresh ginger is primarily due to active ingredients known as gingerols, which are a homologous series of phenols (Ali *et al*., 2008). The most abundant gingerol in fresh ginger is 6-gingerol (Wohlmuth *et al*., 2005). The hypoglycemic effect of ginger is well-documented through decreasing glucose absorption (Al-Amin *et al*., 2006; Goyal and Kadnur, 2006) and improving insulin sensitivity (Kadnur and Goyal, 2005; Kubra and Rao, 2012). Ginger has aldose reductase inhibitors that are considered to have remarkable potential for treatment of diabetes (Giannoukakis, 2006). Moreover, the antidiabetic effect of ginger was also proved by its antioxidant, antiglycation and potential to express or transport Glut 4 receptors from internal vesicles (Li *et al*., 2012; Rani *et al*., 2012). The GI of ginger was high (72), as seen in Table 2. As mentioned before, no detailed studies on the effect of ginger on postprandial glucose level, although the hypoglycemic effect is well-known.

Combination treatment showed the lowest GI (60; moderate) and PI (20±7.3), which indicated that combination of active ingredients from green tea, cinnamon and ginger exerted synergistic action on reducing of postprandial glucose levels. Although the amount of each herb used for combination treatment preparation was 8.33 g L^{-1} and for each herb was 25 g L^{-1} to prepare 2.5% concentration, but the synergism between active ingredients unexpectedly decreased GI. Such synergism should be studied further *in vitro* to determine exactly how extent these active ingredients affect postprandial blood glucose. Also, other combinations should be studied like green tea and cinnamon, ginger and cinnamon as well as green tea and ginger.

The strength points of this study are the first that determined the effect of combination of herbs on postprandial glucose, no studies calculated the GI of ginger alone and the study design and recruited subjects were matched with other similar studies. A potential limitation of this study is the absence of determination of the postprandial insulin response to herbal treatments.

CONCLUSION

This study showed that GI of cinnamon tea was the lowest as compared with green and ginger teas alone. A prospective synergism after mixing previous herbs on postprandial glucose levels was revealed. This conclusion will support further studies with more herbal combinations for better regulating glucose levels in healthy or diabetic people.

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