

ORIGINAL ARTICLE**The Association between Fruit and Vegetable Intake and Liver Enzymes (Aspartate and Alanine Transaminases) in Tehran, Iran****Mehdi Mollahosseini^{1,2}, Elnaz Daneshzad¹, Mohammad Hossein Rahimi^{1,2}, Mir Saeed Yekaninejad³, Zhila Maghbooli^{2*}, Khadijeh Mirzaei^{1*}****OPEN ACCESS**

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ABSTRACT

BACKGROUND: Intake of fiber and antioxidants and following hypocaloric diets has beneficial effects on reduction of the liver enzymes. Fruits and vegetables are low in calorie and rich in fiber and antioxidants. There are few studies about special dietary effects on liver function. The aim of this study was to evaluate the association between fruit and vegetables intake and liver function enzymes.

METHODS: This cross-sectional study was conducted on 265 Tehrani healthy adults. Fruit and vegetable intake was assessed by a 147-items semi-quantitative food frequency questionnaire. Serum glucose, lipids, liver enzymes (alanine aminotransferase (ALT), aspartate aminotransferase (AST)), hs-Crp and body composition were measured in a fasting state.

RESULTS: The mean age (\pm SD) of the participants was 35 ± 8.78 . In the higher quartiles of vegetable intake, low-density lipoprotein (LDL) serum and total cholesterol (TC) levels were lower after adjusting for confounders ($p = 0.03$ and 0.02 respectively). Individuals in the upper quartile of vegetable intake were less likely to have elevated ALT (OR=0.21; 95% CI =0.08-0.49) and AST (OR=0.33; 95% CI =0.15-0.75) levels before adjusting for confounders. After controlling for potential confounders, only the association between vegetable intake and ALT level remained significant (OR=0.32; 95% CI =0.12-0.90). Liver enzymes had no significant relationship with the quartiles of fruit intake. In the higher quartiles of fruit intake, the visceral fat rating was lower after adjustment ($p = 0.04$) but not in the higher vegetable intake ($p = 0.50$).

CONCLUSIONS: The results of this study showed that vegetable intake is reversely associated with LDL, TC and ALT level in Tehrani healthy adults, whereas fruit intake is only associated with lower visceral fat rating.

KEYWORDS: AST (SGOT), ALT (SGPT), fruit, vegetables, Anthropometric status, Biochemical testes

INTRODUCTION

Metabolic diseases are increasing among many communities. Obesity, nonalcoholic fatty liver disease (NAFLD) and metabolic syndrome are among the disorders that are associated with changes in liver enzymes. Elevated alanine aminotransferase (ALT) and aspartate aminotransferase (AST) are markers of liver injury and steatosis (1). ALT is related to insulin resistance, which plays a special role in metabolic syndromes (2). Also, metabolic diseases are strongly correlated with atherosclerosis and cardiovascular disease (1,3). Cardiovascular diseases account for most deaths from non-communicable disease (approximately 17.5 million deaths annually)(4).

Several conditions that hurt liver tissue may elevate the levels of functional liver enzymes in serum such as ALT and AST. One of the most common diseases that elevate liver enzymes is NAFLD that is the buildup of extra fat in liver cells that is not caused by alcohol (5). This condition is usually associated with obesity specially central adiposity, type 2 diabetes mellitus, hyperlipidemia and oxidative stress (6, 7).

Lifestyle and environmental factors affect these diseases. Diet as an alterable factor is a major part of environmental factors (8). A low calorie diet, one which is high in fiber and protein, has a beneficial effect on hepatic steatosis with reductions of the liver enzymes, serum lipids and body composition parameters (9). A hypocaloric diet enriched with almonds reduced body weight and improved ALT and AST serum levels (10). Daily chocolate consumption lowered serum ALT in a healthy population (11). Some dietary patterns rich in fruits and vegetables like the Nordic diet and the Dietary Approaches to Stop Hypertension (DASH) diet were associated with decreasing incidence of hypertension, abdominal obesity, lipid profile and high fasting plasma glucose (12, 13).

Vegetables and fruits have some characteristics that may seem to be beneficial for liver health. For example some of the beneficial characteristics of fruits and vegetables are their low

energy but high fiber, vitamins and minerals of them (14).

