Nutrire
https://doi.org/10.1186/s41110-019-0099-0

RESEARCH

Effect of Ethiopian Orthodox Christian (EtOC) religious fasting with vegan diet on changes of blood metabolites and body composition: an observational study

Wondyefraw Mekonen[1] · Diresibachew Haile[1]

Received: 8 February 2019 / Accepted: 25 April 2019
© Springer Nature Switzerland AG 2019

Abstract

Purpose Studies on Ethiopian Orthodox Christian (EtOC) religious fasting with vegan diet influencing body composition and blood metabolites remain limited. This study assessed the effect of consuming a vegan diet on changes of body composition and blood metabolites in a group of EtOC religious fasters and associated results with cardio-metabolic health.

Methods Participants were 98 EtOCs, with a mean age of 27 years. They 1st consumed a non-vegetarian omnivorous (OM) diet for 7 weeks. Then they switched to a vegan diet (VD) on the occasion of the Ethiopian Orthodox fasting (EOF) again for 7 weeks. Body compositions including height (m), weight (kg), BMI (kg/m^2), percent body fat (%BF), and waist-to-hip (W/H) ratio were measured after the end of the OM and VD dietary regimen. Moreover, blood metabolites including TC, TG, LDL-C, HDL-C, glucose, urea, and total protein (TP) were analyzed and calculated for significant differences.

Results The Ethiopian OF with vegan diet induced significantly lower BMI, %BF, TC, LDL-C, HDL-C, and blood urea levels compared with the (OM) diet ($p < 0.05$). Blood TG, glucose, and TP did not reach significance ($p > 0.05$). Changes in TC were positively and significantly correlated ($r = 0.9$, $p < 0.001$) both with LDL-C and BMI following the vegan diet.

Conclusion Ethiopian OF with vegan diet induced lower TC, LDL-C, and body composition to optimal levels favoring a better cardio-metabolic health. The decrease in blood urea may reflect insufficient intake of complete protein (essential and non-essential amino acids) during the fasting periods. This indicated the need to consume varieties of plant foods in order to compensate amino acids that vegan diets lack during the Orthodox fasting.

Introduction

People become vegetarians because of religious beliefs [1, 2], health reasons [3], lifestyle changes [4], or supporting the cause of animal welfare. Concerning religion, Orthodox Christians, Catholics, Adventists, Hindus, and Buddhists fast by consuming vegetarian diets for short- or long-term periods [5, 6]. Fasting in a religious sense means partial or total abstention from prohibited foods [2, 6]. The current Ethiopian population is a little more than 100 million and 43.5% of this belongs to Ethiopian Orthodox Church [7]. Most of the followers consume strict vegetarian (vegan) diets during the Orthodox fasting (OF) and one of these fasting periods include the Lent-fast that takes about 7 weeks. It is known that vegans completely avoid animal products [4], while other vegetarians consume either fish (pescatarian), egg (ovo vegetarians), dairy products (lacto vegetarians), or both dairy and egg products (lacto-ovo vegetarians) in their daily diets [4].

A previous study conducted on Greek Orthodox Christians has shown that long-term fasting (180–200 days/year) by consuming vegetarian diets resulted in lower blood concentrations of TC, LDL-C, and body weight [8]. Egyptian Coptic [9] and other Christian oriented studies [2, 6, 8, 10–12] suggested the benefits of taking vegetarian diets in promoting cardio-metabolic health including hypertension, stroke, obesity, and type II diabetes. Different from EtOC fasting practices, however, subjects in Greek [8] and other studies [3–5] included individuals who consumed seafood and fishes that may have different metabolic effects in the body. Moreover, some plant-based vegetarian diets consumed in developing countries like Ethiopia are different from those in developed

✉ Wondyefraw Mekonen
w.mekonen@gmail.com; wondyefraw.mekonen@aau.edu.et

Diresibachew Haile
direshaile@gmail.com

[1] Physiology Department, School of Medicine, College of Health Sciences, Addis Ababa University, Addis Ababa, Ethiopia

Published online: 03 July 2019

countries. For example, a cereal called "Tef" (*Eragrostis tef*), which is gluten-free [13] and possesses high fiber, high carbohydrate (CHO), high protein, and minerals [14], is a staple diet consumed at least two times every day by millions of Ethiopians, Eritreans, and many others living in the Horn of Africa [14]. Because of its chemical composition, such a cereal may have clinical importance in regulating blood metabolites and body composition to optimal levels. To date, however, the impact of Ethiopian Orthodox fasting with a vegan diet in altering different metabolic parameters was not adequately explored.

