https://doi.org/10.48048/tis.2022.4606

30 Days Randomized Ginger Ingestion on Blood Lipid and Sugar Levels in Hypertensive Older Women

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Received: 31 December 2020, Revised: 8 May 2021, Accepted: 31 May 2021

Abstract

Gingers is widely used as the complimentary household herbal medicine since it promotes varieties of health-protective effects including anti-hyperlipidemia and anti-hypertension. This study aimed to evaluate the effect of a 30-day ginger (*Zingiber officinale* Roscoe, Zingiberaceae) ingestion on lipid and glucose profiles and blood pressures in hypertensive older women. The randomized double-blinded ginger consumption was designed in normotensive and hypertensive older women. Thirty-two female volunteers were randomly allocated into 4 groups of normotensives and hypertensives without and with ginger consumption, named as normotensive control (NC); normotensive with ginger consumption (NG); hypertensive control (HC) and hypertensive with ginger consumption (HG). On daily basis, the ginger-treated groups (NG and HG) ingested ginger powder at 75 mg/kgBW/day dissolved in 150 mL water after breakfast whereas control groups (NC and HC) received 150 mL water only for 30 days. Data were collected, in the morning, at pre- and post-intervention. Blood lipids, including cholesterol (chol), triglycerides (TG), high density lipoproteins (HDL), and low density lipoproteins (LDL), glucose levels and blood pressures were evaluated and compared from pre- and post-interventions. The results showed that 30-day ingestion of ginger exerted no change in normotensive groups, where alterations of blood lipid profiles were found in hypertensive groups. Both hypertensive groups (HC and HG) showed the significant reductions in SBP ($p < 0.05$), however, HC showed significantly increase in blood TG and LDL. HG group showed the reduction in TG and unchanged in LDL. There were no significant differences in chol, HDL, glucose levels and health-related performance from either within or between-groups comparisons ($p > 0.05$). This study primarily shows the minimal duration of 30-day ingestion of dissolved ginger on lowering systolic blood pressure and triglycerides but plays no roles in glycemic control in hypertensive subjects. Ginger might possibly play an important alternative role in alleviating certain health risks in the hypertensive aged females. To build up confidence on its therapeutic effect, more sample size of this local herb is needed in further investigation.

Keywords: Ginger, Lipid profile, Ageing, Women, Hypertension

Introduction

Dyslipidemia, such as high levels of triglyceride, total cholesterol, and low-density lipoprotein cholesterol and low level of high-density lipoprotein cholesterol, represents the major risk incidence of atherosclerosis which leads to various cardiovascular diseases. According to the 2009 national health examination survey IV, it was reported the high prevalence of dyslipidemia among Thai population, especially in the north and north-east regions. Moreover, the higher percentage of most blood lipids level were usually found in women and older age than men and youngers, respectively. Overall, 66.5 % of Thais had some forms of dyslipidemia with a low level of awareness and treatment [1]. Generally, women play critical roles in managing for daily needs, meals, household chores and well-being of all family members including in northeast of Thailand [2]. With the traditional beliefs, most people from the northeast of Thailand remain in their old lifestyle of daily living despite the fact that various health promotion strategies were intervened [3].

The usefulness of ginger is widely reported in traditional medicine to relieve symptoms and certain diseases such as indigestion, nausea and vomiting, joints and muscle pain, cold, and asthma through anti-

