



Applied nutritional investigation

White grape juice increases high-density lipoprotein cholesterol levels and reduces body mass index and abdominal and waist circumference in women

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ABSTRACT

Objectives: Grape juice is a drink that is rich in phenolic compounds, which are important natural antioxidants that reduce the incidence of diseases linked to oxidative stress including cardiovascular disease. Studies on the effects of purple grape juice supplementation have already been conducted; however, there are no data on the effects of the consumption of white grape juice (WGJ) to date. The aim of this study was to evaluate the effects of WGJ supplementation on body mass index, waist and abdominal circumference, blood pressure and glucose, insulin, oxidative damage, and lipid profile in women.

Methods: A total of 25 women, ages 50 to 67 y, were included in this study. The volunteers were instructed to consume 7 mL/Kg/d of WGJ (*Vitis labrusca*) without other changes in diet energy consumption or habitual lifestyle. The supplementation occurred over 30 d. Anthropometric data and blood samples were collected before and after the intervention.

Results: Supplementation with WGJ reduced the women's body mass index and waist and abdominal circumference ($P < 0.001$). There were no significant differences in blood pressure before and after the consumption of WGJ. In addition, no changes in blood glucose, insulin, and levels of oxidative damage were found. Women who supplemented with WGJ showed an increase of 16% in high-density lipoprotein cholesterol levels.

Conclusions: These results demonstrate that the consumption of WGJ can improve metabolic parameters in women, which may help reduce the risk of cardiovascular diseases.

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Introduction

Phenolic compounds comprise a large family of natural products that are widely found in vegetables, fruits, chocolate, coffee, tea, wine, and grape juice [1]. Some phenolic compounds are known to be efficient free radical scavengers that have antimicrobial properties providing cardio-protection, anticancer, antiinflammation, and anti-ageing benefits [2]. One of the most important

sources of bioactive compounds are grapes and their derivative products such as juice.

Grape juices can be manufactured using any grape variety (white or purple) once they reach appropriate maturation. Observational studies indicate that the intake of pure (100%) grape juice can reduce the risk of hypertension, cardiovascular disease, and diabetes mellitus [3], which indicates the importance of these beverages in health maintenance.

Studies on the beneficial effect of purple grape juice on health have already been conducted and showed that the intake of 750 mL/d of purple grape juice for 2 wk increased serum antioxidant capacity and protected low-density lipoprotein (LDL) against oxidation in healthy volunteers [4]. Moreover, purple grape juice supplementation of 5.5 mL/Kg/d during 8 wk reduced the blood pressure of hypertensive individuals [5]. In both hemodialysis and healthy subjects, the intake of concentrated purple grape juice

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(100 mL/d during 14 d) exhibited antioxidant and hypolipidemic effects [6]. In addition, white grape juice (WGJ) contains resveratrol, which is an important polyphenol that enhances redox and carbohydrate metabolism [7] as well as element metabolism [8].

Although some data on the beneficial effects of grape juice exist in the scientific literature, no study, to our knowledge, has yet investigated the effects of WGJ consumption. Therefore, the aim of this study was to evaluate the effects of WGJ supplementation on anthropometric measurements, blood pressure, lipid profile, glycemia and insulin levels, and oxidative markers in women. In addition, the polyphenol profile and *in vitro* antioxidant activity of WGJ were also evaluated.

Materials and methods

White grape juice

For this study, concentrated WGJ (100% grape) was used. The juice did not contain added sugar or preservatives, was produced from *Vitis labrusca* grapes, and was provided by a company located in Vale dos Vinhedos, Bento Gonçalves, Rio Grande do Sul, Brazil.

Physicochemical assay

The physicochemical parameters of WGJ were evaluated in accordance with the methodologies described by the Instituto Adolfo Lutz [9]. The relative density, pH, total titratable acidity, volatile acidity, and solvable solids content were determined.