This study has, therefore, assessed the effect of consuming a strict vegetarian (vegan) diet on body composition and blood metabolites on a group of EtOC fasting subjects and related the results with cardio-metabolic health. Blood metabolites analyzed were lipids (TC, TG, LDL-C, HDL-C) and other parameters including glucose, urea, and total protein (TP). For body composition, BMI, percent body fat (%BF), and waist-to-hip (W/H) ratio were considered. We hypothesized that consumption of vegan diet following Ethiopian OF for 7 weeks would be associated with lower body composition and lipid profiles compared with non-fasting (NF) dietary regimen.

Methods

Subjects

A total of 98 subjects (52 females and 46 males) with a mean age of 27 years (range, 18–55) participated in the study. All subjects were members of Ethiopian Orthodox Church, who practice religious fasting by taking a vegan diet. Participants were college students, physicians, nurses, and high-school teachers from the capital city of Addis Ababa, with similar educational backgrounds. Before the test, subjects were informed about the procedures of the test and completed a questionnaire concerning their diet, lifestyle, and medical history. Smokers, alcoholics, and those on medications were screened and canceled from the study. Permission to conduct the study was obtained from the Ethical Committee of College of Health Sciences, Addis Ababa University.

Anthropometric measurements

Anthropometry and blood samples of each individual were collected in the morning hours between 9 and 10 am. By wearing light clothes, height (m) and weight (kg) were measured by wall-mounted stadiometer (Tanita HR-200, Japan) and digital weight scale (Tanita HD-313, Japan), respectively. For waist-to-hip (W/H) ratio calculation, waist circumference was measured at the navel point and hip circumference was measured around the widest portion of the buttocks [15]. Each measurement for W/H ratio was repeated twice and the average was taken. Body mass index (BMI) was calculated from the weight in kilogram (km) divided by the height in meters (m) squared (kg/m^2). Percent body fat (%BF) was calculated from the BMI according to the formula provided by Deurenberg et al. [16].

Diet and physical activity

Self-reported dietary data was collected through questionnaire from each subject. A vegan platter of one serving size is about 890 g and contains one piece of injera (a local spongy flatbread prepared from the cereal "Tef," and a stew, locally named as "Wat"), prepared from varieties of cereals like lentils, dry pea, and beans that also involve pepper and different types of spices. Boiled cabbages, carrots, and other vegetables are also provided with the meal. As estimated by a dietitian, each of the non-vegetarians (OM) diet and Ethiopian OF with vegan diet had a caloric content of about 2000 kcal/day. Except for their routine workplace activities, all of the participants led sedentary life and reported to have engaged in no physical exercise in their leisure times.

Chemical analysis

Each subject rested for 10 min and blood was withdrawn from the antecubital vein by a trained nurse and collected in tubes with no additives. The blood was left to clot for 30 min at room temperature and centrifuged at 1500*g* for 5 min. Serum was extracted from the clot and frozen at − 20 °C until analyses. Serum TC, TG, HDL-C, LDL-C, glucose, urea, and total protein (TP) were assayed enzymatically to standard laboratory procedures using automatic chemistry analyzer (Mindray, BE-2000, China). All tests were analyzed at the Diagnostic Laboratory of Blacklion School of Medicine, Addis Ababa University.

Statistics

Descriptive statistics were presented as mean ± SD. Values of the non-vegetarian OM and the vegan dietary levels were compared by paired Student's *t* test. Person's correlation coefficient was used to calculate associations between different variables. SPSS (ver.21) software was used for the statistical calculations with significance level attained at $p < 0.05$.