obesity, anti-inflammatory and anti-cancer effects [4]. Recently, its effectiveness was identified in Periodontitis patients [5]. Ginger contains various chemical constituents including gingerols, shogaols, paradols and zingerone [6], which have been shown to reduce pain via various mechanisms: a) inhibition on the activity of cyclooxygenase enzymes (COX-1 and COX-2), b) blocking the synthesis of leukotriene, c) inhibition on the production of interleukin (IL-1, IL-12) and tumor necrosis factor alpha (TNF-a) in activated macrophages [4,7]. Study in adults reported the safety doses for ginger intake are about 600 - 2,500 mg per day [8] where its bioactive components are well tolerated even at a very high dose without any toxic effects [9]. In the oriental world, ginger is one among herbaceous plants widely consumed as dietary supplement and herbal remedy with need no advice from a physician, known as natural food therapy, in particular among the aged [10]. In the United States, ginger is one among 10 common natural products used as complementary and alternative medical (CAM) treatments [10]. It was specified an effective duration of ginger on changes in blood lipids, glucose and hemoglobin A1C (HbA1C) of about 8 weeks of intervention [5,11]. In Thailand, ginger has been used among Muslim population for the belief on positive effects in hypertensive patients where dose and duration were unclear [12]. The present study hypothesized that long-term oral ginger consumption, minimum of 30 days, may improve health status via its anti-hypertensive properties. In a study in obese patients, ginger consumption showed significant reductions in levels of cholesterol (chol) and low density lipoprotein (LDL) [13]. While, ginger reduced only serum triglyceride (TG) concentration but no significant changes of serum total cholesterol, LDL-C and high-density lipoprotein (HDL-C) in peritoneal dialysis patients [14]. Controversial results of ginger consumption on blood sugar were also reported with both reduction in glucose level in diabetes patients [15] and no effect on either blood glucose or lipid [16]. As ginger is one of the most popular medicinal herb in traditional Chinese Medicine and Indian Ayurvedic System of Medicine [17]. In the present day, people around the world routinely use ginger for both food and herbal medicine with ranges from small kids to the aged for the treatment of numerous ailments [10]. As endogenous metabolic hormones remarkably decline in females after middle age, the protection from cardiovascular complications appears earlier than in males [18]. Ginger has been freely and randomly used as a household herbal agent with non-systematic study. We rely on controversial information on the effect of ginger, especially for older people. Thus, the objective of this study was aimed to evaluate the effect of ginger in the aged females in the north-east part of Thailand. Changes in blood lipid and sugar were used as the main indicators.

Materials and methods

Participants

Native women from an elderly club of local health promotion hospital (LHPH) in the north-east of Thailand, aged between 60 - 69 years old, voluntarily participated with the present study. Inclusion criteria were set up as follows: 1) no current cardiorespiratory and muscular diseases, 2) non-obese with body mass index (BMI) between 23 - 28 kg/m^2 [19] 3) resting blood pressures about 120/80 mmHg (control group) and asymptomatic hypertension stage 1 (hypertension group), 4) blood lipid levels at upper normal limits (TG between 150 - 199 mg/dL or chol 200 - 239 mg/dL or LDL 130 - 159 mg/dL) 5) fasting blood glucose 80 - 120 mg/dL, and 6) no history of ginger allergy. Vital signs and physical examination were conducted by a physiotherapist investigator. Informed consent forms were completed by all subjects before starting the experiment. This study was approved by Khon Kaen University Ethics Committee for Human Research (HE602231).

Study design

This study was the randomized double-blind intervention for 30 days (**Figure 1**). To avoid variations, this study necessarily recruited all members of an elderly club from the LHPH without a calculation of sample size. According to their baseline blood pressures, participants were initially and purposefully divided into normotensive and hypertensive groups. Thereafter, they were randomly divided into 4 subgroups by sequentially numbered containers: Normotensive control (NC), normotensive with ginger consumption (NG), hypertensive control (HC) and hypertensive with ginger consumption (HG). Groups with ginger consumption (NG and HG) orally ingested ginger powder (*Zingiber officinale* Roscoe, Zingiberaceae, HOTTA, Thailand's FDA 10-1-25830-1-0028), 75 mg/kgBW/day [20] once a day dissolved with 150 mL water after breakfast. This allocation sequence was conducted by LHPH's staffs, nurses and public health practitioners, who were not part of main investigators. The normotensive and hypertensive control groups (NC and HC) received only 150 mL water as a placebo. Subjects were advised to keep their regular routine lifestyle and diet [21] and not to take any dietary herbs during the study period [14].

