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Effects of Ginger and Clove Oils on Some Physiological Parameters in Streptozotocin-Diabetic and Non-Diabetic Rats

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The effects of ginger and clove oils on some physiological parameters were examined in streptozotocin (STZ)-induced diabetic and non-diabetic male Wistar rats. STZ-induced diabetic rats given the control diet had the lowest body weight change, body temperature, thyroid-stimulating hormone (TSH), triiodothyronine (T_3) and thyroxine (T_4) levels after 2 weeks. Diabetic rats given diets containing the oils of ginger, clove, or mixture of them had higher body weight change, body temperature, TSH, T_3 and T_4 levels than diabetic rats given the control diet. No significant differences were observed in the above physiological parameters of normal rats fed on the examined oils when compared with those rats fed on the control diet after 2 weeks. There were no significant differences in body temperatures of diabetic rats fed on the diets containing the different oils when compared with normal rats fed on the same diets after 2 weeks. These data indicate that the diets containing the oils of ginger, clove, or mixture of them improve the examined physiological parameters in STZ-induced diabetic rats.

Key words: Streptozotocin, diabetes, ginger oil, clove oil, body weight, temperature, thyroid-stimulating hormone, triiodothyronine, thyroxine, rats

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INTRODUCTION

Evidence from several studies indicates that weight gain during adulthood is associated with increased risk of type 2 diabetes (Leprohon-Greenwood and Anderson, 1986; Flaten *et al.*, 1990; Friedman, 1990; Storlien *et al.*, 1991; Wood *et al.*, 1993; Kuller, 1997). Weight gain was associated with substantially increased risk of diabetes among overweight adults and even modest weight loss was associated with significantly reduced diabetes risk (Resnick *et al.*, 2000). Many physiological defects have been reported in diabetic patients (Dhalla *et al.*, 1985; Ren and Daviodoff, 1997; Choi *et al.*, 2002). Several studies have demonstrated reductions in body weight and body temperature of rats following streptozotocin (STZ) treatment (Zhang *et al.*, 2002; Soudamani *et al.*, 2005; Howarth *et al.*, 2004, 2005). Thyroid-stimulating hormone (TSH), triiodothyronine (T_3) and thyroxine (T_4) levels were also reduced in STZ-induced diabetic rats (Gonzalez *et al.*, 1980; Ortiz-Caro *et al.*, 1984; Bestetti *et al.*, 1987; Zhang *et al.*, 2002).

There have been many studies to examine the effect of various oils on physiological parameters and understanding of that has obvious health related significance. The hypothesis that oils can predictably alter blood lipid levels significantly continues to be an issue of considerable interest in the scientific work (Wood *et al.*, 1993). Variations in dietary fatty acid content have been shown to affect several metabolic processes (Flaten *et al.*, 1990; Storlien *et al.*, 1991; Friedman, 1990; Kuller, 1997). Many studies have also shown the capacity of dietary manipulation to modify brain biochemistry (Leprohon-Greenwood and Anderson, 1986; Yehuda, 1987) and behavior (Wurtman, 1982; Maimanee *et al.*, 2003).

The medicinal benefits of herbs have been known for centuries. Herbal remedies (phytomedicines) possess significant pharmacological activity and consequently potential adverse effects and drug interactions (Pribitkin, 2005). Herbal medicinals are being used by an increasing number of patients who typically do not advise their clinicians of concomitant use. Known or potential drug-herb interactions exist and should be screened for (Miller, 1998).

Little information exists concerning the beneficial effects of ginger (*Zingiber officinale*) and clove (*Syzygium aromaticum*) on physiological defects in diabetic animals. To provide more detailed information, the present study was undertaken to investigate the effects of four diets containing 5% ginger oil, 5% clove oil, a mixture of 2.5% ginger oil plus 2.5% clove oil, or the control diet on the body weight change, body temperature, blood thyroid-stimulating hormone (TSH), triiodothyronine (T_3) and thyroxine (T_4) levels in streptozotocin (STZ)-induced diabetic and non-diabetic male Wistar rats.