Results

The comparisons of body composition and blood metabolites between NF and EOF with vegan diets are shown in (Table 1). Dependent paired *t* test showed that the Ethiopian OF with

Table 1 Mean ± SD for body composition and blood metabolites (mg/dl) during non-vegetarian OM diet and Ethiopian Orthodox fasting (OF) vegan diet, each for 7-week periods ($n = 98$)

Variables	Non-fasting (NF) diet	Orthodox fasting (OF) with vegan diet	Mean difference	% change from NF	p level (sig.)
Age (18–55)	27.47 ± 0.82	27.47 ± 0.82	–	–	–
BMI (kg/m^2)	21.75 ± 3.13	21.22 ± 3.22	− 0.53	− 2.43	$p = 0.015$*
Waist/hip ratio	0.78 ± 0.06	0.79 ± 0.09	+ 0.01	+ 1.28	$p = 0.468$
%BF	21.95 ± 7.79	21.17 ± 7.80	− 0.78	− 3.55	$p = 0.000$**
TC	166.86 ± 48.63	157.64 ± 41.88	− 9.22	− 5.52	$p = 0.003$*
TG	109.83 ± 59.13	102.91 ± 60.15	− 6.92	− 6.30	$p = 0.417$
LDL-C	113.21 ± 42.66	107.95 ± 39.97	− 5.26	− 4.64	$p = 0.044$*
HDL-C	45.68 ± 9.20	42.21 ± 9.22	− 3.47	− 7.59	$p = 0.000$**
TC/HDL	3.65 ± 0.96	3.73 ± 0.97	+ 0.08	+ 2.19	$p = 0.059$*
Glucose	93.04 ± 16.30	91.35 ± 14.45	− 1.69	− 1.81	$p = 0.376$
Urea	20.36 ± 5.16	18.96 ± 5.35	− 1.4	− 6.87	$p = 0.031$*
TP	7.78 ± 0.48	7.77 ± 0.50	− 0.01	− 0.12	$p = 0.631$

*$p < 0.05$, **$p < 0.001$

vegan diet induced significantly lower levels for BMI ($p = 0.015$), %BF ($p = 001$), TC ($p = 0.003$), LDL-C ($p = 0.044$), HDL-C ($p = 001$), and blood urea concentrations ($p = 0.031$) compared with their corresponding non-vegetarian (OM) diet. Blood glucose, TP, and ratio value of TC/HDL were not different between the vegan and non-vegetarian (OM) diets ($p > 0.05$). The percent decrease (%) for TC after taking the vegan diet was 5.5% (or − 9.22 mg/dl), for LDL-C was 4.6% (or − 5.26 mg/dl), and for HDL-C was 7.5% (or − 3.47 mg/dl) when compared with their corresponding non-fasting dietary regimen.

Table 2 indicates Person's correlation coefficient of TC with LDL-C and BMI. TC was strongly and positively correlated with BMI ($r = 0.98$, $p < 0.001$) and LDL-C ($r = 0.89$, $p < 0.001$), while it showed a weak negative association with blood urea concentration ($r = -0.27$, $p < 0.021$).

Table 2 Pearson's correlations of TC to anthropometric and blood metabolites (mg/dl) following consumption of non-vegetarian OM and Ethiopian Orthodox fasting (OF) with vegan diet for 7 weeks ($n = 98$)