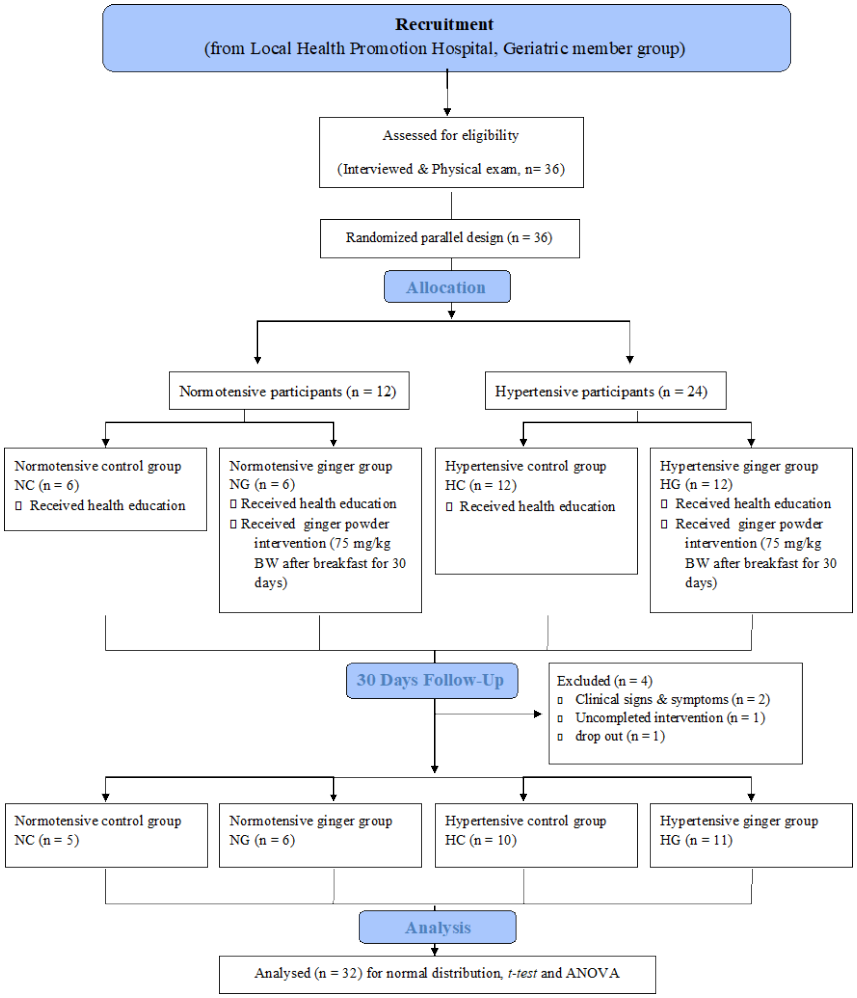

Figure 1 Flow diagram of the study.

Measurement and data collection

All of experimental processes were completed at Khon Kaen University, Thailand. On the day prior to the test, subjects were instructed to: a) sleep at least 7 - 8 h, b) drink water *ad libitum*, c) avoid alcohol and caffeine beverages, d) avoid to perform or join any vigorous physical activity. Subjects arrived the laboratory at early morning then 10 mL blood samples were taken from antecubital vein and then centrifuged at 3,000 rpm for 15 min at 4 ℃. Plasma aliquots were stored at −80 ℃ for further analysis. Blood parameters, included TG, chol, HDL, LDL and glucose were analyzed using automatic chemistry analyzer Cobas® C501 (Roche Diagnostics Ltd., Switzerland). Anthropometry and health-related performance were also evaluated including subcutaneous fat using skin fold measurement (Lange skinfold caliper); hands and legs strength (handgrip and leg dynamometers); flexibility (sit and reach test).

Statistical analysis

All data was presented as mean and standard error (SE) and carefully analyzed using 2-way ANOVA by the SPSS statistical package (version 16; SPSS, Inc., New York, USA). The different between groups were determined by independent t-test. Statistical significance was accepted when $p < 0.05$.

Results and discussion

Results

Four women were excluded from the experiment because of elevated resting heart rate, signs and symptoms of abnormal cardiorespiratory function during period of the study. Finally, 32 older women completed 30-day intervention. **Table 1** showed the characteristics of subjects in 4 groups at the

beginning of the study. There were no significant differences in age, body weight, height, BMI, resting heart rate and diastolic blood pressure (DBP) among 4 groups. Only systolic blood pressures (SBP) in HC is higher than NC groups ($p < 0.05$) and NG than HG groups ($p < 0.05$).

Table 1 Characteristics of subjects at rest at the beginning of the study.

Variables	NC (n = 6)	NG (n = 5)	HC (n = 10)	HG (n = 11)
Age (years)	66.70 ± 2.11	65.00 ± 2.32	62.40 ± 1.59	66.00 ± 1.39
Body weight (kg)	59.00 ± 2.75	63.60 ± 5.48	58.60 ± 1.76	60.60 ± 2.66
Height (cm)	153.30 ± 1.26	151.80 ± 1.80	153.20 ± 2.30	154.00 ± 2.38
Heart rate (bpm)	82.33 ± 1.67	80.60 ± 2.31	86.50 ± 2.16	84.82 ± 1.98
BMI (kg/m)	25.07 ± 1.02	27.69 ± 2.62	25.10 ± 0.98	25.60 ± 0.68
SBP (mmHg)	118.50 ± 2.29	117.40 ± 1.91	150.00 ± 4.21*#	145.82 ± 3.31*#
DBP (mmHg)	72.33 ± 3.07	67.80 ± 2.57	70.40 ± 3.11	69.91 ± 4.04

Values are mean and standard errors. BMI: Body mass index; SBP: Systolic blood pressure; DBP: Diastolic blood pressure; NC: Normotensive control group; NG: Normotensive with ginger consumption group; HG: Hypertensive control group; HG: Hypertensive with ginger consumption group.
* $p < 0.05$; significant difference from NC;
# $p < 0.05$; significant difference from NG.