The nutrient content of fruits and vegetables probably has an impact on liver function and liver enzyme levels (15). On the other hand, these food groups are rich in antioxidants, which have beneficial effects in the prevention and treatment of metabolic diseases (16). There are few studies about special dietary effects such as fruits and vegetables on liver function. This study evaluated the association of vegetable and fruit intake with liver enzymes, body composition, lipid profile, fasting blood glucose and hs-Crp.

MATERIALS AND METHODS

A total of 265 individuals (139 females and 126 males) aged from 18 to 55 years participated in this cross-sectional study. The study population was collected from all the regions of Central and West Tehran, using community-based sampling based on cluster sampling. All cases signed an informed consent for taking part in the study. Subjects were chosen according to the following inclusion and exclusion criteria:

Inclusion criteria are aged 18–55 years, no alcohol or drug abuse, absence of any acute or chronic inflammatory disease, no history of hypertension, and not being pregnant. Exclusion criteria are alcohol or drug abuse, history of hypertension, being pregnancy, current smoker, having hepatic diseases such as viral hepatitis, thyroid, renal or cardiovascular diseases, heart failure, malignancies, diabetes mellitus, being in any acute or chronic inflammatory state that affects inflammatory markers, and having any kind of infection.

This study was approved by the local Ethics Committee of the Endocrinology and Metabolism Research Center of Tehran University of Medical Sciences (Ethics number: 93-04-161-27722-149580).

Anthropometric assessments: Weight and height were measured in light clothing and barefoot respectively. Waist circumference was measured in the slimmest area while subjects were at the end of a normal exhalation by a non-elastic tape with accuracy of 0.1 cm. Hip circumference was

measured in the largest part of the hip over light clothing.

Complete body composition analysis: The body composition of all subjects was assessed with the use of Body Composition Analyzer *BC-418MA - Tanita* (United Kingdom). This equipment has been designed to send out a very weak electric current which measures the impedance (electrical resistance) of the body. Participants were barefoot when they were assessed by this device. We avoided taking measurements after vigorous exercise and waited until the subjects had rested sufficiently, in order to prevent possible discrepancies in measured values. Measurements were also performed in the morning in a fasting condition (always urinating before taking measurements, etc.). The device calculated body fat percentage, fat mass and fat free mass (FFM), and predicted muscle mass on the basis of data using Bioelectrical Impedance Analysis (BIA). The main outputs of the device are BMI, fat percent, fat mass, FFM and visceral fat levels.

Dietary intake assessment and blood pressure measurement: Participants consumed their usual diet. They were instructed to fill in a 147-item food frequency questionnaire (FFQ) that had been validated by previous studies (17). Questionnaires were completed in the presence of a trained dietitian. Data were recorded in household measures and servings, then later, converted into grams and milliliters. Dietary intake data were analyzed using the NUTRITIONIST 4 (First Data Bank, San Bruno, CA) food analyzer.

Blood pressure measurement: Blood pressure was measured by the Automatic Inflate Blood Pressure Monitor (Samsung BA507S automatic digital blood pressure monitor, Samsung America, Inc.). Blood pressure for all participants was measured after a 15-min rest in a chair-seated position by the same person.

Blood sampling and biochemical parameters: All of the participants were referred to Shariati Hospital's Outpatient Clinic. Blood samples were obtained after 10 to 12 hours of overnight fasting. All baseline blood samples were obtained between 8:00 and 10:00 am. After centrifuging, the serum was isolated and stored at a temperature of 80°C. All assessments were performed at the

Endocrinology and Metabolism Research Center Laboratory of Shariati Hospital. Assessments were as follows:

Fasting Blood Sugar (FBS) levels were measured by a colorimetric method based on the glucose oxidase phenol 4-Aminoantipyrine Peroxidase (GOD/PAP) method. Triglyceride measurements were performed using the enzyme glycerol-3-phosphate oxidase Phenol 4-Aminoantipyrine Peroxidase (GPO-PAP) method. Total cholesterol (TC) levels, direct low-density lipoprotein (LDL) and high-density lipoprotein (HDL) cholesterol were determined by the enzymatic endpoint method and enzymatic clearance assay, respectively. 7 Randox Laboratories kits (Randox Laboratories Ltd., Ardmore, UK) were used for all evaluations. Serum high-sensitivity C-reactive protein (hs-Crp), a proinflammatory marker, was evaluated using a high-sensitivity immunoturbidimetric assay (Hitachi 902 analyzer; Hitachi Ltd., Tokyo, Japan). Serum alanine aminotransferase (ALT) and aspartate aminotransferase (AST) were determined by an automatic analysis system (Autoanalyzer; Hitachi Ltd, Tokyo, Japan) with a Randox laboratories kit.

