Original Article

Vegetable juice preload ameliorates postprandial blood glucose concentration in healthy women: A randomized cross-over trial

Risa Iehara[1, 2], Saeko Imai[1]*, Shizuo Kajiyama[3, 4], Mai Yamamoto[1, 5], Takashi Miyawaki[1], Shinya Matsumoto[1], Yoshitaka Hashimoto[4], Neiko Ozasa[6], Shintaro Kajiyama[3, 4, 7], Michiaki Fukui[4]

Abstract

Background and Objectives: The aim of this study was to evaluate the acute effect of drinking vegetable juice 20 min before carbohydrate on postprandial blood glucose concentrations in young healthy women.

Method: In this randomized controlled cross-over study, 24 women (age 21.3 ±0.6 years, HbA1c 5.4 ±0.2 %, mean ± SD) consumed either 200 g of vegetable juice, vegetable (150 g of tomato and 40 g of broccoli), or water at 20 min before consuming 200 g of boiled white rice for 3 separate days. The blood glucose concentrations were measured by self-monitoring blood glucose pre- and post-breakfast at −20, 0, 15, 30, 45, 60, 120, and 180 min. The glycemic parameters were compared among 3 days.

Results: The incremental glucose peak at 45 min (vegetable juice 48.3 ± 4.1, vegetable 47.4 ± 3.3 vs. water 66.8 ± 4.3 mg/dl, respectively, both $p < 0.01$, mean ± SEM) and large amplitude of glycemic excursion (LAGE; vegetable juice 57.1 ± 3.1, vegetable 58.3 ± 3.6 vs. water 78.3 ± 4.3 mg/dl, respectively, both $p < 0.05$) in consuming vegetable juice and vegetable at 20 min before carbohydrate intake were all significantly lower than those of water. There was no significant difference between glycemic parameters of vegetable juice and vegetable.

Conclusions: Drinking vegetable juice 20 min before carbohydrate ameliorates the postprandial blood glucose concentrations as well as vegetable preload, despite total amounts of energy and carbohydrate of vegetable juice or vegetable are higher than those of water.

Key Words: diet, vegetable juice, vegetable, postprandial blood glucose, carbohydrate, diabetes

(Received 4 October, 2022, Accepted 7 November)

Introduction

Postprandial hyperglycemia develops arteriosclerosis, cerebral infarction, and myocardial infarction[1)]. Therefore, reducing the blood glucose excursion is important to decrease the risk of macrovascular complications in individuals with type 2 diabetes. Moreover, suppressing postprandial blood glucose concentration is one of the keys for extension of healthy life expectancy in healthy people, because it decreases the risk of type 2 diabetes and other metabolic disorders[1, 2)].

We have reported that consuming vegetables first and carbohydrates last was effective to suppress the postprandial blood glucose concentrations and insulin secretion in people with and without diabetes[3–7)]. This simple and easy meal plan is widely spread for dietary education for patients with diabetes and healthy individuals[8–10)]. However, average amounts of vegetable intake in Japan and U.S.A. were reported to be under the target of recommendations[11–13)]. The reasons for limited vegetable intake are economical reason, limited cooking time and skills, low availability of fresh products, taste preference, and lack of knowledge of the benefits of vegetable intake. Previously we have reported that drinking tomato juice at 30 minutes before carbohydrate decreases postprandial blood glucose concentration as well as preload of consuming fresh tomato in healthy women[14)].

[1] Department of Food and Nutrition, Kyoto Women's University, Kyoto, Japan
[2] Division of Health Promotion, Shimane Prefecture Government, Shimane, Japan
[3] Kajiyama Clinic, Kyoto, Japan
[4] Department of Endocrinology and Metabolism, Kyoto Prefectural University of Medicine, Graduate School of Medical Science, Kyoto, Japan
[5] Kyoto Chubu Medical Center, Kyoto, Japan
[6] Department of Cardiovascular Medicine, Kyoto University, Graduate School of Medicine, Kyoto, Japan
[7] Japanese Red Cross Kyoto Second Hospital, Kyoto, Japan
* Tel: +81-75-531-7128, Fax: +81-75-531-7170
Email: imais@kyoto-wu.ac.jp, poooch@hotmail.co.jp

In order to explore the benefit of drinking vegetable juice for shorter time before carbohydrate, we examined the effect of drinking vegetable juice 20 min before carbohydrate on postprandial blood glucose concentrations of a randomized controlled cross-over study in young healthy women.