On Day 0, data showed no significant differences of glucose, chol and HDL (**Table 2**) with the exception for higher TG in HG than NC ($p < 0.05$) and HC ($p < 0.05$). Within-group comparisons from pre- (Day 0) and post-ginger intervention (Day 30) revealed the significant reduction of TG in HG ($p < 0.05$). On the contrary, there was significantly increased TG after 30 days of intervention in HC ($p < 0.05$). Results also showed significant reduction in SBP after interventions for both HC ($p < 0.05$) and HG ($p < 0.05$) groups. These reductions were similar in magnitude for both groups. Health-related performance including subcutaneous fat, handgrip and leg strength and flexibility did not change between day 0 and day 30 in all four groups (**Table 3**).

Table 2 Changes in plasma lipids and glucose levels, resting systolic, diastolic and mean arterial blood pressures (SBP, DBP and mABP, respectively) in normotensive control (NC), normotensive with ginger consumption (NG), hypertensive control (HC) and hypertensive with ginger consumption (HG) groups before (Day 0) and after interventions (Day 30).

Variables	NC (n = 6)		NG (n = 5)		HC (n = 10)		HG (n = 11)	
	Day 0	Day 30	Day 0	Day 30	Day 0	Day 30	Day 0	Day 30
Glucose (mg/dL)	118.83 ± 9.02	113.33 ± 17.47	128.60 ± 2.41	123.00 ± 16.13	117.00 ± 9.44	125.30 ± 12.35	130.09 ± 13.42	138.09±13.43
chol (mg/dL)	154.33 ± 10.03	169.50 ± 12.33	185.20 ± 15.64	193.00 ± 15.04	158.30 ± 8.57	174.90 ± 11.87	197.27 ± 9.85	209.64 ± 9.88
TG (mg/dL)	83.17 ± 11.76	99.33 ± 20.44	155.20 ± 14.07	136.20 ± 11.68	81.00 ± 5.65	98.50 ± 8.03	185.70 ± 19.1#∞	177.10 ± 18.66#∞
HDL (mg/dL)	63.67 ± 4.73	62.00 ± 7.55	63.40 ± 3.11	62.60 ± 3.41	64.60 ± 3.10	63.60 ± 3.09	64.36 ± 2.75	62.73 ± 2.94
LDL (mg/dL)	74.17 ± 10.51	87.67 ± 11.09	91.00 ± 14.20	103.00 ± 14.24	77.50 ± 7.12	91.70 ± 10.50	96.82 ± 8.42	111.36 ± 10.53*
SBP (mmHg)	118.50 ± 2.29	118.83 ± 0.87	117.40 ± 1.91	117.20 ± 1.59	150.00 ± 4.21	147.30 ± 3.73*#¶	145.82 ± 3.31#¶	142.54 ± 3.69*#¶
DBP (mmHg)	72.33 ± 3.07	74.00 ± 2.11	67.80 ± 2.57	71.40 ± 2.46	70.40 ± 3.11	71.70 ± 1.88	69.91 ± 4.04	72.00 ± 3.08
mABP (mmHg)	87.72 ± 1.61	88.94 ± 1.43	84.33 ± 1.89	85.06 ± 0.53	96.90 ± 3.06	96.60 ± 2.18¶	95.21 ± 3.28	95.51 ± 2 .79

Values are means and standard errors.
* $p < 0.05$; significantly difference between day 0 and day 30 with in the same group;
# $p < 0.05$; significantly difference from NC at the same day;
¶ $p < 0.05$; significantly difference from NG at the same day;
∞ $p < 0.05$; significantly difference from HC at the same day.

Table 3 Health-related performance of all participants in each group under different conditions.