MATERIALS AND METHODS

Animals: Wistar rats (bred and housed in the animal house of King Fahd Medical Research Center, King Abdul Aziz University, Jeddah, Saudi Arabia) were maintained in a temperature-controlled room (24±1°C) with a 12 h light/dark cycle and were given free access to food and water. The maintenance and experimental procedures were conducted in King Fahd Medical Research Center, in June 2006.

Healthy eighty young adult male Wistar rats (225-252 g) were transferred shortly before being used in experiments to a specific experimental room. In this new location, animals were housed 5 per cage and they were maintained under the same photo-thermal regime.

The eighty rats were divided into eight groups (each one of 10 rats). Rats of the first group were intraperitoneally injected with 0.5 mL sodium citrate buffer solution (pH 4.5), served as controls, fed ad libitum on normal commercial chow and had free access to water. Diabetes was induced in forty of the eighty rats by a single intraperitoneal injection of STZ (Sigma Chemical Company, St. Louis, Mo, USA) at a dose of 30 mg kg^{-1} body weight in 0.5 mL sodium citrate buffer solution. Four days after STZ injection, the blood samples were collected from orbital venous plexus in the fasted rat (2 samples from each group of the diabetic rats), water not restricted and the level of serum glucose was determined. The serum glucose level of over 277 mg dL^{-1} was defined as diabetic model rats. Therefore, the second, third, fourth and fifth groups were STZ-induced diabetic rats. Rats of the second group fed the same diet given in the first group. The third, fourth and fifth groups fed the diets contained by weight: 5% ginger oil, 5% clove oil and 2.5% ginger oil plus 2.5% clove oil, respectively. Similarly, the sixth, seventh and eighth groups of the normal rats received 0.5 mL sodium citrate buffer solution (pH 4.5) and fed the diets contained by weight: 5% ginger oil, 5% clove oil and 2.5% ginger oil plus 2.5% clove oil, respectively. The duration of these experiments was two weeks.

Body weight: Rats were weighed at the start of the experimental period and weekly for two weeks, using a digital balance. These weights were determined at the same time during the morning.

Body temperature: The core temperature of each rat was measured at the start of the experimental period and weekly for two weeks, by inserting the probe of a digital thermometer into the rectum for a distance of approximately one cm. The body temperatures were determined at the same time during the morning. The animals were handled gently for this purpose and did not appear to struggle excessively (a factor which could have elevated body temperature).

Blood sampling: After two weeks, the rats were fasted for 8 h before blood sampling, water was not restricted. Blood samples were rapidly taken from orbital venous plexus into non-heparinized tubes, centrifuged at 2000 rpm for 20 min and blood sera were then collected and stored at 4°C. Thyroid-stimulating hormone (TSH), triiodothyronine (T_3) and thyroxine (T_4) concentrations were determined by the radioimmunoassay (RIA). All experimental procedures were approved by the Animal Care and Use Committee of King Abdul Aziz University.

Statistical analysis: Statistical analyses were performed using SPSS package for Windows version 10 (SPSS Inc., 1999). Data are expressed as means±standard errors. One-way ANOVA and two-way ANOVA were used to analyze differences among groups. Post-hoc analyses of significance were made using least-significant difference (LSD) test. Differences were considered significant at $p<0.05$.

RESULTS

Body weight change: Table 1 shows mean body weight and mean body weight change (gain or loss) in the eight groups of male rats after one week and two weeks. Two-way ANOVA demonstrated significant effects for the treatment ($p<0.001$) and duration ($p<0.001$). The treatment x duration ($p<0.001$) interaction was also significant. Further analysis with LSD test revealed that STZ-induced diabetic rats given the control diet had the lowest body weight change after two weeks ($p<0.05$). STZ-induced diabetic rats given diets containing the oils of ginger, clove, or mixture of them had higher body weight changes than STZ-induced diabetic rats given the control diet after two weeks ($p<0.05$). STZ-induced diabetic rats given diets containing the oils of ginger or mixture of ginger and clove had higher body weight changes than STZ-induced diabetic rats given the diet containing clove oil after two weeks ($p<0.05$). No significant differences were observed in body weight change of healthy rats fed on diets containing the oils of ginger, clove, or mixture of them when compared with those rats fed on the control diet