Methods

Subjects

We recruited research participants in Kyoto Women's University. Exclusion criteria were as follows. (1) People with type 1 and type 2 diabetes, (2) taking drugs that affect blood glucose concentrations, (3) pregnant, (4) smoking more than 40 cigarettes per day or drinking more than 50 ml alcohol per day (5), or people who were considered inappropriate for the study by the doctor. This study was designed after complying with the ethical guidelines for medical research involving human subjects in accordance to the Helsinki Declaration. The study was approval by the Clinical Research Review Committee in Kyoto Women's University (2020–8) and registered UMIN-CTR (000034944). The study purpose, design, and risk of the study were explained to each participant and the written informed consent was obtained prior to the study. The body weight and height of participants were measured by the research group in Kyoto Women's University. Fasting blood glucose (FBG) and Hemoglobin A1c (HbA1c) of participants were examined in Rakuwakai Toji Minami Hospital. FBG was measured by amperometic method and HbA1c were determined by high-performance liquid chromatography (HPLC) method.

Study protocol

This is a randomized controlled three-treatment cross-over open-labeled study within-participant. The participants consumed 200 g of vegetable juice (Kagome Yasai Juice, Kagome Co., Ltd., Tokyo), fresh vegetable (150 g of tomato and 40 g of broccoli), or 200 g of water 20 min before consuming 200 g of boiled white rice with herb salt (0.7 g of salt, Mishima Foods Co., Ltd., Hiroshima) for 3 separate days (Figure 1). The vegetable juice contains certain amount of tomato besides carrot, lettuce, cabbage, celery, and spinach. All meals were prepared and served by the research group for 3 days at Kyoto Women's University. The macronutrient content of the test meals was shown in Table 1. The amounts of nutrients in vegetable and vegetable juice were adjusted to be equal, but energy, carbohydrate content, and dietary fiber in water (control) were less than vegetable and vegetable juice (Table 1).

Participants arrived at Kyoto Women's University at 8:20 am after an overnight fast. Participants finished consuming either vegetable juice, vegetable, or water at 8:40 am and consumed boiled white rice at 9:00 am for 3 separate mornings in a randomized cross-over study (Figure 1). All participants performed the capillary finger pricks (Gentlet, Sanwa Chemical Institute, Nagoya, Japan) and blood glucose analyses with self-monitoring blood glucose (SMBG) device (Glutest neo alpha, Sanwa Chemical Institute, Nagoya, Japan) by themselves under the physician's instruction. Pre- and post-meal blood glucose concentrations were measured at -20, 0, 15, 30, 45, 60, 120, and 180 min (Figure 1). The mean blood glucose concentration, standard deviation for blood glucose, max blood glucose (MAX),

Table 1. The macronutrient content of boiled white rice with vegetable juice, vegetable, and water

	Vegetable juice	Vegetable	Water
Energy (kcal)	379	380	340
Carbohydrate (g)	83.7	83.7	74.9
Boiled white rice (g)	74.2	74.2	74.2
Shiso seasoning (g)	0.7	0.7	0.7
Vegetable (g)	—	8.8	—
Vegetable juice (g)	8.8	—	—
Dietary fiber (g)	4.8	6.4	3.4
Fat (g)	0.7	1.0	0.7
Protein (g)	6.9	7.7	5.2
Salt (g)	1.0	0.7	0.7

The nutritional contents of the test meals were analyzed by computer software (Microsoft Excel Eiyokun for Windows ver.7.0 Kenpakusya, Tokyo, Japan).