Phenolic compounds

The concentration of total phenolic compounds was determined with the colorimetric method as described by Singleton and Rossi [10]. For the chemical characterization of WGJ, the levels of caffeic acid, ferulic acid, coumaric acid, (+) catechin, (-) epicatechin, and trans-resveratrol were determined by high-performance liquid chromatography, using a precolumn Zorbax SB C18 (250 mm × 4.6 mm; 5 μm) and column Zorbax SB 300 C18 (12 mm × 4.6 mm; 5 μm). The wavelengths were 204, 280, and 320 nm for the diode array detector with excitation at 280 nm and emission at 320 nm for the fluorescence detector.

Antioxidant activity

The *in vitro* antioxidant activity of WGJ was evaluated using the 2,2-diphenyl-1-picrylhydrazyl (DPPH) and 2,2-azino-bis (3-ethylbenz-6-sulphonic acid; ABTS⁺) methods as described by Yamaguchi et al. [11] and Re et al. [12], respectively. The results were expressed as μL for the amount of juice necessary to reduce the radicals by 50%.

Volunteers and experimental design

A total of 25 women were included in this study. The sample size was calculated using Programs for Epidemiologists version 4.0 and based on the study by O'Byrne et al. [4] to detect differences among the volunteers before and after WGJ supplementation. The significance level was set at 5%, power of 90%, and a size of standardized effect of at least 0.8 standard deviations in the parameters of oxidative markers.

The participants agreed to consume WGJ and were instructed to maintain their habitual diet. To standardize the intake of calories, we included the energy (kcal) of WGJ to adapt the intake to the participants' diets. The volunteers were from the city of Caxias do Sul in Rio Grande do Sul, Brazil, and ages 50 to 67 y. Women who smoked, were taking dietary supplements (especially vitamins), were diabetic, and currently undergoing chemotherapy were excluded from the study.

The volunteers were instructed to consume 7 mL/Kg/d of WGJ during 30 d without other changes in diet energy consumption or lifestyle. They were advised to avoid consuming grape derivate products throughout the intervention period (30 d). The juice intake was administered into two to three portions, and the volunteers were instructed to consume WGJ with morning and afternoon snacks and at dinner time in accordance with their daily intake. The first blood collection was performed before the start of the supplementation, and the last collection after supplementation for 30 d.

A nursing technician collected 10 ml of blood in dry tubes of Vacutainer (BD Diagnostics, São Paulo, Brazil) from volunteers' antecubital veins after 12 h of fasting. The tubes were centrifuged for 15 min at 4°C to obtain the serum, which was immediately pipetted to Eppendorf tubes and stored at -80°C until the analysis. All experimental procedures conducted in accordance with the Declaration of Helsinki. Moreover, the Ethics Committee in Human Beings from the Universidade de

Caxias do Sul approved the study (authorization number 1.093.796; 06/02/15). The participants signed an informed consent form to authorize participation in this project.

Questionnaires and interviews

The participants answered three questionnaires, always under the supervision of a dietitian. The first questionnaire was about sociodemographic and anthropometric characteristics. Physical activity was defined as the practice of any type of exercise for at least 30 min. Individuals were classified into three categories according to the amount of time spent and the frequency of the physical activity (i. e., no activity, 1–2 times/wk, and ≥3 times/wk) [13].

Body mass index (BMI) was calculated from the relationship between weight (kg) and the square of height (m). For women ages 50 to 60 y, the classification per the World Health Organization guidelines [14] was <18.5 kg/m² low weight, >18.5 kg/m² and <24.9 kg/m² eutrophy, >25.0 to 29.9 kg/m² overweight, and >30 kg/m² obese. For women ages 60 y, the classification per the Pan-American Health Organization [15] was <23 kg/m² low weight, >23 kg/m² to <28 kg/m² eutrophy, >28 kg/m² to <30 kg/m² overweight, and >30 kg/m² obese.

The second questionnaire evaluated participants' dietary intake before starting the supplementation through a 24-h dietary recall. Individuals were prompted to remember all foods including snacks and beverages that were consumed during the preceding day. Interviews were conducted from Tuesday to Thursday because the weekend could be an atypical feeding day [13]. Dietwin Software (Software Program for Nutritional Assessment professional version 2008, Brazil) was used for the data analysis to quantify the content of the total calories and macro- and micronutrients in food and beverages on the basis of regional tables of food chemical composition.