Variables	Total cholesterol (TC)	
	Non-vegetarian (OM)	Ethiopian (OF) vegan
BMI (kg/m^2)	$r = 0.379$ ($p = 0.001$)	$r = 0.231$ ($p = 0.050$*)
W/H ratio	$r = 0.393$ ($p = 0.001$)	$r = 0.046$ ($p = 0.100$)
BF %	$r = 0.375$ ($P = 0.002$)	$r = 0.281$ ($p = 0.016$*)
TG	$r = 0.324$ ($p = 0.007$)	$r = 0.357$ ($p = 0.002$*)
LDL-C	$r = 0.887$ ($p = 0.001$)	$r = 0.894$ ($p = 0.001$**)
HDL-C	$r = 0.441$ ($p = 0.001$)	$r = 0.273$ ($p = 0.027$*)
Glucose	$r = 0.132$ ($p = 0.285$)	$r = -0.012$ ($p = 0.919$)
Urea	$r = 0.085$ ($p = 0.492$)	$r = -0.270$ ($p = 0.021$*)
TP	$r = 0.045$ ($p = 0.715$)	$r = 0.321$ ($p = 0.006$**)

*$p < 0.05$, **$p < 0.001$

Discussion

This study has found that the vegan diet consumed following EOF induced a significant decrease in blood metabolites including TC, LDL-C, HDL-C, and blood urea concentration compared with their non-vegetarian (OM) dietary habits (Table 1). Moreover, significantly lower BMI and %BF were calculated during the OF vegan diet compared with the OM dietary habits (Table 1). These results primarily suggest the potent effect of the vegan diet on lowering both lipid profiles and body composition to optimal levels. Our findings of lower lipids and body compositions are in agreement with several previous studies undertaken on Egyptian Copts [9] and as well as Greek Orthodox Christian followers [6, 8, 10, 12, 17]. Further, other studies also explain to have seen lower lipids and body compositions as the result of taking plant-based vegetarian diets [3, 5, 18, 19].

Changes on TC and LDL-C

Normally, accumulation of either TC or LDL-C on arterial walls is associated with the development of atherosclerosis causing heart diseases [20]. In this study, an observation of significant reductions both in TC (by 5.5%) and in LDL-C (by 4.6%) concentrations following the Ethiopian OF with vegan diet, indicated the potential of the vegan diet in down regulating the biosynthesis of the above lipid profiles in the body. Some of the reasons provided for the down regulation of lipids include the presence of plant fibers and phytochemicals found in plant structures [21, 22]. Plant fibers have the capacity to slow down the absorption of lipids from the intestine [22], while phytochemicals [23] inhibit the synthesis of cholesterol in the body. Our participants reported taking varieties of plant foods including vegetables, fruits, cereals, and whole grains

during their 7 weeks fast with vegan diet. These plant-based diets, we suggest, may have caused for the significant decrease of TC and LDL-C levels as observed in this study (Table 1). In addition, we speculate that the cereal "Tef" (*Eragrostis tef*) may have played a role in the reduction of TC and LDL-C, because studies have emerged showing the anti-hyperlipedemic and anti-hyperglycemic property of the cereal "Tef" [13, 14, 24]. However, its specific role in depressing lipid metabolism still requires further studies because available evidence remains very limited. In this study, a strong positive association of TC with LDL-C ($r = 0.9$, $p = 0001$) was also calculated following intakes of the vegan diet (Table 2). This association indicated that a change in one variable is also reflected with a similar change in the other variable (Table 2). Thus, controlling for TC level in the blood with the vegan diet has a benefit of controlling the level of LDL-C as well.

Changes on HDL-C

High-density lipoprotein cholesterol (HDL-C) functions in reverse transport of cholesterol from tissues to the liver and values below 35 mg/dl are considered a cardiac risk [18]. In this study (Table 1), Ethiopian OF with vegan diet showed a significant decrease in HDL-C (mean, 45.68 vs. 42.21; $p = 0.001$) compared with the non-vegetarian (OM) dietary habits. Similarly, a significant decrease with vegetarian diet on HDL-C was observed in some of the previous studies [25, 26], suggesting that plant diets have the potential in arresting the synthesis of HDL-C in the body. Lower apo A-1 production rate [6] and high-CHO content of plant diets [18] have been suggested as contributory factors in decreasing HDL-C concentration in the body. Though a decrease in HDL-C below 35 mg/dl is not good for cardiac health [20], Radar et al. [26] and Baumgartner et al. [27] suggest that the reduction of HDL-C by low-fat vegetarian diet does not casually increase the risk of cardiovascular disease in a setting of co-existing low TC and LDL-C levels [6]. A recent review by Koufakis et al. [6] explains also the importance of undertaking longitudinal studies to ascertain the effect of Orthodox fasting on changes of lipid levels by including co-modalities that may influence lipoprotein metabolism. It has been argued that the TC/HD-C ratio is a better assessment of cardiac risk than considering single lipid components (4). This study has observed the ratio values of TC/HDL (Table 1) following the Orthodox fasting to fall in the normal level of < 4, indicating that our participants were in optimal lipid levels.