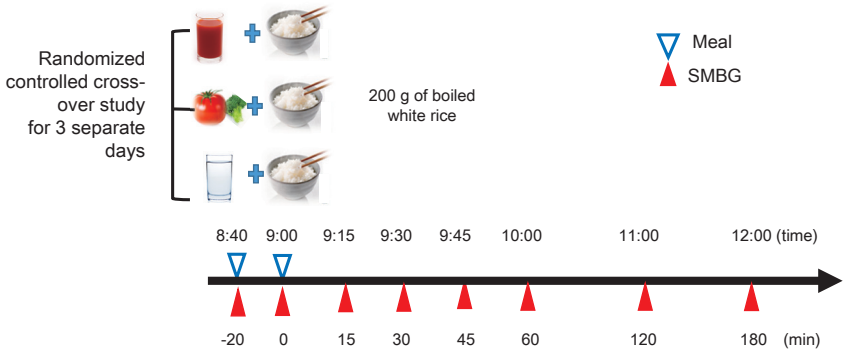

Figure 1. The study protocol of randomized cross-over control trial for 3 days. All participants consumed vegetable juice, vegetable, or water and consumed boiled white rice 20 min later for 3 separate days. The blood glucose concentrations were measured at -20, 0, 15, 30, 45, 60, 120, and 180 min pre- and post-breakfast. SMBG; Self-monitoring blood glucose.

large amplitude of blood glucose excursion (LAGE), incremental glucose concentrations, incremental glucose peak (IGP), and incremental area under the curve for glucose (IAUC) after the test meals were compared among 3 days.

Data analysis

Sample size of 20 participants conferred a 95% power to detect a 5% difference (G*Power 3.1, Heinrich-Heine-Universität Düsseldorf, Germany) in IGP based on our previous study of preload tomato juice in postprandial blood glucose concentrations[14]. Twenty-five participants were enrolled the study. Incremental blood glucose concentrations and IGP were calculated by subtracting the blood glucose concentration of baseline at 8:40 am for breakfast. IAUC were calculated by trapezoidal method. As a normal distribution and homogeneity of all glycemic parameters could not be confirmed by Shapiro-Wilk and Levene test, we performed a paired comparison by Wilcoxon matched-pairs signed-rank test followed by *post hoc* Bonferroni's inequality when Friedman's test revealed significant effects for glycemic parameters ($p < 0.05$). All analyses were performed with SPSS Statistics version 24 software (IBM Corp., Armonk, NY, USA). The data are reported as means ± standard error of the mean (SEM) unless otherwise stated.

RESULTS

Twenty-five women enrolled the study, but 24 women (age 21.3 ± 0.6 years, body weight 50.7 ± 5.0 kg, BMI 20.0 ± 1.5 kg/m^2, FBG 88.0 ± 6.9 mg/dl, HbA1c 5.4 ± 0.2%: mean ± SD) completed the study, since one participant could not follow the study protocol. The Figure 2 demonstrated the mean blood glucose profiles in 3 days consumed vegetable juice, vegetable, and water 20 min before carbohydrate in young healthy women.

The glycemic parameters were shown in Table 2. The MBG, SD, MAX, LAGE, incremental blood glucose concentration at 45 min, and IGP in both vegetable juice and vegetable were all significantly lower than those of water. The incremental blood glucose concentration at 30 min in vegetable was significantly lower than that of water, and the incremental blood glucose concentration at 60 min in vegetable juice tended to be lower than

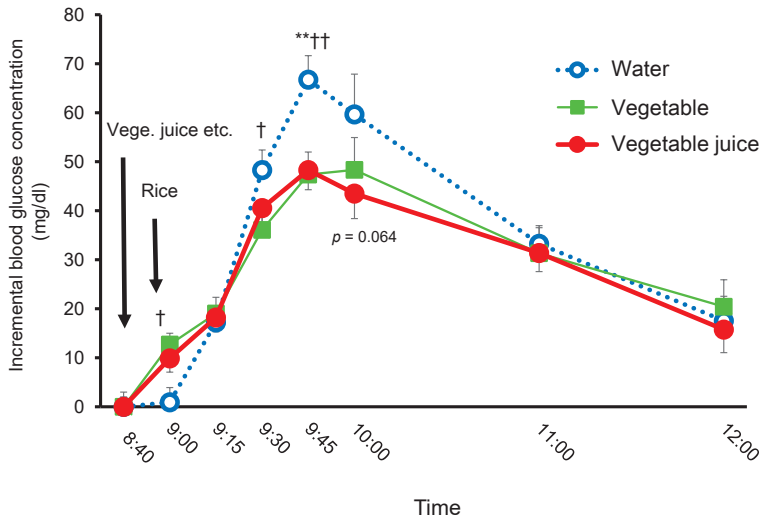

Figure 2. The mean incremental blood glucose concentrations of vegetable juice, vegetable, and water 20 min before boiled rice in young healthy women (n=24). Data are mean ± SEM. Vegetable juice vs. Water (control) ** $p < 0.01$. Vegetable vs. Water (control) $^{\dagger}p < 0.05$, $^{\dagger\dagger}p < 0.01$.