Variables	NC		NG		HC		HG	
	Day 0	Day 30	Day 0	Day 30	Day 0	Day 30	Day 0	Day 30
Subcutaneous fat (mm)	26.67 ± 4.08	25.83 ± 3.97	28.00 ± 7.58	27.00 ± 6.86	25.60 ± 2.07	25.80 ± 1.14	26.18 ± 5.95	26.55 ± 4.61
Hand strength (kg)	14.67 ± 1.18	15.15 ± 1.45	17.82 ± 5.75	18.26 ± 5.29	13.63 ± 3.25	14.22 ± 2.93	16.96 ± 7.27	17.80 ± 5.72
Leg strength (kg)	10.33 ± 1.63	10.83 ± 1.94	11.40 ± 2.51	12.40 ± 2.70	10.90 ± 3.18	12.00 ± 3.06	10.91 ± 2.47	11.45 ± 2.62
Flexibility (cm)	10.00 ± 3.52	10.83 ± 3.31	9.00 ± 4.12	10.80 ± 3.70	6.70 ± 4.76	7.40 ± 2.76	8.00 ± 2.90	9.36 ± 2.91*

Values are mean and standard errors. NC: Normotensive control group; NG: Normotensive with ginger consumption group; HG: Hypertensive control group; HG: Hypertensive with ginger consumption group. *$p < 0.05$; significantly difference between day 0 and day 30 with in the same group.

Discussion

To the best of our knowledge, there is no investigation of effects of ginger on blood lipids and glucose levels in the north-east part of Thailand. The study successfully recruited normotensive and asymptomatic hypertensive subjects. Hypertensive subjects treated with ginger shows reductions in TG and SBP without changing in their performance. With suitable control for diets, physical activity and lifestyle, the above changes are, most likely, due to the effects of ginger drink.

Characteristics of older women in this study revealed that their body weights and heights were in the normal ranges of Thai population at this age range [22]. As hypertension is one among the main age-related problems found in Thai population [23], the present study provides some preliminary evidence to cope with the problem using ginger. All subjects were recruited from the same rural area in the north-east of Thailand with grade 6 for highest education level. However, their understandings in experimental procedures were acceptable and could follow properly for the whole 30 days. The most important finding of the present study found that ginger supplementation significantly reduced some blood lipid profile while glucose was not affected. Even though subjects were instructed to keep their routine lifestyles, diets with *ad libitum* of water, fluctuations of blood lipid profiles are considered in that we did not quantitate for level of hydration among subjects. Other causes of fluctuations were reported from a 4-day study on blood lipids in which the numbers of days between blood draws and from self-selected diet [24].

The hypolipidemic effects of ginger could have, partly, resulted from inhibition of cellular cholesterol biosynthetic processes [25]. However, effects of ginger on changes of blood lipids remain inconsistent depend on pathological underlying of subjects being used and forms of ginger. For example, daily oral administration of ginger extract at 4 mg/kg to diabetic rats resulted in reducing the plasma glucose and all kinds of lipids [26]. In type 2 diabetic patients, ginger has been suggested to improve insulin sensitivity and some fractions of lipid profile [27]. Other study showed no significant changes of all blood lipid parameters in the obese when taking ginger capsules daily for 10 weeks [28]. Some study showed the only reduction in total cholesterol [16] while a study showed no change in plasma LDL level [14].

Other mechanisms "the antihypertensive action of ginger" can be partly attributed to its antioxidant, anti-inflammation and activities since ginger contains plentiful of phenolic compounds such as gingerols, zingerone, shogaols and paradol [4,29,30]. Some previous studies have reported the antihypertensive and antioxidant effects of polyphenol, protocatechuic acid, in young and aged hypertensive rats which partly works through the restoration of endothelial function indicated by an increased vasodilation [31,32]. Moreover, this improvement was associated with the increase in serum nitric oxide concentration and its enzyme of production, endothelial nitric oxide synthase (eNOS). Similarly, the vasodilatory properties of ginger phenolic compounds have been reported together with increasing plasma nitric oxide level [33]. Reducing lipid peroxidation can be an alternative reason of BP-lowering effect of these components since this process is a key factor to vascular blockage and development of atheromatous lesions causing vasoconstriction and endothelial lesions occurring in atherosclerosis [34].

Ginger, in form of crude extract, lowered arterial blood pressure through the obstruction of voltage-dependent calcium channels. This will cause the reduction of vascular smooth muscle function which results in more relaxation of arterial walls that allow blood to flow more easily and reduce blood pressure [35]. Ginger solution exhibited antihypertensive effect through angiotensin-converting enzyme (ACE) and inhibitory outcome by stimulus of muscarinic receptors [36]. A study used steamed ginger

supplementation show the reductions of plasma total cholesterol and triglyceride [37] in which might be due to the inhibition of cellular cholesterol synthesis [38]. Moreover, the mechanism was related to higher liver expression of peroxisome proliferator-activated receptors (PPARα and PPARγ), which were related to atherosclerosis [39]. The reduction in TG levels in the present study confirms the results of previous investigations, which conducted in the ginger-treated diabetic rats [40] and in cardiac patients [25].