Table 1: Effects of ginger, clove and ginger plus clove oils supplementation on body weight (mean±SE) in STZ-diabetic and non-diabetic rats, n = 10. Percent changes (mean±SE) are included in parentheses

| Treatment	Time (week)		
	0	1	2
Control	239.10±2.10	265.50±3.26 (11.02±0.55)	291.00±3.67 (21.68+0.70)
STZ	241.90±2.19	264.00±2.65 (9.14±0.63)	264.80±2.76 (9.47±0.57)
STZ + ginger oil	237.90±1.92	260.40±2.15 (9.46±0.42)	277.40±2.20 (16.62±0.51)
STZ + clove oil	236.00±1.69	257.90±1.70 (9.29±0.20)	266.70±2.01 (13.01±0.42)
STZ + ginger plus clove oils	235.90±2.41	260.10±2.86 (10.27±0.67)	277.60±3.08 (17.67±0.42)
Ginger oil	233.70±2.62	259.00±2.91 (10.84±0.55)	282.10±5.05 (20.64±0.88)
Clove oil	238.30±2.58	262.30±2.75 (10.09±0.57)	288.60±3.03 (21.13±0.71)
Ginger plus clove oils	237.70±2.16	262.70±2.22 (10.53±0.44)	286.40±3.36 (20.47±0.51)
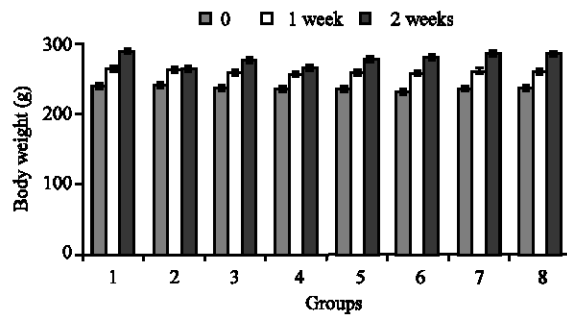
Fig. 1: Body weight changes (mean±SE) at 0, 1 and 2 weeks in groups 1(control), 2 (STZ), 3 (STZ+ ginger oil), 4 (STZ+ clove oil), 5 (STZ+ ginger plus clove oils), 6 (ginger oil), 7 (clove oil) and 8 (ginger plus clove oils), n = 10

after two weeks. Normal rats exposed to the diets containing tested oils for two weeks had higher body weight changes than those exposed for one week ($p<0.05$). STZ-induced diabetic rats exposed to the diets containing tested oils for two weeks had higher body weight changes than those exposed for one week ($p<0.05$). However, the body weight change of STZ-induced diabetic rats given the control diet after two weeks did not differ from STZ-induced diabetic rats given the control diet after one week (Fig. 1).

Body temperature: Two-way ANOVA demonstrated significant effects for the treatment ($p<0.001$) and duration ($p<0.001$). The treatment x duration ($p<0.001$) interaction was also significant (Table 2). Further analysis with LSD test revealed that STZ-induced diabetic rats given the control diet had the lowest body temperature after two

Table 2: Effects of ginger, clove and ginger plus clove oils supplementation on body temperature (mean±SE) in STZ-diabetic and non-diabetic rats, n = 10

Treatment	Time (week)		
	0	1	2
Control	36.75±0.06	36.78±0.06	36.80±0.05
STZ	36.82±0.03	34.47±0.30	34.06±0.32
STZ + ginger oil	36.73±0.07	35.68±0.35	36.31±0.08
STZ + clove oil	36.76±0.06	36.07±0.15	36.40±0.13
STZ + ginger plus clove oils	36.72±0.06	36.69±0.10	36.73±0.08
Ginger oil	36.77±0.05	36.67±0.08	36.75±0.09
Clove oil	36.76±0.04	36.78±0.08	36.68±0.10
Ginger plus clove oils	36.72±0.07	36.70±0.04	36.70±0.08