Statistical analysis: All statistical analysis was performed using SPSS 16 (SPSS Inc., Chicago, IL). The values were expressed as mean \pm standard deviation. The Kolmogorov-Smirnov test was used to assure for normal distributions. Pearson's correlation coefficient was used to identify the degree of correlation between vegetable and fruit intake and anthropometric and biochemical measurements. Quartile relationships for each variable were evaluated from Post-Hoc analyses through Tukey's procedure after using the ANCOVA test. Total intake of fruit and vegetable were adjusted for total calorie intake through residual methods in linear regression. In addition, binary logistic regression was used to predict the relationship between liver enzymes and quartiles of intake after adjusting for confounder variables. The level of significance was considered as displaying a p value ≤ 0.05 for all analyses.

RESULTS

A total of 265 participants (126 men, 139 women) aged 18-55 years were recruited in the study. The mean age (\pm SD) of the participants was 35 ± 8.78 , and the mean BMI was 25.93. The mean (\pm SD) total calorie intake was 2210.64 ± 607.44 kcal/d.

The mean (\pm SD) intakes of vegetables, fruit and juices were 242.28 ± 146.98 , 208.48 ± 154.95 and 14.79 ± 27.64 g/d, respectively. Table 1 shows the description of demographic-anthropometrics and biochemical characteristics in this population.

Table 1: Description of demographic-anthropometrics and biochemical characteristics (N=265)

Variable	Mean \pm Std. Deviation	Minimum	Maximum
Age (years)	35.08 \pm 8.789	18	55
Weight (kg)	73.5144 \pm 15.66475	36.50	142.00
Height (cm)	167.5569 \pm 13.96938	1.79	193.50
BMI (kg/m ²)	25.9325 \pm 4.89634	14.62	46.22
Waist (cm)	88.8048 \pm 12.50951	58.00	130.00
Hip (cm)	102.6235 \pm 9.57406	68.00	144.00
Visceral fat rating	5.5203 \pm 3.40552	1.00	17.00
Fat percent (%)	25.5923 \pm 9.37635	2.40	48.20
Basal Metabolic Rate	1603.3402 \pm 324.27466	1050.00	2676.00
SBP (mmHg)	11.9466 \pm 1.28853	9.00	17.30
DBP (mmHg)	7.7393 \pm 0.91057	5.00	10.90
FBS (mmol/L)	94.1023 \pm 18.51772	73.00	292.00
TG (mmol/L)	126.0417 \pm 96.01791	32.00	726.00
TC(mg/dL)	184.5871 \pm 40.33255	109.00	433.00
HDL-C (mg/dL)	48.7803 \pm 11.68035	20.00	84.00
LDL (mg/dL)	101.2841 \pm 27.22025	44.00	282.00
AST (Iu/L)	20.4659 \pm 6.82750	5.00	70.00
ALT (Iu/L)	17.0530 \pm 10.97028	4.00	121.00
hs-CRP (mg/L)	2.3381 \pm 3.34809	0.10	20.00

The correlation coefficient of triglycerides for fruit was -0.14 ($P=0.025$) before adjustment for age, sex and weight. However, none of the variables had a correlation with fruit intake after adjusting for confounding factors. Before adjustment for the mentioned variables, the correlation coefficients of age and height for vegetables were 0.24 ($P<0.001$) and 0.15 ($P=0.015$), respectively. Also, the correlation coefficients of fat percent and ALT for vegetables were 0.20 ($P<0.001$) and 0.15 ($P=0.012$), respectively. Table 2 shows partial correlation coefficients for the association of anthropometric variables, biochemical variables and blood pressure with fruit and vegetable intake, after controlling for confounding factors, including age, sex and weight.

Table 3 and table 4 show descriptions of the characteristics among the quartiles of vegetable and fruit intakes. Fat percent and ALT serum level showed significant relationships with vegetable intake ($p=0.004$ and 0.001 , respectively) before adjusting for confounders, but there was not any significant relationship between them after adjusting for confounders. In the higher quartiles of vegetables, LDL serum levels and total cholesterol were lower after adjustment ($p=0.03$ and 0.02 , respectively).