The third questionnaire was developed to determine the total diet antioxidant capacity (DTAC) in 48 h as described by Fogel et al. [16]. Volunteers were asked to recall their intake of antioxidant food and beverages during the 2 d before the questionnaire. DTAC was calculated in accordance with the antioxidant capacity of each food or drink, multiplied by the amount consumed per day. The results were expressed as mg vitamin C equivalents per day (mg VCE/d).

Lipid profile

Serum lipid measurements were determined by evaluating the total cholesterol, high-density lipoprotein (HDL) cholesterol, and triacylglycerols using a detection kit (Labtest Diagnostic S/A, Minas Gerais, Brazil) in accordance with the manufacturer's instructions. Estimates of LDL cholesterol were calculated using the Friedewald formula as follows: [LDL cholesterol] = (total cholesterol - HDL cholesterol) - (triacylglycerols/5). The results were expressed in mg/dL.

Serum glucose and insulin levels

Glucose serum concentration was determined through an enzymatic-colorimetric test using a detection kit (Labtest Diagnostic S/A, Minas Gerais, Brazil) in accordance with the manufacturer's instructions. The results were expressed in mg/dL. Insulin levels were quantified with a commercial kit (Beckman Coulter) and the results were expressed as μIU/mL.

Oxidative damage to lipids

Lipid peroxidation in serum was evaluated through the determination of thiobarbituric-acid reactive substances (TBARS) as described by Wills [17]. Malondialdehyde (MDA) was used as the standard, and the results were expressed in nmol MDA/mL.

Nitric oxide levels

Nitric oxide (NO) levels were assessed from the spontaneous decomposition of sodium nitroprusside. Once generated, NO interacts with oxygen to produce nitrite, which was measured by Griess reaction [18]. For NO quantification, a standard curve with sodium nitroprusside was used, and the results were expressed in mmol/L.

Superoxide dismutase activity

Superoxide dismutase (SOD) activity was determined in accordance with the method by Bannister and Calabrese [19]. The results were expressed in units of SOD (USOD) per mg of protein. One USOD was defined as the amount of enzyme necessary to decrease adrenochrome formation by 50%.

Statistical analysis

The statistical analyses were performed with STATA software version 12.0 (Stata Corp., College Station, TX) and SPSS version 20.0 (SPSS Inc., Chicago, IL). The

sample characteristics were described through absolute and relative frequency. The paired *t* test was used to compare the averages of anthropometric and laboratory measurements before and after WGJ supplementation. To check the association between the independent variables and DTAC, a Spearman correlation analysis was used. The results were considered statistically significant if $P \leq 0.05$.

Results

The grape juice that was provided to the volunteers presented a high content of total phenolics. As expected, a high-performance liquid chromatography/diode array detector analysis of the grape juice showed the presence of caffeic acid, *P*-coumaric acid, ferulic acid, (+) catechin, (-) epicatechin, and trans-resveratrol in its composition (Suppl. Fig. 1). Moreover, the grape juice displayed *in vitro* antioxidant capacity as measured by both the DPPH[•] and ABTS^{•+} methods, which demonstrates that the amount of juice that is necessary to reduce radicals by 50% is approximately 3.5 times higher in ABTS^{•+} than those from the DPPH[•] assay (Table 1).

Age, education level, physical activity, and nutritional status are shown in Table 2. Female volunteers, ages between 50 to 67 y, were classified as eutrophic (44%) or overweight (40%). Eighty-four percent of women reported that they practiced physical activity, especially hiking, Pilates, and gymnastics. The majority (88%) of the volunteers indicated that they take continuous medication, specifically thyroid hormones, bisphosphonates, sex hormones, statins, antihypertensive drugs, antidepressant medications, and diuretics.

The results with regard to the anthropometric and biochemical measurements are shown in Table 3. Supplementation with WGJ reduced the BMI and waist and abdominal circumferences of the participants. There was no difference in blood pressure before and after WGJ consumption. Women who supplemented with WGJ showed an increase of 16% in HDL cholesterol without changes in LDL, total cholesterol, and triacylglycerols. The consumption of WGJ did not alter blood glucose or insulin levels and no changes were observed in oxidative damage to lipids (TBARS), NO, and SOD activity in women who supplemented with WGJ.