weeks ($p<0.05$). STZ-induced diabetic rats given diets containing the oils of ginger, clove, or mixture of them had higher body temperatures than STZ-induced diabetic rats given the control diet after one week or two weeks ($p<0.05$). STZ-induced diabetic rats given the diet containing the mixture of ginger and clove oils had significantly higher mean body temperatures than STZ-induced diabetic rats given the diet containing clove or ginger oils after one week ($p<0.05$). No significant differences were observed in body temperature of STZ-induced diabetic rats given the diet containing the mixture of ginger and clove oils when compared with healthy rats fed on diets containing the oils of ginger, clove, or mixture of them after one week. No significant differences were observed in body temperature of STZ-induced diabetic rats fed on diets containing ginger, clove, or mixture of them when compared with healthy rats fed on the same diets after two weeks. There were no significant differences in body temperature of healthy rats fed on diets containing the oils of ginger, clove, or mixture of them when compared with those rats fed on the control diet after one week or two weeks. STZ-induced diabetic rats given the control diet after two weeks had lower body temperatures than STZ-induced diabetic rats given the control diet after one week ($p<0.05$). However, STZ-induced diabetic rats exposed to the diet containing ginger oil for two weeks had higher body temperatures than those exposed for one week ($p<0.05$) (Fig. 2).

Blood TSH: One-way ANOVA demonstrated significant effects for the treatment ($p< 0.001$) after two weeks (Table 3). Further analysis with LSD test showed that STZ-induced diabetic rats given the control diet had the lowest TSH level ($p<0.05$). STZ-induced diabetic rats given diets containing the oils of ginger, clove, or mixture of them had higher TSH levels than STZ-induced diabetic rats given the control diet ($p<0.05$). STZ-induced diabetic rats given the diets containing the oils of ginger or the mixture of ginger and clove had significantly higher mean blood TSH values than STZ-induced diabetic rats given
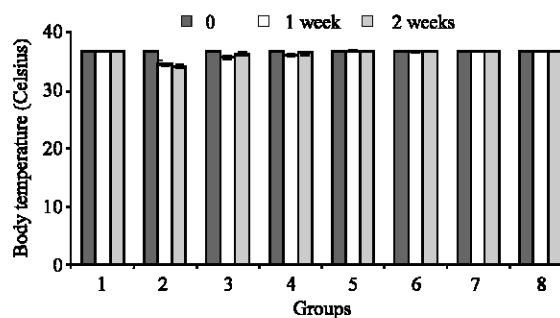

Fig. 2: Body temperature changes (mean±SE) at 0, 1 and 2 weeks in groups 1(control), 2 (STZ), 3 (STZ+ ginger oil), 4 (STZ+ clove oil), 5 (STZ+ ginger plus clove oils), 6 (ginger oil), 7 (clove oil) and 8 (ginger plus clove oils), n = 10

Table 3: Influences of ginger, clove and ginger plus clove oils supplementation on the levels of serum TSH, T_3 and T_4 (mean±SE) in STZ-diabetic and non-diabetic rats, n = 5

Treatment	TSH (ng mL^{-1})	T_3 (nmol L^{-1})	T_4 (nmol L^{-1})
Control	0.83±0.03	1.43±0.07	49.68±1.21
STZ	0.44±0.03	0.67±0.02	26.58±1.27
STZ + ginger oil	0.72±0.02	1.08±0.07	40.36±1.28
STZ + clove oil	0.54±0.02	0.90±0.04	35.20±1.17
STZ + ginger plus clove oils	0.67±0.03	0.98±0.08	37.66±1.43
Ginger oil	0.81±0.04	1.48±0.06	49.32±1.09
Clove oil	0.85±0.03	1.47±0.04	48.86±1.53
Ginger plus clove oils	0.83±0.03	1.46±0.04	49.60±1.34

the diet containing clove oil ($p<0.05$). No significant differences were observed in TSH level of healthy rats fed on diets containing the oils of ginger, clove, or mixture of them when compared with those rats fed on the control diet.