Table 2. The glycemic parameters preload of vegetable juice, vegetable, and water in healthy women (n=24)

	Vegetable juice	Vegetable	Water
MBG (mg/dl)	108.1 ± 2.0**	107.4 ± 2.0††	113.2 ± 1.9
SD (mg/dl)	20.7 ± 1.1**	20.6 ± 1.1†††	28.6 ± 1.6
MAX (mg/dl)	137.1 ± 2.9**	135.9 ± 3.6†††	157.0 ± 3.9
LAGE (mg/dl)	57.1 ± 3.1**	58.3 ± 3.6††	78.3 ± 4.3
IGP (mg/dl)	54.9 ± 3.3**	55.4 ± 3.8††	74.3 ± 4.6
IAUC 1h for glucose (mg/dl×min)	2,133 ± 181	2,200 ±173	2,492 ± 189
IAUC 2h for glucose (mg/dl×min)	4,383 ± 342	4,590 ± 356	5,282 ± 414
IAUC 3h for glucose (mg/dl×min)	5,807 ± 487	6,183 ± 516	6,859 ± 559

MBG; mean blood glucose, SD; standard deviation for glucose, MAX; max blood glucose, LAGE; large amplitude of glycemic excursion, IGP; incremental glucose peak, IAUC; incremental area under the curve for glucose. Data are mean ± SEM. Vegetable juice vs. Water (control) ** $p < 0.01$. Vegetable vs. Water (control) $^{\dagger\dagger}p < 0.01$, $^{\dagger\dagger\dagger}p < 0.001$.

that of water (p = 0.064). However, there was no significant difference in glycemic parameters between vegetable juice and vegetable.

DISCUSSION

In this acute randomized cross-over open-labeled trial, we demonstrated that drinking vegetable juice 20 minutes prior to boiled rice was effective to suppress the postprandial blood glucose concentrations as well as consuming fresh vegetable compared to those of water in young healthy women, despite the energy and carbohydrate contents of vegetable juice or fresh vegetable were higher than those of water. This result coincides to our previous studies of the acute effect of tomato juice before carbohydrate[14], and the acute and the chronic effects of eating vegetable before carbohydrate on blood glucose concentrations[3–7]. Thus, vegetable juice preload is almost equal to the effect of tomato juice or fresh vegetable preload. The time of preload of drinking vegetable juice is shortened from 30 min to 20 min, which can apply easier to the daily life. Therefore, vegetable juice as well as tomato juice preload can substitute the fresh vegetable preload in order to reduce the postprandial blood glucose concentrations in Japanese young women without type 2 diabetes.

This reduction of postprandial blood glucose levels observed in the study might be explained by the effect of dietary fiber in the vegetable juice or fresh vegetable. Water-soluble dietary fiber suppresses the postprandial blood glucose concentrations, since the dietary fiber slows the absorption of carbohydrates and delay the transition from the stomach to the small intestine[15]. Another reason for amelioration of the postprandial blood glucose concentrations might be related to the secretion of insulin and incretin hormones, such as glucagon-like peptide-1 (GLP-1) and glucose-dependent insulinotropic polypeptide (GIP). Incretin hormones are secreted from gut in response to consumption of nutrients and enhance insulin secretion to lower the blood glucose concentrations. Particularly, GLP-1 suppresses glucagon secretion and delays gastric emptying rate, and consequently, ameliorates the postprandial blood glucose elevation[16, 17]. Although, we did not examine serum hormones in this study, therefore, the roles of insulin, incretin hormones, and gastric emptying rate on glycemic responses are still unclear.