Changes on triglyceride

An increase in blood triglyceride (TG) concentrations above the desired level (> 150 mg/dl) can be a cardiac risk [20]. In this study (Table 1), the vegan diet consumed during the Ethiopian OF for 7 weeks did not induce significant changes on the TG level compared with the non-vegetarian (OM) diet. A review by Ferdowsian et al. [25] states that people eating plant-based diets, over the long term, consistently show lower TG levels in the blood. Our participants took the vegan diet for a short duration of 7 weeks, implying that this time span was not adequate enough to bring a change in the metabolism of TG during the Orthodox fasting. A further prospective study, however, would be necessary to see the effect of vegan diet on changes of TG, because the results in literatures remain controversial.

Changes in blood urea, total protein, and glucose

Blood urea is a by-product of protein degradation in the liver and the rate of urea production is influenced by the quality and quantity of protein in the diet [28]. Normally, protein food consists of essential and non-essential amino acids. Plant sources produce low-quality protein because of the lack of some essential amino acids that in turn result in diminished urea production [28]. This study observed a significant decrease (by 6.8%, $p = 0.031$) in blood urea concentration compared with the non-vegetarian (OM) diet, suggesting that the quality of the protein consumed during Ethiopian OF was of low-quality protein. In such conditions of low protein quality, it was suggested that eating combinations of plant foods including soy, legumes, grains, and varieties of vegetables can help provide sufficient amino acids for the body [29]. Particularly, soya is regarded as "good-quality" protein because it consists of both essential and non-essential amino acids in its chemical structure [28]. It can thus be deduced from this study that during the Ethiopian religious fasting, it would be beneficial to consume varieties of plant foods in order to supplement the needed amino acids (protein) in the daily diet. Mean blood glucose and as well as total protein (TP) concentrations after the vegan diet were not significantly different from the non-vegetarian OM diet, suggesting that plant-based vegan diets maintain optimal changes in glucose and total protein levels in the blood.

Changes in body composition (BMI, %BF, and W/H ratio)

BMI and W/H ratio are used conventionally as indices of obesity and fat distribution in epidemiological studies [27]. In this study, the vegan diet taken for 7 weeks significantly decreased BMI ($p = 0.015$) and %BF ($p = 0.001$) compared with their respective non-vegetarian (OM) diets (Table 1). Several previous studies are in line with our results [19] explaining that the presence of fibers and low-saturated fats in vegan diets favor reduced accumulation of adipose tissues that lower body weight and fat deposition. Other studies, however, did not see lower BMI following religious fasting.

Differences in the results may be attributed to differences in the dietary composition, because Ethiopians different than other Orthodox fasters (Greek or Egypt) consume cereals like "Tef" [13, 14] that may have a different impact on body composition. This effect of the cereal "Tef" on body weight and body fat store, however, requires further prospective studies.

Limitations

Our data represented only those subjects living in the urban city of Addis Ababa with similar educational and living standards and did not include the rural population. Secondly, we did not exactly record the faster's dietary composition in macro- and micronutrient level and this remains our limitation. The diet was purely vegan diets and we are confident that our participants took the vegan diet properly because of their spiritual commitments. Considering the negative effects of vegetarianism is also important clinically and this will be our future goal. Lastly, in this study, we dealt without separating genders, but gender differences on metabolic parameters will also be our future motto.