Blood T_3: Table 3 shows mean blood T_3 levels in eight groups of male rats after two weeks. One-way ANOVA demonstrated significant effects for the treatment ($p<0.001$) after two weeks. Further analysis with LSD test showed that STZ-induced diabetic rats given the control diet had the lowest T_3 level ($p<0.05$). STZ-induced diabetic rats given diets containing the oils of ginger, clove, or mixture of them had higher T_3 levels than STZ-induced diabetic rats given the control diet ($p<0.05$). STZ-induced diabetic rats given the diet containing ginger oil had significantly higher mean blood T_3 values than STZ-induced diabetic rats given the diet containing clove oil ($p<0.05$). No significant differences were observed in T_3 level of healthy rats fed on diets containing the oils of ginger, clove, or mixture of them when compared with those rats fed on the control diet.

Blood T_4: Table 3 shows mean blood T_4 levels in eight groups of male rats after two weeks. One-way ANOVA demonstrated significant effects for the treatment

(p<0.001) after two weeks. Further analysis with LSD test showed that STZ-induced diabetic rats given the control diet had the lowest T_4 level (p<0.05). STZ-induced diabetic rats given diets containing the oils of ginger, clove, or mixture of them had higher T_4 levels than STZ-induced diabetic rats given the control diet (p<0.05). STZ-induced diabetic rats given the diet containing ginger oil had significantly higher mean blood T_4 values than STZ-induced diabetic rats given the diet containing clove oil (p<0.05). No significant differences were observed in T_4 level of healthy rats fed on diets containing the oils of ginger, clove, or mixture of them when compared with those rats fed on the control diet.

DISCUSSION

In the present study, STZ-induced diabetic rats given the control diet had the lowest body weight change after two weeks. Similarly, several studies showed that the diabetic rats had significantly lower weight gain than the controls (Howarth *et al.*, 2004; Lo *et al.*, 2004; Vasudevan and McNeill, 2006). In the study of Vasudevan and McNeill (2006), they demonstrated that the diabetic rats lost significant body weight (357±2 g) compared to controls (482±3 g). Moreover, Howarth *et al.* (2004) found that body weight in diabetic rats declined from 271 g before the administration of STZ to 238 g at 30 days after STZ treatment, whereas the body weight of control rats increased significantly from 247 to 314 g. Failure to use glucose for energy leads to increased utilization and decreased storage of proteins as well as fat. Therefore, a person with severe untreated diabetes mellitus suffers rapid weight loss and lack of energy despite eating large amounts of food. Without treatment, these metabolic abnormalities can cause severe wasting of the body tissues and death within a few weeks (Guyton and Hall, 2000). Numerous reports showed that several of herbal extracts prevented the decreases in body weight in diabetic rats (Dhandapani *et al.*, 2002; Ozsoy-Sacan *et al.*, 2004, 2006). Also, Al-Amin *et al.* (2006) reported that the ginger-treated diabetic rats sustained their initial weights during the treatment period.

The dietary composition may alter metabolism and physical activity, resulting in body temperature change. It is suggested that quantitative changes in dietary fat content are capable of altering physiological mechanisms, which mediate indices including thermoregulation in rats (Yehuda *et al.*, 1986). Thermogenesis affects the energy expenditure and energetic efficiency in mammals (Rothwell and Stock, 1983). Body temperature is affected by many factors such as food, exercise, time of day, environmental temperature, drug, disease, sex and age (Zari, 1998; Ganong, 1999; Guyton and Hall, 2000). The results of the present study have revealed significant

reductions in body temperature following STZ treatment. STZ-induced diabetic rats given the control diet had the lowest body temperature after two weeks. Similarly, rectal temperature was significantly decreased in STZ- diabetic rats (Zhang *et al.*, 2002). Howarth *et al.* (2004, 2005) reported that heart rate, heart rate variability, physical activity and body temperature declined rapidly to a new steady state soon after the administration of STZ. Reduced physical activity may partly underlie the reduction in heart rate, heart rate variability and body temperature. Reductions in high frequency spectral power suggest that parasympathetic drive to the heart may be altered during the early stages of STZ-induced diabetes (Howarth *et al.*, 2004). Moreover, in the investigations of Attele *et al.* (2002) and Xie *et al.* (2004), they showed that herbal supplementations increased body temperature in hypothermic diabetic-animals. Additionally, Attele *et al.* (2002) reported that the diabetic mice were significantly hypothermic (35.6±0.2°C) compared with their lean littermates (36.9±0.2°C). After treatment with *Panax ginseng* berry extract, body temperature in diabetic mice significantly increased from 35.6±0.1 to 36.6±0.1°C .

