IVYSPRING INTERNATIONAL PUBLISHER

Journal of Biomedicine

2017; 2: 8-11. doi: 10.7150/jbm.17587

Short Research Communication

Mushroom Intake and Advanced Glycation End Products in the Skin among Community-Dwelling Elderly Subjects: Preliminary Data

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Received: 2016.09.15; Accepted: 2016.10.19; Published: 2017.01.01

Abstract

PURPOSE: Food intakes against advanced glycation end products (AGEs), which is involved in aging and related pathologies, remain explored. The current study was aimed to investigate the relationship between some food intakes and skin AGEs in a general elderly population.

METHODS: In 39 subjects (19 men/20 women, mean age 76.6 years), a questionnaire on intakes of foods, including mushrooms, was self-reported. Their AGEs were measured in the skin of upper arm by an AGE Reader™ employing a method of autofluorescence (AF).

RESULTS: The mean skin AF value was 2.1 AU and the mean mushroom intake was 15.7 g per day. The mushroom intake was significantly and inversely correlated with skin AF (correlation coefficient = -0.42, $P < 0.05$).

CONCLUSIONS: The inverse correlation between the mushroom intake and skin AF in this population may imply the mushroom intake to be lowering AGEs. This is preliminary; thus, future research is warranted.

Key words: glycation, mushroom, skin autofluorescence.

Introduction

Advanced glycation end products (AGEs), formed *via* the Maillard reaction during aging process and related diseases [1], have been implicated in several pathologies such as metabolic and cardiovascular disorders [2,3]. As foods contain AGEs, food intake is one of the factors influencing the formation of AGEs [4,5]. Indeed, foods which contain some nutrients such as polyphenols [6], vitamin D [5,7] and vitamin B6 [8] can reduce the AGEs.

While assessment on the *in vivo* levels of AGEs is also an issue to study the relationship between food intake and AGEs, a simple method to measure the AGEs in the skin by autofluorescence has been recently used [9-15]. The use of skin AGEs is thought to have merits as an index reflective to their long-term accumulation [9]. Elderly people can be a population suitable for assessing a long-term accumulation of AGEs. Thus, the current study was aimed to

investigate preliminarily the relationship between some food intakes and skin AGEs in a general elderly population.

Methods

Thirty-nine subjects (19 men/20 women, mean age 76.6 ± 4.8 [standard deviation] years) were recruited from a community (the Yurin area in Kyoto City, Japan). Subjects who were ≥ 65 years of age and in self-reportedly good physical situation were included and those with overt cardio- and cerebro-vascular diseases were excluded. The study protocol was approved by Doshisha University (No. 0832, 14089) and all subjects gave informed consent.

The body mass index (BMI) was calculated by height and body weight (BS-221; DRETEC Co., Ltd., Saitama, Japan). The skin AGEs were assessed with a level of autofluorescence (AF) measured by an AGE Reader™ (DiagnOptics, Groningen, the Netherlands) [15]. The measurements were conducted three times at the site of 10 cm above the elbow inside of the upper arm and the mean value was used for the study. The coefficient variation of skin AF is 2.7% [15]. Subjects with hypertension, hyperlipidemia and diabetes mellitus were identified in cases of self-reported medication for these diseases. The intake (per day) of food was self-reported by each subject using the brief-type diet history questionnaire [16]. The questionnaire included the following: cereals (rice, noodles, bread), potatoes, sugar, confectioneries, fruits, fruit juice, vegetables (green/yellow, hypochromic), seaweeds, mushrooms, fish/shellfish, meat, eggs, soybeans, milk/dairy products, and alcoholic beverages.

The correlation coefficients between food intakes and skin AF were analyzed by Pearson or Spearman correlation tests with an unadjusted model and the model adjusted for age, gender and BMI. The between-group difference in skin AF was analyzed by t-test. All statistical analyses were conducted using the SPSS program (IBM SPSS 20.0, Tokyo, Japan). A *P* value < 0.05 was considered significance.

Results

Clinical characteristics of all subjects and their correlations with skin AF are shown in **Table 1**. The mean value of skin AF was 2.1 AU. The subject age was significantly and positively correlated with the skin AF, while there were no significant correlations between the other parameters and skin AF.

Clinical values of food intakes and their correlations with skin AF are shown in **Table 2**. The mean of mushroom intake was 15.7 g per day. The mushroom intake was significantly and inversely correlated with the skin AF. This correlation remained to be maintained after adjusting for age, gender and BMI. When we divided all subjects into the two subgroup, by the mean of 15.7 g, the subgroup with ≥ 15.7 g showed a significant lower skin AGE value (n = 17, value [standard deviation] = 1.92 [0.34]) than the subgroup with < 15.7 g (n = 22, 2.18 [0.28]; *P* = 0.01). No significant correlations were observed between the other food intakes and skin AF.

Table 1. Clinical characteristics of all subjects and their correlations with skin autofluorescence.