Strength

In developing countries like Africa where pharmacological drugs are not easily accessible, this study has shown the potential of reducing non-communicable disease manifestations by consuming plant-based diets. Furthermore, this study, similar to previous works, has indicated that religious fasting (beyond its spiritual goals) is also important in providing cardiometabolic health.

Conclusion

This study has shown that consuming a plant-based vegan diet even for a short period is beneficial to optimize lipid profiles and regulate body weight, thereby minimizing cardiometabolic disease risk. The lower blood urea level observed following the vegan diet may signify consumption of low-quality protein during the fasting period. Consequently, religious fasters may need to take varieties of plant foods, in order to compensate amino acids that plant diets lack.

Acknowledgments We thank all participants, who joined the study from Hemen Maternal and Children Specialty Medical Center and Addis Ababa Megabit 28 primary School. The technical support offered by our Master's students including Ms. Hana, Mr. Tariku, Mr. Chala, and staffs of Diagnostic Lab are highly appreciated.

Authors' contribution Dr. Wondyefraw Mekonen designed, wrote the proposal, calculated the statistics, and wrote the manuscript. Dr. Diresibachew took part in developing the proposal. Both authors read and approved the final manuscript.

Funding This study is supported by Addis Ababa University, adaptive problem-solving research fund, Ref. No: RD/LT/824/2016.

Data availability Available from the corresponding author on request.

Compliance with ethical standards

Competing interests The authors declare that they have no competing interests.

Ethics approval letter Approved by Ethical Review Board of College of Health Sciences (No: 071/17/Phy), Addis Ababa University.

Abbreviations EtOC, Ethiopian Orthodox Christian; NF, non-fasting; OF, orthodox fasting; TC, total cholesterol; TG, triglyceride; LDL-C, low-density lipoprotein cholesterol; HDL-C, high-density lipoprotein cholesterol; TP, total protein; BMI, body mass index; W/H, waist-to-hip ratio; %BF, percent body fat

References

1. Sabate J. Religion, diet, and research. Invited commentary. Br J Nutr. 2004;92:199–201.
2. Trepanowski JF, Bloomer RJ. The impact of religious fasting on human health. Nutr J. 2010;9:57.
3. Craig WJ. Nutrition concerns and health effects of vegetarian diet. Nutr Clin Pract. 2010;25:613–20.
4. Agrawall S, Millett CJ, Dhillon PK, Subramanian SV, Ebrahim S. Type of vegetarian diet, obesity and diabetes in adult Indian population. Nutr J. 2014;13:89.
5. Kyung K, Woon SC, Kyoung PY. Long-term vegetarians have low oxidative stress, body fat, and cholesterol levels. Nutr Res Pract. 2012;62(155):161.
6. Koufakis T, Karras SN, Pantelis Zebekakis P, Kalliopi Kotsa K. Orthodox religious fasting as a medical nutrition therapy for dyslipidemia: where do we stand and how far can we go? Eur J Clin Nutr. 2018;72:74–479.
7. Central Intelligence Agency. The World Fact book, Country Profiles: Ethiopia 2018 [cited 2018 March 24]. Available from: https://www.cia.gov/library/publications/the-world-factbook/geos/et.html.
8. Papadaki A, Vardavas C, Hatzis C, Kafatos A. Greek Orthodox fasting rituals: calcium, nutrient and food intake of Greek Orthodox Christian monks during a fasting and non-fasting week. Public Health Nutr11. 2008:1022–9.
9. Morcos NYS, Seoudi DM, Kamel I, Marian M, Youssef MM. Effect of Coptic Orthodox Christian church fasting on healthy and diabetic subjects. Int J Nutr Pharm Neuro Dis. 2013;3(4):375–82. https://doi.org/10.4103/2231-0738.119853.
10. Koufakis T, Karras SN, Antonopoulou V, Angeloudi E, Zebekakis P, Kotsa K. Effects of Orthodox religious fasting on human health: a systematic review. Eur J Nutr. 2017;56:2439–55.
11. Sarri KO, Linardakis MK, Bervanaki FN, Tzanakis NE, Kafatos AG. Greek Orthodox fasting rituals: a hidden characteristic of the Mediterranean diet of Crete. Br J Nutr. 2004;92:277–84.
12. Sarri KO, Tzanakis NE, Linardakis MK, Mamalakis GD, Kafatos AG. Effects of Greek Orthodox Christian Church fasting on serum lipids and obesity. BMC Public Health. 2003;3(3):16.