Reduced body temperature may partly be explained by a reduction in calorigenic response to noradrenaline which is observed only 2 days after STZ treatment but is normalized by insulin treatment (Shibata *et al.*, 1987; Howarth *et al.*, 2006). Cold exposure produced severe hypothermia in diabetic rats. It is suggested that diabetic rats were unable to maintain body temperature in the cold, probably because of a failure to generate an adequate amount of heat by non-shivering thermogenesis in brown adipose tissue (Macari *et al.*, 1986). There was also an extreme sensitivity of diabetics to high environmental temperature and heat stress (Frascella *et al.*, 1977). At 28°C, STZ-induced diabetic rats had higher rate of oxygen consumption, tail skin blood flow, but lower rectal temperatures than saline-injected controls. Chronic exposure of the diabetic rats to 35 and 5°C caused sharp a sharp rise and decline in rectal temperatures, respectively. It is suggested that hypothermia in diabetic rats may be associated with impairment of vasoconstriction and hyperthermia may be related to an increase in the rate of oxygen consumption not accompanied by greater vasodilation (Shalaby *et al.*, 1989).

In this study, STZ-induced diabetic rats given the control diet had the lowest TSH, T_3 and T_4 levels. Several studies showed that STZ-induced diabetes mellitus resulted in reduced blood levels of TSH, T_3 and T_4 (van Haasteren *et al.*, 1997; Alaez *et al.*, 2001; Baydas *et al.*, 2002). Vasa and molitch (2001) reported

that the endocrine adaptations to critical illness are varied. In the diabetic patient, counterregulatory hormones predispose to insulin resistance and hyperglycemia, a derangement accentuated by the use of glucocorticoids and enteral or parenteral nutrition. Thyroid abnormalities include the euthyroid sick syndrome, which may manifest as a low T3, low T4, low TSH, or all three. Illness in patients with pre-existing hypothyroidism or hyperthyroidism may precipitate myxedema coma or thyroid storm, respectively. Alaez *et al.* (2001) demonstrated that the influence of hypothalamic and pituitary type II 5'deiodinase (5'D-II) activities and T3 content on pituitary TSH content was investigated in streptozotocin (STZ)-induced diabetic rats. These results in diabetic rats indicate that the hypothalamic and pituitary 5'D-II activity and hypothalamic T3 content are affected by diabetes and play a role in the regulation of pituitary TSH content. Additionally, Gonzalez *et al.* (1980) reported that STZ-diabetic Wistar rats showed decreased plasma TSH and diminished pituitary TSH content, with greater alterations in rats receiving the highest STZ dose. Diabetic rats showed an almost 50% reduction of hypothalamic TRH content in comparison with the mean control value. The fact that diabetes caused a reduction in the hypothalamic TRH content indicates that the primary cause of pituitary-thyroid alterations in STZ-diabetic rats lies in the hypothalamus (Gonzalez *et al.*, 1980). Diabetes resulted in a significant depression of TSH, T_4 and T_3 peaks. However, insulin administration to diabetic rats restored the normal pattern of secretion (Ortiz-Caro *et al.*, 1984). Insulin replacement was only able to prevent the adverse effects of diabetes on certain parameters and this response was region-specific (Soudamani *et al.*, 2005). Bestetti *et al.* (1987) demonstrated that streptozotocin diabetes in rats is associated with reduced function of the hypothalamo-pituitary-thyroid axis. Plasma T_3, T_4 and TSH levels were markedly reduced and the TSH response to TRH was deficient in diabetic animals. There are severe structural changes in the thyroid and pituitary glands of diabetic rats which are accompanied by marked alterations of their secretory activity. Moreover, Zhang *et al.* (2002) found that serum free thyroxine concentrations were significantly decreased in the 8 week diabetic group. These changes were prevented by administration of triiodothyronine or insulin. Insulin treatment is often associated with weight gain. Reasons for this weight gain include: patients who have poorly controlled diabetes sometimes experience weight loss because their bodies are unable to properly convert food into energy and taking insulin helps reverse that process and can result in