Even though, blood glucose level did not change in this study. The mechanisms of ginger on lowering blood sugar composed of facilitation of insulin-independent glucose uptake via translocation of glucose transporter GLUT4 together with activation on total GLUT4 protein expression [41], the inhibition of hepatic phosphorylase enzyme, which prevent glycogen break down [15]. These consequently decreases blood glucose level. However, the reduction of blood sugar was reported only after fasting condition in many studies[15] and in diabetic rats [42].

To our knowledge, this study identified the 30-day duration of ginger intervention on blood chemistry level in Thai elderly. This will, at least, provide clearer picture of the effectiveness of ginger. While, the limitations of this study are that 1) be unable to blind the taste of the ginger dissolved in the water and 2) limited sample size without the systematic calculation. Thus, more sample size of this therapeutic herb needs to be further investigated.

Conclusions

This study indicates the minimal duration of 30 days of ginger ingestion at 75 mg/kgBW/day, reduces systolic blood pressure and alongside with the reduction in triglycerides level in hypertensive older women. No therapeutic effect of ginger on blood glucose level was found. Ginger might possibly play an important role in alleviating certain health risk in the aged via partially improvement of some lipid levels.

Acknowledgements

The present study was supported by Research and Technology Transfer Affairs (KKU-NKC60-009), Khonkaen University, Thailand. Moreover, the authors would like to thank all subjects and team for kindly help and cooperation in this work.

References

[1] W Aekplakorn, S Taneepanichskul, P Kessomboon, V Chongsuvivatwong, P Putwatana, P Sritara, S Sangwatanaroj and S Chariyalertsak. Prevalence of dyslipidemia and management in the Thai population, National Health Examination Survey IV, 2009. *J. Lipids* 2014; **2014**, 249584.

[2] A Sriruksa, N Wongpongkham and B Homhuan. The role of women in Isaan culture under a capitalist society. *Eur. J. Soc. Sci.* 2014; **44**, 363-85.

[3] S Sasat and BJ Bowers. Spotlight Thailand. *Gerontologist* 2013; **53**, 711-7.

[4] QQ Mao, XY Xu, SY Cao, RY Gan, H Corke, T Beta and HB Li. Bioactive compounds and bioactivities of ginger (*Zingiber officinale* Roscoe). *Foods* 2019; **8**,185.

[5] H Gholinezhad, H Rashidi, P Salehi, MH Haghighi-zadeh and AZ Javid. Using ginger supplement in adjunct with non-surgical periodontal therapy improves metabolic and periodontal parameters in patients with type 2 diabetes mellitus and chronic periodontitis: A double-blind, placebo-controlled trial. *J. Herb. Med.* 2019; **20**, 100315.

[6] S Dugasani, MR Pichika, VD Nadarajah, MK Balijepalli, S Tandra and JN Korlakunta. Comparative antioxidant and anti-inflammatory effects of [6]-gingerol, [8]-gingerol, [10]-gingerol and [6]-shogaol. *J. Ethnopharmacol.* 2010; **127**, 515-20.

[7] M Zhang, E Viennois, M Prasad, Y Zhang, L Wang, Z Zhang, MK Han, B Xiao, C Xu, S Srinivasan and D Merlin. Edible ginger-derived nanoparticles: A novel therapeutic approach for the prevention and treatment of inflammatory bowel disease and colitis-associated cancer. *Biomaterials* 2016; **101**, 321-40.

[8] I Lete and J Alluć. The effectiveness of ginger in the prevention of nausea and vomiting during pregnancy and chemotherapy. *Integr. Med. Insights* 2016; **11**, 11-7.

[9] S Kumar, K Saxena, UN Singh and R Saxena. Anti-inflammatory action of ginger: A critical review in anemia of inflammation and its future aspects. *Int. J. Herb. Med.* 2013; **1**, 16-20.

[10] AM Bode and Z Dong. *The amazing and mighty ginger. In*: IFF Benzie and S Wachtel-Galor (Eds.). Herbal medicine: Biomolecular and clinical aspects. 2nd ed. CRC Press, Boca Raton, United Statates, 2011.