Chronic effects of vegetable juice have been reported such as reducing of serum cholesterol concentrations[18] and inflammatory adipokines[19], and increasing the resting energy expenditure[20]. The effects of lycopene and carotenoid on lower prevalence of metabolic syndrome[21] and cardiovascular risk factors for long-term have been reported[22], so these polyphenol and vitamins contained in vegetable and vegetable juice may be effective to lower the postprandial blood glucose concentration in the current study. Also, lycopene and 13-oxo-9, 11-octadecadienoic acid (13-OXO-ODA) in the vegetable juice have the effect of modulating adipokine secretion, lowering plasma glucose and serum lipids concentrations including triglyceride in obese animal[24, 25]. Because the high serum triglyceride concentration increases insulin resistance, reducing serum triglyceride concentrations leads to improve glycemic control in epidemiological research[23]. Thus, vegetable juice preload may have possibility to shift circulating adipokine concentrations for anti-inflammatory profile and serum lipid profiles, then ameliorate the postprandial blood glucose concentrations for long-term in human.

The similar report of the acute effect of vegetable juice preload on suppression of the postprandial blood glucose concentrations has been reported, but there is a major difference in the study protocol[26]. They compared blood glucose concentrations between vegetable juice with 110 g of boiled rice vs. water with 150 g of boiled rice in their study design. The postprandial blood glucose concentrations positively correlate the amount of boiled rice, therefore, their conclusion of the effect of vegetable juice preload is unreliable because the effect was presumed to be caused by the smaller amount of boiled rice.

The present study demonstrates the effect of drinking vegetable juice prior to the meal in healthy women, although we have to mention several limitations in this study. First limitation was that this study was the acute effect on postprandial blood glucose responses, so chronic effect of vegetable juice preload was uncertain. Second, the study was conducted in Japanese young healthy women, the effect of different population has not been confirmed. Third, the blood glucose concentrations were measured by SMBG, not by laboratory analysis with venous sampling blood. Fourth, we should have examined serum insulin and incretin hormones, so the role of insulin and incretin hormones on glycemic responses is still unclear. The insulin secretion was suppressed 30% by consuming vegetable salad 10 min before rice compared to the reverse regimen in our study[3], so vegetable juice preload was presumed to suppress the insulin secretion. However, the reason why no difference observed in glycemic parameters between preload of vegetable and vegetable juice in this study is not elucidated. Additionally, the effect of different kinds of vegetable juice on glycemic parameters need to be evaluate. Further studies to investigate serum hormone concentrations are required for detailed mechanisms of vegetable juice preload on glycemic responses, and the caution should be taken in extrapolating the present finding to other population like individuals with type 2 diabetes, different gender, different age, and other ethnic groups. Additionally, to verify the acute effect of suppress the postprandial blood glucose concentrations by drinking vegetable juice less than 20 min prior to carbohydrate should be examined.

Conclusion

Drinking vegetable juice 20 min before carbohydrate significantly ameliorates the postprandial blood glucose concentrations as well as fresh vegetable preload in young healthy women, despite the total amounts of energy and carbohydrate of vegetable juice and vegetable were higher than those of water. Vegetable juice preload is easy, practical, and cost-effective method to lower the postprandial blood glucose concentrations in women without type 2 diabetes.

ACKNOWLEDGEMENT

We thank all of the investigators and volunteers who participated in this study.

FUNDING

This study was supported by grants by Kyoto Women's University.

Institutional Review Board Statement: The study was conducted according to the guidelines of the Declaration of Helsinki. This study was approved by the Ethics Committee of Kyoto Women's University (30–5), and registered UMIN-CTR (000034944).

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study. There are no entities or relationships, etc. presenting a potential conflict of interest requiring disclosure in relation to this study.