a weight gain; when blood glucose runs high the individual can become dehydrated as his body works to clear itself of all that excess glucose and getting the blood glucose under better control may cause the body to retain fluid; once the patient starts taking insulin injections, glucose in his blood can get into the body's cells and be used rather than remaining in his bloodstream and being excreted in his urine; high blood glucose may cause diabetic patients to feel hungry and eat more and eating patterns may continue after insulin has been started and allows more-efficient use of nutrients.

Diet has been recognized as a corner stone in the management of diabetes mellitus. Spices are the common dietary adjuncts that contribute to the taste and flavour of foods. Besides, spices are also known to exert several beneficial physiological effects including the anti-diabetic influence. Among the spices, ginger and clove have been experimentally documented to possess anti-diabetic potential (Srinivasan, 2005b). Essential oils are commonly recognized as having immune modulating properties (Standen and Myers, 2004). In the present study, the beneficial physiological effects of ginger and clove on diabetic rats were evident. STZ-induced diabetic rats given diets containing the oils of ginger, clove, or mixture of them had higher body weight change, body temperature, TSH, T_3 and T_4 levels than STZ-induced diabetic rats given the control diet. However, no significant differences were observed in body weight, body temperature, TSH, T_3 and T_4 levels of healthy rats fed on diets containing the oils of ginger, clove, or mixture of them when compared with those rats fed on the control diet after two weeks. There were no significant differences in body temperature of STZ-induced diabetic rats fed on diets containing the oils of ginger, clove, or mixture of them when compared with healthy rats fed on the same diets after two weeks. STZ-induced diabetic rats given the diet containing ginger oil had significantly higher mean TSH, T_3 and T_4 values than STZ-induced diabetic rats given the diet containing clove oil. In addition, STZ-induced diabetic rats given the diet containing the mixture of ginger and clove oils had significantly higher mean blood TSH values than STZ-induced diabetic rats given the diet containing clove oil. Shishodia *et al.* (2005) stated that 6-gingerol derived from the root of ginger exhibits a biologic activity profile similar to that of curcumin which mediates its effects by modulation of several important molecular targets, including transcription factors, enzymes, cell cycle proteins, cytokines, receptors and cell surface adhesion molecules. Because it can modulate the expression of these targets, it is now being used to treat the different inflammatory diseases. The antioxidant effects of eugenol (of clove) were also evidenced and

the consequential health beneficial anti-inflammatory influences were documented. All these observations strongly indicate that many spices and their active principles are excellent nutraceuticals (Srinivasan, 2005a). Nangle *et al.* (2006) reported that the dominant ingredient of clove oil, eugenol, has antioxidant and anti-inflammatory properties. Aspects of both vascular and neural complications in experimental diabetes are improved by eugenol, which could have potential therapeutic implications for diabetic neuropathy and vasculopathy. The study of free radicals and antioxidants in biology is producing medical revolution that promises a new age of health and disease management (Aruoma, 2003). The activation of nuclear transcription factor kB has now been linked with a variety of inflammatory diseases, including diabetes, allergy, asthma and cancer. Extensive research in the last few years has shown that the pathway that activates this nuclear transcription factor can be interrupted by phytochemicals derived from spices such as cloves (eugenol) and ginger (gingerol) (Aggarwal and Shishodia, 2004).

In conclusion, the present data suggest that using the oils of ginger, clove, or a mixture of them may improve body weight, body temperature, TSH, T_3 and T_4 profile in STZ-induced diabetic rats. The responses in body weight and body temperature in these animals are also influenced by duration of exposure to these oils. Moreover, this investigation is from the first studies that apply scientific methodology for looking at how the tested oils exert its role in the protection action against physiological disturbances in diabetic cases and may be in its complications. Finally, our findings suggest that further studies are needed to unravel the antidiabetic mechanism of tested oils via acute and chronic periods.

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