HDL and DBP both had a significant relationship with fruit intake. Liver enzymes had no significant relationship with the quartiles of fruit intake. In the higher quartiles of fruits, the visceral fat rating was lower after adjustment ($p=0.04$)

Table 2: Correlation coefficient for association of anthropometric variables, biochemical variables and blood pressure with fruit and vegetable intake.

Variable	Vegetable		Fruit	
	r	p	r	p
Height (cm)	0.087	0.242	0.073	0.329
Waist (cm)	-0.045	0.542	-0.074	0.318
Hip (cm)	-0.078	0.295	-0.034	0.643
Fat percent (%)	-0.018	0.805	0.0001	0.992
Visceral fat rating	-0.043	0.564	-0.117	0.114
FBS (mmol/L)	0.080	0.280	0.049	0.510
TG (mmol/L)	-0.20	0.790	-0.064	0.390
TC (mg/dL)	-0.148	0.046	0.104	0.161
HDL (mg/dL)	-0.051	0.494	0.011	0.886
LDL (mg/dL)	-0.137	0.064	0.121	0.103
hs-CRP (mg/L)	0.130	0.079	0.056	0.452
AST (Iu/L)	-0.116	0.116	0.029	0.699
ALT (Iu/L)	-0.171	0.021	0.072	0.332
SBP (mmHg)	0.017	0.823	0.045	0.541
DBP (mmHg)	-0.041	0.582	0.006	0.940

Table 3: Description of characteristics among quartiles of vegetables intake

Variable	Q1#	Q2	Q3	Q4	P	P*
	Mean ± SD	Mean ± SD	Mean ± SD	Mean ± SD		
Age (year)	30.81 ± 8.40 ^{a,b,c,**}	35.80 ± 7.83 ^a	35.84 ± 8.83 ^b	37.28 ± 8.99 ^c	<0.001	<0.001
Anthropometric						
BMI (kg/m ²)	25.99 5.20	25.83 ± 4.80	25.64 ± 5.31	25.94 ± 4.15	0.978	0.09
Waist (cm)	89.83 ± 13.65	88.58 ± 12.00	88.10 ± 13.72	87.68 ± 10.63	0.796	0.67
Hip (cm)	102.42 ± 10.74	102.35 ± 7.93	102.25 ± 10.71	102.69 ± 8.57	0.995	0.84
Fat percent (%)	22.80 ± 9.62 ^d	24.15 ± 9.82	26.57 ± 8.31	28.39 ± 8.55 ^d	0.004	0.60
Visceral fat rating	5.19 ± 3.71	5.78 ± 3.34	5.22 ± 3.22	5.62 ± 3.19	0.711	0.50
Biochemical						
FBS (mmol/L)	93.07 ± 17.39	93.37 ± 9.73	91.49 ± 8.52	98.14 ± 30.43	0.216	0.17
TG (mmol/L)	130.75 ± 82.45	138.21 ± 97.46	117.03 ± 92.64	114.12 ± 91.98	0.396	0.61
TC (mg/dL)	186.09 ± 45.48	187.75 ± 35.38	186.01 ± 40.36	176.32 ± 33.65	0.333	0.02
HDL (mg/dL)	47.09 ± 10.64	47.62 ± 12.20	49.19 ± 12.41	50.89 ± 11.33	0.251	0.58
LDL (mg/dL)	103.07 ± 31.77	102.92 ± 22.17	102.93 ± 27.61	94.76 ± 22.83	0.202	0.03
AST (Iu/L)	22.31 ± 7.95	19.78 ± 6.04	19.60 ± 6.13	19.53 ± 6.04	0.050	0.27
ALT (Iu/L)	21.82 ± 15.78 ^{e,f,g}	15.84 ± 8.61 ^e	15.42 ± 8.88 ^f	15.04 ± 7.99 ^g	0.001	0.08
hs-CRP (mg/L)	2.68 ± 3.80	1.70 ± 2.57	2.12 ± 2.73	2.70 ± 4.00	0.268	0.89
SBP (mmHg)	12.00 ± 1.40	11.90 ± 1.16	11.86 ± 1.29	11.96 ± 1.35	0.936	0.45
DBP (mmHg)	7.80 ± 0.96	7.73 ± 0.93	7.63 ± 1.00	7.72 ± 0.76	0.802	0.43

Quartiles of vegetables intake; *p value reported after adjusting age, sex and weight with ancova model

**The same letters demonstrated the significant value from Tuckey procedure of Posthoc analyzes through

Table 4: Description of characteristics among quartiles of fruit intake.