Parameters	Values	Correlation coefficient (*P*)
Age (years)	76.6 (4.8)	0.38 (0.02)*
Gender (female %)	20 (51.3%)	-0.30 (0.06)
Body mass index (kg/m^2)	22.8 (2.8)	-0.01 (0.95)
Hypertension	19 (48.7%)	-0.11 (0.61)
Hyperlipidemia	10 (28.2%)	-0.08 (0.61)
Diabetic mellitus	5 (12.8%)	-0.02 (0.92)
Skin autofluorescence (AU)	2.1 (0.3)	-

Values: mean (standard deviation) or number (%). **P*: < 0.05 (significance).

Table 2. Correlation coefficient between food intakes and skin autofluorescence

Food groups (g/day)	Values	Unadjusted (*P*)	Adjusted (*P*)
Cereals	412.0 (165.0)	0.08 (0.63)	-0.25 (0.14)
Rice	268.9 (120.4)	-0.03 (0.86)	-0.25 (0.15)
Noodles	82.4 (58.2)	0.06 (0.70)	-0.12 (0.47)
Bread	60.7 (37.6)	0.23 (0.17)	-0.09 (0.59)
Potatoes	58.3 (50.6)	-0.17 (0.30)	-0.24 (0.16)
Sugar	7.3 (5.0)	-0.13 (0.43)	-0.17 (0.33)
Confectioneries	81.3 (63.1)	0.10 (0.56)	0.15 (0.40)
Fruits	180.6 (100.6)	-0.02 (0.91)	-0.10 (0.55)
Fruit Juice	55.3 (79.5)	0.18 (0.29)	0.22 (0.21)
Vegetables	342.2 (153.3)	-0.02 (0.89)	-0.09 (0.60)
Green/yellow vegetables	137.3 (75.5)	0.09 (0.60)	-0.14 (0.43)
Hypochromic vegetables	204.9 (90.4)	-0.14 (0.41)	-0.12 (0.49)
Seaweeds	15.5 (14.6)	-0.16 (0.34)	-0.13 (0.44)
Mushrooms	15.7 (11.1)	-0.42 (< 0.01)*	-0.48 (< 0.01)*
Fish/Shellfish	133.8 (70.8)	-0.24 (0.15)	-0.20 (0.24)
Meat	75.9 (33.5)	0.03 (0.84)	-0.09 (0.62)
Eggs	44.4 (29.4)	0.13 (0.43)	-0.01 (0.95)
Soybeans	84.0 (57.7)	-0.05 (0.78)	-0.15 (0.38)
Milk/dairy products	169.7 (116.8)	0.54 (< 0.01)*	0.14 (0.40)
Alcoholic beverages	14.8 (27.3)	0.13 (0.45)	0.00 (1.00)

Values: mean (standard deviation). **P*: < 0.05 (significance).
Unadjusted: an unadjusted model, Adjusted: an age-, gender- and body mass index-adjusted model.

Concerning the correlations between the mushroom intake and the other food intakes, mushroom intake was significantly correlated with hypochromic vegetables (correlation coefficient = 0.51, $P < 0.01$), potatoes (correlation coefficient = 0.44, $P < 0.01$), fruits (correlation coefficient = 0.33, $P = 0.04$) and seaweeds (correlation coefficient = 0.36, $P = 0.03$). The significant inverse correlation between the mushroom intake and skin AF remained to be maintained after adjusting for the respective food intakes (data not shown).

The energy intake, protein intake, fat intake, and carbohydrate intake rates were not significantly correlated with the skin AF even after being adjusted for age, gender, and BMI (data not shown).

Discussion

There was an inverse correlation between the mushroom intake and skin AF in the community-dwelling elderly subjects. Given the involvement of AGEs in several pathologies is well documented [2,3] and foods which suppress excess AGEs [5-7] have been explored, the addition of mushrooms to the candidate for lowering AGEs appears to be of note. That is, the current study findings may stimulate further investigation to prevent the accumulation of AGE in the aging population, although we must acknowledge that this is based on preliminary data in a small study.

Vitamin D exhibits anti-glycation/anti-oxidation, which suppresses the Maillard reaction, and increases soluble receptors for AGEs, which act as decoys for binding to AGEs and lead to a reduction of AGEs [17,18], Mushrooms are generally vitamin D-enrich and in fact, a possibility of mushrooms correlated inversely to AGEs has been implied [3,6,8]. Ergothioneine also exhibits anti-oxidation [19] and mushrooms are known to be a rare source of ergothioneine. The suppressive effects of selenium, fiber and minerals on AGEs are considered [19]. As the volume of selenium, fiber and minerals in mushrooms is said to be equal to or more than the volume in vegetables [20], the components may partly influence the AGEs. The current study did not measure these factors; thus, further research for mechanistic explanation is necessary.

The current study is associated with several limitations. The sample size was small. The study was cross-sectional not fully to define the causality. The data of diets were self-reported. Only a single method to measure AGEs was used. The other methods such as biochemical indices of blood AGEs could be added to the skin AF measurement. These must be address in the future work.

Collectively, the current study found an inverse correlation between the mushroom intake and skin AF in the community-dwelling elderly subjects. While the mushroom intake for lowering AGEs is suggested, future research is needed to validate second population and intervention study.