AUTHOR DISCLOSURES

Y.H. reports grants from Asahi Kasei Pharma and personal fees from Mitsubishi Tanabe Pharma Corp., Novo Nordisk Pharma Ltd., Sanofi K.K., and Daiichi Sankyo Co. Ltd. outside the submitted work. M.F. received grants from Takeda Pharma Co. Ltd., Sanofi K.K., Kissei Phama Co. Ltd., Mitsubishi Tanabe Pharma Corp, Astellas Pharma Inc., Nippon Boehringer Ingelheim Co. Ltd., Daiichi Sankyo Co. Ltd., MSD K.K., Sanwa Kagagu Kenkyusho CO., LtD., Kowa Pharma Co. Ltd., Kyowa Kirin Co., Ltd., Sumitomo Dainippon Pharma Co., Ltd., Novo Nordisk Pharma Ltd., Ono Pharma Co. Ltd., Eli Lilly Japan K.K., Taisho Pharma Co., Ltd., Tejin Pharma LtD., Nippon Chemiphar Co., Ltd., Johnson & Johnson k.k. Medical Co., Abbott japan Co. Ltd., and Terumo Corp., and personal fees from Teijin Pharma Ltd., Arkray Inc., Kissei Pharma Co., Ltd., Novo Nordisk Pharma Ltd., Mitsubishi Tanabe Pharma Corp., Sanofi K.K., Takeda Pharma Co. Ltd., Astellas Pharma Inc., MSD K.K., Kyowa Kirin Co. Ltd., Sumitomo Dainippon Pharma Co. Ltd., Daiichi Sankyo Co. Ltd., Kowa Pharma Co. Ltd., Ono Pharma Co. Ltd., Sanwa Kagaku Kenkyusho Co. Ltd., Nippon Boehringer Ingelheim Co., Ltd., Taisho Pharma Co., Ltd., Bayer Yakuhin, Ltd., AstraZeneca K.K., Mochida Pharma Co. Ltd., Abbott japan Co. Ltd., Eli Lilly Japan K.K., Medtronic Japan Co. Ltd., and Nipro Corp. outside the submitted work. The sponsors were not involved in the study design; in the collection, analysis, interpretation of data; in the writing of this manuscript; or in the decision to submit the article for publication. The authors, their immediate families, and any research foundations with which they are affiliated have not received any financial payments or other benefits from any commercial entity related to the subject of this article. The authors declare that although they are affiliated with a department that is supported financially by a pharmaceutical company, the authors received no current funding for this study and this does not alter their adherence to all the journal policies on sharing data and materials. The other authors have nothing to disclose.

REFERENCES

1) Ceriello A, Esposito K, Piconi L, et al.: Oscillating glucose is more deleterious to endothelial function and oxidative stress than mean glucose in normal and type 2 diabetic patients. Diabetes. 2008, 57: 1349–54, doi: 10.2337/db08-0063.

2) Cederberg H, Saukkonen T, Laakso M, et al.: Postchallenge Glucose, A1C, and Fasting Glucose as Predictors of Type 2 Diabetes and Cardiovascular Disease. A 10-year prospective cohort study.Diabetes Care. 2010, 33: 2077–2083, doi. org/10.2337/dc10-0262.

3) Imai S, Matsuda M, Miyatani S, et al.: Crossover Study of the Effect of Vegetables Before Carbohydrates on the Reduction of the Postprandial Glucose and Insulin Levels in Japanese Patients with Type 2 Diabetes Mellitus. J Japan Diabetes Soc. 2010, 53: 112–5.

4) Imai S, Fukui M, Ozasa N, et al.: Eating vegetables before carbohydrates improves postprandial glucose excursions. Diabet Med. 2013, 30: 370–2, doi: 10.1111/dme.12073.

5) Imai S, Fukui M, Kajiyama S: Effect of eating vegetables before carbohydrates on glucose excursions in patients with type 2 diabetes. J Clin Biochem Nutr. 2014, 54: 7–11, doi: 10.3164/jcbn.13-67.

6) Imai S, Matsuda M, Togawa C, et al.: Effect of eating 'vegetables before carbohydrates' on glycemic control in Japanese outpatients with type 2 diabetes. J Japan Dietetic Asso. 2010, 53: 1084–1091, doi.org/10.11379/jjda.53.1084.

7) Imai S, Matsuda M, Hasegawa G, et al.: A simple meal plan of 'eating vegetables before carbohydrate' was more effective for achieving glycemic control than an exchange-based meal plan in Japanese patients with type 2 diabetes. Asia Pac J Clin Nutr. 2011, 20: 161–8.

8) The Japan Diabetes Society. Guideline for treatment of diabetes. 2019. Tokyo: Nankodo; 2019, p. 31–55.

9) Japan Diabetes Society. Food exchange lists: dietary guidance for persons with diabetes. Tokyo: Bunkodo; 2013.

10) Shukla AP, Iliescu RG, Thomas CE: Aronne LJ. Food Order Has a Significant Impact on Postprandial Glucose and Insulin Levels. Diabetes Care. 2015, 38: e98–99, doi: 10.2337/dc15-0429.