Variable	Q1# Mean ± SD	Q2 Mean ± SD	Q3 Mean ± SD	Q4 Mean ± SD	P	P*
Age (year)	34.44 ± 9.37	35.22 ± 8.87	34.89 ± 7.682	35.19 ± 9.455	0.956	0.63
Anthropometric						
BMI (kg/m ²)	26.39 ± 5.22	25.41 ± 4.48	25.21 ± 4.34	26.37 ± 5.29	0.377	0.42
Waist (cm)	90.45 ± 12.90	88.25 ± 12.07	86.91 ± 12.28	88.57 ± 12.71	0.482	0.51
Hip (cm)	103.60 ± 10.63	101.16 ± 9.07	101.81 ± 8.36	103.14 ± 9.82	0.463	0.41
Fat percent (%)	25.06 ± 9.32	23.48 ± 9.35	25.80 ± 8.06	27.62 ± 10.12	0.104	0.38
Visceralfatrating	5.79 ± 3.53	5.65 ± 3.49	5.00 ± 3.06	5.37 ± 3.37	0.583	0.04
Biochemical						
FBS(mmol/L)	91.31 ± 8.36	95.64 ± 18.79	92.29 ± 9.61	96.92 ± 29.95	0.279	0.10
TG (mmol/L)	150.53 ± 116.21	124.37 ± 79.56	116.93 ± 95.55	108.14 ± 60.64	0.053	0.05
TC (mg/dL)	182.89 ± 49.15	183.48 ± 33.74	183.14 ± 29.57	186.68 ± 41.56	0.943	0.54
HDL (mg/dL)	44.79 ± 9.26	50.06 ± 11.83	50.40 ± 13.27	49.53 ± 11.41	0.021	0.28
LDL (mg/dL)	100.54 ± 32.54	99.79 ± 21.92	99.93 ± 19.72	103.42 ± 30.02	0.855	0.36
AST(Iu/L)	20.67 ± 6.57	20.45 ± 5.40	19.29 ± 4.64	20.82 ± 9.20	0.559	0.59
ALT(Iu/L)	17.03 ± 7.93	16.76 ± 9.09	15.82 ± 7.54	18.57 ± 17.15	0.574	0.11
hs-CRP (mg/L)	2.27 ± 3.03	2.14 ± 3.59	1.75 ± 1.96	3.04 ± 4.28	0.166	0.37
SBP (mmHg)	12.15 ± 1.27	11.84 ± 1.19	11.78 ± 1.52	11.95 ± 1.17	0.429	0.73
DBP (mmHg)	7.97 ± 0.94	7.59 ± 0.85	7.55 ± 0.99	7.78 ± 0.80	0.042	0.19

#Quartiles of vegetables intake; *p value reported after adjusting age, sex and weight with ancova model

AST and ALT relationship with quartiles of vegetables and fruits intake is shown in Table 5 and Table 6 by two models. ALT had a significant relationship with the quartiles of vegetable intake

after adjusting for confounders in both models. Liver enzymes had no significant relationship with the quartiles of fruits intake, after adjusting for confounders.

Table 5: Relationship between liver enzymes and quartiles of vegetable intake

variable	AST		P _{trend}	ALT		P _{trend}
	OR (95%CI)	P		OR (95%CI)	P	
Crude Model			0.007			< 0.001
Q1	1			1		
Q2	0.44 (0.20-0.96)	0.03		0.36 (0.16-0.77)	0.009	
Q3	0.41 (0.19-0.90)	0.02		0.33 (0.15-0.73)	0.006	
Q4	0.33 (0.15-0.75)	0.008		0.21 (0.08-0.49)	<0.001	
Model 1*			0.123			0.052
Q1	1			1		
Q2	0.48 (0.22-1.05)	0.06		0.38 (0.16-0.86)	0.02	
Q3	0.55 (0.24-1.23)	0.15		0.50 (0.21-1.19)	0.11	
Q4	0.50 (0.21-1.18)	0.11		0.39 (0.15-0.99)	0.04	
Model2**			0.129			0.042
Q1	1			1		
Q2	0.49 (0.22-1.12)	0.09		0.37 (0.15-0.89)	0.02	
Q3	0.53 (0.23-1.25)	0.15		0.45 (0.18-1.12)	0.08	
Q4	0.47 (0.19-1.17)	0.10		0.32 (0.12-0.90)	0.03	