Acknowledgments

This study was supported by the Japanese Council for Science, Technology and Innovation, SIP (Project ID 14533567), Technologies for creating next-generation agriculture, forestry and fisheries (Bio-oriented Technology Research Advancement Institution, NARO), the Hokuto Foundation for Bioscience and the JSPS KAKENHI Grant No. 16K08900.

Competing Interests

There is no competing interest to declare.

References

1. Dyer DG, Dunn JA, Thorpe SR et al. Accumulation of Maillard reaction products in skin collagen in diabetes and aging. J Clin Invest. 1993; 91: 2463-2469.
2. Clarke RE, Dordevic AL, Tan SM et al. Dietary advanced glycation end products and risk factors for chronic disease: A systematic review of randomised Controlled trials. Nutrients. 2016; 8: 125.
3. Krul-Poel YH, Agca R, Lips P et al. Vitamin D status is associated with skin autofluorescence in patients with type 2 diabetes mellitus: a preliminary report. Cardiovasc Diabetol. 2015; 14: 89.
4. Macías-Cervantes MH, Rodríguez-Soto JM, Uribarri J et al. Effect of an advanced glycation end product-restricted diet and exercise on metabolic parameters in adult overweight men. Nutrition. 2015; 31: 446-451.
5. Nikooyeh B, Neyestani TR, Tayebinejad N et al. Daily intake of vitamin D- or calcium-vitamin D-fortified Persian yogurt drink (doogh) attenuates diabetes-induced oxidative stress: evidence for antioxidative properties of vitamin D. J Hum Nutr Diet. 2014; Suppl 2: 276-283.
6. Nagasawa T, Tabata N, Ito Y et al. Dietary G-rutin suppresses glycation in tissue proteins of streptozotocin-induced diabetic rats. Mol Cell Biochem. 2003; 252: 141-147.
7. Sukino S, Kotani K Nirengi S et al. Dietary intake of vitamin D is related to blood levels of advanced glycation end products during a weight loss program in obese women. J Biomed. 2016; 1: 1-4.
8. Williams ME, Bolton WK, Khalifah RG et al. Effects of pyridoxamine in combined phase 2 studies of patients with type 1 and type 2 diabetes and overt nephropathy. Am J Nephrol 2007; 27: 605-614.
9. Meerwaldt R, Graaff R, Oomen PH et al. Simple non-invasive assessment of advanced glycation endproduct accumulation. Diabetologia. 2004; 47: 1324-1330.
10. Samborski P, Naskręt D, Araszkiewicz A et al. Assessment of skin autofluorescence as a marker of advanced glycation end product accumulation in type 1 diabetes. Pol Arch Med Wewn. 2011; 121: 67-72.
11. Stirban A, Pop A, Fischer A et al. Variability of skin autofluorescence measurement over 6 and 12 weeks and the influence of benfotiamine treatment. Diabetes Technol Ther. 2013; 15: 733-737.
12. Hartog JW, de Vries AP, Lutgers HL et al. Accumulation of advanced glycation end products, measured as skin autofluorescence, in renal disease. Ann N Y Acad Sci. 2005; 1043: 299-307.
13. Yue X, Hu H, Koetsier M et al. Reference values for the Chinese population of skin autofluorescence as a marker of advanced glycation end products accumulated in tissue. Diabet Med. 2011; 28: 818-823.
14. Kimura H, Tanaka K, Kanno M et al. Skin autofluorescence predicts cardiovascular mortality in patients on chronic hemodialysis. Ther Apher Dial. 2014; 18: 461-467.
15. Nomoto K, Yagi M, Arita S et al. A survey of fluorescence derived from advanced glycation end products in the skin of Japanese: differences with age and measurement location. J Anti Aging Med. 2012; 9: 119-124.

16. Kobayashi S, Murakami K, Sasaki S et al. Comparison of relative validity of food group intakes estimated by comprehensive and brief-type self-administered diet history questionnaires against 16 d dietary records in Japanese adults. Public Health Nutr. 2011; 14: 1200-1211.
17. Irani M, Minkoff H, Seifer DB, et al. Vitamin D increases serum levels of the soluble receptor for advanced glycation end products in women with PCOS. J Clin Endocrinol Metab. 2014; 99: E886-890.
18. Salum E, Kals J, Kampus P, et al. Vitamin D reduces deposition of advanced glycation end-products in the aortic wall and systemic oxidative stress in diabetic rats. Diabetes Res Clin Pract. 2013; 100: 243-249.
19. Feeney MJ, Dwyer J, Hasler-Lewis CM et al. Mushrooms and Health Summit proceedings. J Nutr. 2014; 144: 1128S-1136S.
20. [Internet] Ministry of Education, Culture, Sports, Science and Technology (MEXT): Tokyo, Japan. STANDARD TABLES OF FOOD COMPOSITION IN JAPAN -2015- (seventh Rev Ver). http://www.mext.go.jp/english/science_technology/1347490.htm