13. Liesbeth SD, Winkelaar YK, Koning F. The Ethiopian cereal Teff in celiac disease. N Engl J Med. 2005;353(16):1748–9.
14. El-Alfy TS, Ezzat SM, Sleem AA. Chemical and biological study of the seeds of Eragrostistef (Zucc.) Trotter. Nat Prod Res. 2012;26(7):619–29. https://doi.org/10.1080/14786419.2010.538924.
15. Gupta R, Rastogi P, Sarna M, Gupta VP, Sharma SK, Kothari K. Body-mass index, waist-size, waist-hip ratio and cardiovascular risk factors in urban subjects. J Assoc Physicians India. 2007;55:621–7.
16. Deurenberg P, Weststrate JA, Seidell JC. Body mass index as a measure of body fatness, age-and sex specific prediction formula. Br J Nutr. 1991;65(2):105–14.
17. Bloomer RJ, Kabir MM, Canale RE, Trepanowski JF, Marshall KE, Farney TM, et al. Effect of a 21 day Daniel fast on metabolic and cardiovascular disease risk factors in men and women. Lipids Health Dis. 2010;9:94.
18. Katan MB. Effect of low-fat diets on plasma high-density lipoprotein concentrations. Am J Clin Nutr. 1998;67(suppl):573S–6S.
19. Spencer EA, Appleby PN, Devey GK, Key TJ. Diet and body mass index in 38000 EPIC-Oxford meat eaters, fish eaters, vegetarians, and vegans. Int J Obes. 2003;27:728–34.
20. Adult Treatment panel III. Executive summary of the report of the National Cholesterol Education Program (NCEP) expert panel on the detection, evaluation, and treatment of high blood cholesterol in adult. JAMA. 2001;285:2486–97.
21. Liu L, Yeh Y. Inhibition of cholesterol biosynthesis by organosulfur compounds derived from garlic. Lipids. 2000;35:197–203.
22. Plat J, Mensink RP. Plant stanol and sterol esters in the control of cholesterol levels: mechanism and safety aspects. Am J Cardiol. 2005;96:15–22.
23. Fardet A. New hypotheses for the health-protective mechanisms of whole grain cereals: what is beyond fiber? Nutr Res Rev. 2010;23:65–134.
24. https://ethnomed.org/clinical/diabetes/diabetes-in-the-eritrean-and-ethiopian-community-cultural-information-and-recommendations-for-diabetes-educators. Accessed 22 Mar 2019.
25. Ferdowsian HR, Barnard ND. Effects of plant-based diets on plasma lipids. Am J Cardiol. 2009;104:947–56.
26. Rader DJ, Hovingh GK. HDL and cardiovascular disease. Lancet. 2014;384:618–25.
27. Baumgartner RN, Heyms FB, Roche AF. Human body composition and the epidemiology of chronic diseases. Obes Res. 1995;3(1):73–95.
28. Bassily NS, Michael KG, Said AK. Blood urea content for evaluating dietary protein quality. Nahrung. 1982;26(9):759–64.
29. Goldberg AP, Lim D, Kola JB, Grundhauser JJ. Soya bean protein independently lowers plasma cholesterol levels in primary hypercholesterolemia. Atherosclerosis. 1994;43:355–67.
30. Yoko Yokoyama Y, Susan M Levin SM, Barnard ND. Association between plant-based diets and plasma lipids: a systematic review and meta-analysis. Nutrition Reviews. 2017;75(9):683–98.
31. Ornish D, Scherwitz LW, Billings JH, et al. Intensive lifestyle changes for reversal of coronary heart disease. JAMA. 1998;280:2001–7.