11) Japanese National Health and Nutrition Survey in 2016. https://www.mhlw.go.jp/file/04-Houdouhappyou-10904750-Kenkoukyoku-Gantaisakukenkouzoushinka/kekkagaiyou_7.pdf (accessed 6 September 2020)

12) U.S. Department of Human Services. Dietary guidelines for Americans. Washington DC: US Department of Agriculture 2005; 1–84.

13) Casagrande SS, Wang Y, Anderson C, et al.: Have Americans increased their fruit and vegetable intake? The trends between 1988 and 2002. Am J Prev Med. 2007, 32: 257–63, doi: 10.1016/j.amepre.2006.12.002.

14) Imai S, Saito Y, Kajiyama S, et al.: Tomato juice preload has a significant impact on postprandial glucose concentration in

healthy women: A randomized cross-over trial. Asia Pac J Clin Nutr. 2020, 29: 491–497.

15) Jenkins DJ, Wolever TM, Taylor RH: Barker H, Fielden H, Baldwin JM, Bowling AC, Newman HC, Jenkins AL, Goff DV. Glycemic index of foods: a physiological basis for carbohydrate exchange. Am J Clin Nutr. 1981, 34: 362–6, doi: 10.1093/ajcn/34.3.362.
16) Imai S, Saito Y, Kajiyama S, et al.: Late-night-dinner deteriorates postprandial glucose and insulin whereas consuming dinner dividedly ameliorates them in patients with type 2 diabetes: A randomized crossover clinical trial. Asia Pac J Clin Nutr. 2020, 29: 68–76.
17) Kuwata H, Iwasaki M, Shimizu S, et al.: Meal sequence and glucose excursion, gastric emptying and incretin secretion in type 2 diabetes: a randomised, controlled crossover, exploratory trial. Diabetologia. 2016, 59: 453–61, doi: 10.1007/s00125-015- 3841-z. 22.
18) Silaste ML, Alfthan G, Aro A, et al.: Tomato juice decreases LDL cholesterol levels and increases LDL resistance to oxidation. Br J Nutr. 2007, 98: 1251–8, doi: 10.1017/S0007114507787445.
19) Li YF, Chang YY, Huang HC, et al.: Tomato juice supplementation in young women reduces inflammatory adipokine levels independently of body fat reduction. Nutrition. 2015, 31: 691–6, doi: 10.1016/j.nut.2014.11.008.
20) Hirose A, Terauchi M, Tamura M, et al.: Tomato juice intake increases resting energy expenditure and improves hypertriglyceridemia in middle-aged women: an open-label, single-arm study. Nutr J. 2015, 14: 34, doi: 10.1186/s12937-015-0021-4.
21) Sluijs I, Beulens JW, Grobbee DE, et al.: Dietary carotenoid intake is associated with lower prevalence of metabolic syndrome in middle-aged and elderly men. J Nutr. 2009, 139: 987–92, doi: 10.3945/jn.108.101451.
22) Cheng HM, Koutsidis G, Lodge JK, et al.: Tomato and lycopene supplementation and cardiovascular risk factors: A systematic review and meta-analysis. Atherosclerosis. 2017, 257: 100–8, doi: 10.1016/j.atherosclerosis.2017.01.009.
23) von Bibra H, Saha S, Hapfelmeier A, et al.: Impact of the Triglyceride/High-Density Lipoprotein Cholesterol Ratio and the Hypertriglyceremic-Waist Phenotype to Predict the Metabolic Syndrome and Insulin Resistance. Horm Metab Res. 2017, 49: 542–9, doi: 10.1055/s-0043-107782.
24) Kim YI, Hirai S, Goto T, et al.: Potent PPARα activator derived from tomato juice, 13-oxo-9,11-octadecadienoic acid, decreases plasma and hepatic triglyceride in obese diabetic mice. PLoS One. 2012, 7: e31317, doi: 10.1371/journal.pone.0031317.
25) Luvizotto Rde A, Nascimento AF, Imaizumi E, et al.: Lycopene supplementation modulates plasma concentrations and epididymal adipose tissue mRNA of leptin, resistin and IL-6 in diet-induced obese rats. Br J Nutr. 2013, 110: 1803–9, doi: 10.1017/S0007114513001256.
26) Yoshida K, Sunahori R, Suganuma D: Effect of consuming vegetable juice or vegetable salad before rice on postprandial glucose concentrations. Japan Soc Metabo Clin Nutr. 2018, 21: 487–94.