[11] H Mozaffari-Khosravi, B Talaei, BA Jalali, A Najarzadeh and MR Mozayan. The effect of ginger powder supplementation on insulin resistance and glycemic indices in patients with type 2 diabetes: A randomized, double-blind, placebo-controlled trial. *Compl. Ther. Med.* 2014; **22**, 9-16.
[12] P Rasamejam, P Akaratanapol, P Limteerayos and K Khungtumneam. Factors predict health promotion behaviors among Thai muslim with hypertension. *J. Nurs. Siam Univ.* 2018; **19**, 56-68.
[13] MH Gayar, MM Aboromia, NA Ibrahim and MHA Hafiz. Effects of ginger powder supplementation on glycemic status and lipid profile in newly diagnosed obese patients with type 2 diabetes mellitus. *Obes. Med.* 2019; **14**, 100094.
[14] H Tabibi, H Imani, S Atabak, I Najafi, M Hedayati and L Rahmani. Effects of ginger on serum lipids and lipoproteins in peritoneal dialysis patients: A randomized controlled trial. *Perit. Dial. Int.* 2016; **36**, 140-5.
[15] N Khandouzi, F Shidfar, A Rajab, T Rahideh, P Hosseini and MM Taheri. The effects of ginger on fasting blood sugar, hemoglobin A1c, apolipoprotein B, apolipoprotein A-I and malondialdehyde in type 2 diabetic patients. *Iran. J. Pharm. Res.* 2015; **14**, 131-40.
[16] S Mahluji, VE Attari, M Mobasseri, L Payahoo, A Ostadrahimi and SE Golzari. Effects of ginger (*Zingiber officinale*) on plasma glucose level, HbA1c and insulin sensitivity in type 2 diabetic patients. *Int. J. Food Sci. Nutr.* 2013; **64**, 682-6.
[17] R Grzanna, L Lindmark and CG Frondoza. Ginger - an herbal medicinal product with broad anti-inflammatory actions. *J. Med. Food* 2005; **8**, 125-32.
[18] BT Palmisano, L Zhu, RH Eckel and JM Stafford. Sex differences in lipid and lipoprotein metabolism. *Mol. Metabol.* 2018; **15**, 45-55.
[19] WHO expert consultation. Appropriate body-mass index for Asian populations and its implications for policy and intervention strategies. *Lancet* 2004; **363**, 157-63.
[20] G Saravanan, P Ponmurugan, MA Deepa and B Senthilkumar. Anti-obesity action of gingerol: Effect on lipid profile, insulin, leptin, amylase and lipase in male obese rats induced by a high-fat diet. *J. Sci. Food Agr.* 2014; **9**, 2972-7.
[21] P Manasatchakun, T Choowattanapakorn, A Roxberg and M Asp. Community nurses' experiences regarding the meaning and promotion of healthy aging in northeastern Thailand. *J. Holistic Nurs.* 2018; **36**, 54-67.
[22] P Narongchai ans S Narongchai. Study of the normal internal organ weights in Thai population. *J. Med. Assoc. Thai*. 2008; **91**, 747-53.
[23] P Manasatchakun, P Chotiga, A Roxberg, and M Asp. Healthy ageing in Isan-Thai culture - a phenomenographic study based on older persons' lived experiences. *Int. J. Qual. Stud. Health Well Being* 2016; **11**, 29463.
[24] MA Pereira, RM Weggemans, DR Jacobs, PJ Hannan, PL Zock, JM Ordovas and MB Katan. Within-person variation in serum lipids: Implications for clinical trials. *Int. J. Epidemiol.* 2004; **33**, 534-41.
[25] R Alizadeh-Navaei, F Roozbeh, M Saravi, M Pouramir, F Jalali and AA Moghadamnia. Investigation of the effect of ginger on the lipid levels. A double blind controlled clinical trial. *Saudi Med. J.* 2008; **29**, 1280-4.
[26] AEA Elshater, M Salman and M Moussa. Effect of ginger extract consumption on levels of blood glucose, lipid profile and kidney functions in alloxan induced-diabetic rats. *Egypt. Acad. J. Biol. Sci.* 2009; **2**, 153-62.
[27] T Arablou, N Aryaeian, M Valizadeh, F Sharifi, A Hosseini and M Djalali. The effect of ginger consumption on glycemic status, lipid profile and some inflammatory markers in patients with type 2 diabetes mellitus. *Int. J Food Sci. Nutr.* 2014; **65**, 515-20.
[28] S Atashak, M Peeri, MA Azarbayjani, SR Stannard and MM Haghighi. Obesity-related cardiovascular risk factors after long-term resistance training and ginger supplementation. *J. Sports Sci. Med.* 2011; **10**, 685-91.
[29] AJ Akinyemi, GR Thomé, VM Morsch, NB Bottari, J Baldissarelli, LS de Oliveira, JF Goularte, A Belló-Klein, T Duarte, M Duarte, AA Boligon, ML Athayde, AA Akindahunsi, G Oboh and MR Schetinger. Effect of ginger and turmeric rhizomes on inflammatory cytokines levels and enzyme activities of cholinergic and purinergic systems in hypertensive rats. *Planta Med.* 2016; **82**, 612-20.
[30] P Azimi, R Ghiasvand, A Feizi, J Hosseinzadeh, M Bahreynian, M Hariri and B Abbasi. Effect of cinnamon, cardamom, saffron and ginger consumption on blood pressure and a marker of endothelial function in patients with type 2 diabetes mellitus: A randomized controlled clinical trial. *Blood Pres.* 2016; **25**, 133-40.