* adjusted for sex, ** adjusted for sex, age and weight

Table 6: Relationship between liver enzymes and quartiles of fruit intake

variable	AST		P _{trend}	ALT		P _{trend}
	OR (95%CI)	P		OR (95%CI)	P	
Crude Model			0.788			0.859
Q1	1			1		
Q2	1.08 (0.49-2.35)	0.84		0.77 (0.34-1.74)	0.53	
Q3	0.92 (0.41-2.03)	0.84		0.92 (0.41-2.03)	0.84	
Q4	0.94 (0.42-2.08)	0.88		1.02 (0.46-2.24)	0.95	
Model 1*			0.623			0.143
Q1	1			1		
Q2	1.04 (0.47-2.33)	0.90		0.70 (0.29-1.67)	0.42	
Q3	1.11 (0.48-2.53)	0.80		1.29 (0.53-3.10)	0.56	
Q4	1.22 (0.53-2.81)	0.63		1.71 (0.70-4.15)	0.23	
Model 2**			0.572			0.123
Q1	1			1		
Q2	1.04 (0.46-2.35)	0.92		0.70 (0.28-1.71)	0.44	
Q3	1.13 (0.49-2.60)	0.75		1.36 (0.56-3.31)	0.49	
Q4	1.25 (0.54-2.89)	0.59		1.78 (0.72-4.40)	0.20	

* adjusted for sex; ** adjusted for sex, age and weight

DISCUSSION

In this cross-sectional study of healthy subjects, the main result seen was the significant relationship between vegetable intake and reduced ALT, whereas no significant association was shown with AST. As some studies had shown a significant weight effect on liver enzymes (18), we examined the significant relationship between ALT and vegetable intake after weight adjustment. There was no association between fruit intake and liver function tests. Overall, there was no significant association between fruit intake and any single variable in the study, but total cholesterol and ALT were reduced by vegetable intake.

Diet and weight loss are important factors in improving liver enzymes (19). Ekhlasi *et al.* observed that liver function enzymes decreased and total antioxidant capacity increased in Non-Alcoholic Fatty Liver Disease (NAFLD) patients who consumed pomegranate juice as an antioxidant and polyphenol-rich source (20). Abazarfard *et al.* showed decreased ALT and AST in overweight and obese women by an almond-

enriched diet, as a good source of fiber and antioxidants (10). Nanri *et al.* elucidated an inverse relationship between Serum Gamma-Glutamyl Transferase (GGT as one of liver enzymes) and a healthy dietary pattern (rich in fruits and vegetables) (21). A Mediterranean dietary pattern-rich in vegetables and fruit-reduced serum GGT (1).

Fruits and vegetables are major sources of antioxidants, polyphenols, fiber, vitamins and minerals. Several studies have demonstrated an inverse relationship between GGT and dietary antioxidants (22, 23). On the other hand, oxidative stress can elevate some liver enzymes like GGT (24), so vegetable antioxidants can reduce it. According to some results, the combined antioxidant effect on health outcomes is better than every individual one of them (25). As well as Vegetables are also a good source of magnesium, which showed an adverse relation with liver function enzymes (26, 27).

Total cholesterol and LDL were reduced in higher quartiles of vegetable intake, and HDL cholesterol increased with higher fruit intake in this study. A hypo-caloric high-fiber diet had

reduced LDL cholesterol (9). HDL cholesterol was increased in high quartiles of fruit intake; however, some studies showed conflicting results with a hypo-caloric, high-fiber diet (28,29).

Fat percent had no significant association with vegetables, but visceral fat rating was reduced in the higher quartiles of fruit intake. Nanri et al. demonstrated that body mass index (BMI) was lower in people with a higher intake of a healthy dietary pattern rich in fruits and vegetables (21). BMI was lower in an almond-enriched diet compared with a nut-free diet (10).

To our knowledge, this is the first study that assessed the relationship between fruit and vegetable intake and liver function enzymes. The strengths of the study were its large population and its adjustment for some major confounders. Also, liver function was only assessed by measuring ALT and AST, not other liver enzymes. Computed tomography scans, liver biopsies and magnetic resonance scanning are other key methods to further evaluate liver function. Certainly, more studies on different age ranges and racial groups, as well as some randomized trials, will be able to reveal better casual associations.

In conclusion, our findings suggest a significant relationship between vegetable intake and reduced ALT. Further randomized clinical trials and observational prospective studies are needed to confirm the relationship between vegetable and fruit intake and liver function.

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