[31] YS Kim, HW Seo, MH Lee, DK Kim, H Jeon and DS Cha. Protocatechuic acid extends lifespan and increases stress resistance in *Caenorhabditis elegans*. *Arch. Pharm. Res.* 2014; **37**, 245-52.
[32] K Masodsai, YY Lin, R Chaunchaiyakul, CT Su, SD Lee and AL Yang. Twelve-week protocatechuic acid administration improves insulin-induced and insulin-like growth factor-1-induced vasorelaxation and antioxidant activities in aging spontaneously hypertensive rats. *Nutrients* 2019; **11**, 699.
[33] K Srinivasan. Ginger rhizomes (*Zingiber officinale*): A spice with multiple health beneficial potentials. *Pharm. Nutr.* 2017; **5**, 18-28.
[34] EE Mulvihill, AC Burke and MW Huff. Citrus flavonoids as regulators of lipoprotein metabolism and atherosclerosis. *Ann. Rev. Nutr.* 2016; **36**, 275-99.
[35] S Vungarala, KT Venkata and R Krishnan. Blockade of voltage dependent calcium channels lowers the blood pressure through ginger. *Int J. Anal. Pharm. Biomed. Sci.* 2013; **2**, 64-6.
[36] Y Wang, H Yu, X Zhang, Q Feng, X Guo, S Li, R Li, D Chu and Y Ma. Evaluation of daily ginger consumption for the prevention of chronic diseases in adults: A cross-sectional study. *Nutrition* 2017; **36**, 79-84.
[37] HJ Kim, B Kim, EG Mun, SY Jeong and YS Cha. The antioxidant activity of steamed ginger and its protective effects on obesity induced by high-fat diet in C57BL/6J mice. *Nutr. Res. Pract.* 2018; **12**, 503-11.
[38] MA Lebda, NM Taha, MA Korshom, AEA Mandour and AM El-Morshedy. Biochemical effect of ginger on some blood and liver parameters in male New Zealand rabbits. *J. Anim. Feed Res.* 2012; **2**, 197-202.
[39] N de Las Heras, M Valero-Muñoz, B Martín-Fernández, S Ballesteros, A López-Farré, B Ruiz-Roso and V Lahera. Molecular factors involved in the hypolipidemic- and insulin-sensitizing effects of a ginger (*Zingiber officinale* Roscoe) extract in rats fed a high-fat diet. *Appl. Phys. Nutr. Metabol.* 2017; **42**, 209-15.
[40] ZM Al-Amin, M Thomson, KK Al-Qattan, R Peltonen-Shalaby and M Ali. Anti-diabetic and hypolipidaemic properties of ginger (*Zingiber officinale*) in streptozotocin-induced diabetic rats. *Br. J. Nutr.* 2006; **96**, 660-6.
[41] Y Li, VH Tran, CC Duke and BD Roufogalis. Gingerols of *Zingiber officinale* enhance glucose uptake by increasing cell surface GLUT4 in cultured L6 myotubes. *Planta Med.* 2012; **78**, 1549-55.
[42] NB Abdulrazaq, MM Cho, NN Win, R Zaman and MT Rahman. Beneficial effects of ginger (*Zingiber officinale*) on carbohydrate metabolism in streptozotocin-induced diabetic rats. *Br. J. Nutr.* 2012; **108**, 1194-201.