The consumption of macro- and micronutrients and phenolic compounds as well as DTAC values are shown in Table 4. The volunteers' energy consumption was 1.645 Kcal and DTAC was 1194.30 mg VCE/d, with an intake of phenolic compounds of 1806.60 mg/d. A positive correlation was observed between DTAC

Table 1

Chemical physical analysis, phenolic profile, and antioxidant activity of white grape juice

Chemical physical analysis	Mean	SD
Density (g cm ⁻³)	1.06	0.00
pH	3.39	0.10
Total acidity (g L ⁻¹)	0.50	0.10
Volatile acidity (g L ⁻¹)	0.01	0.10
Soluble solids (* Brix)	14.4	0.10
Phenolic profile		
Total phenolic (GAE mg L ⁻¹)	267.90	0.07
Caffeic acid (mg L ⁻¹)	13.94	0.09
<i>P</i> -Coumaric acid (mg L ⁻¹)	3.07	0.24
Ferulic acid (mg L ⁻¹)	1.10	0.01
(+) Catechin (mg L ⁻¹)	11.29	0.17
(-) Epicatechin (mg L ⁻¹)	5.95	0.48
Trans-resveratrol (mg L ⁻¹)	0.54	0.03
Antioxidant activity IC ₅₀ (μL)		
DPPH [•]	12.95	0.01
ABTS ^{•+}	45.41	0.03

ABTS, 2,2'-azino-bis (3-ethylbenzothiazoline-6-sulphonic acid); DPPH, 2,2-diphenyl-1-picrylhydrazyl; GAE, equivalent of gallic acid; IC₅₀, amount of juice (μL) that inhibits 50% of DPPH[•] and ABTS^{•+}; SD, standard deviation. Data were expressed in mean ± standard deviation.

Table 2

Description of women's sociodemographic characteristics, nutritional status, and lifestyle (n = 25)

Variable	Frequency	%
Age (y)		
50–55	10	40
56–60	7	28
61–67	8	32
Income (minimum wage)*		
No income	4	16
1–2	4	16
3–4	5	20
≥4	12	48
Education level		
Incomplete primary education	4	16
Complete primary education	1	4
Complete secondary education	6	24
Incomplete college/university	4	16
Complete college/university	7	28
Complete postgraduate course	3	12
Use of medication		
Yes	22	88
No	3	12
Weekly physical activity practice		
Yes	21	84
No	4	16
Minutes of weekly physical activity		
<150	17	81
>150	4	19
Nutritional status		
Eutrophic	11	44
Overweight	10	40
Obese	4	16

* Ranges of minimum wage: 1–2: R\$ 937.00 (US\$ 299.25)–R\$ 1.874 (US\$ 598.49); 3–4: R\$ 1.875 (US\$ 599.00)–R\$ 3.748 (US\$ 1.196.99); ≥5: R\$ ≥3.750 (US\$ 1.198.20).

and the ingestion of carbohydrates ($r = 0.48$; $P = 0.02$), folate ($r = 0.45$; $P = 0.03$), and phenolic compounds ($r = 0.74$; $P < 0.001$). A negative correlation was observed between DTAC and lipids ($r = -0.62$; $P = 0.001$).

Mate, coffee, and tea were the three beverages that contributed the most to increasing the DTAC, and were responsible for more than 40% of the entire DTAC that was estimated before supplementation. The other foods and drinks that were responsible for increasing the DTAC were apples, oranges, bananas, purple wine, grape juice, papayas, and orange juice. Grape juice ranked eighth on the list and contributed 5.06% to volunteers' DTAC. These foods and drinks have significant content of vitamin C and/or phenolic compounds (Table 5).

Discussion

The intake of fruits and vegetables has been well documented as associated with a lower risk to develop chronic diseases [20]. Grapes are berries that are rich in phenolic compounds, which are substances that are known as natural antioxidants. Studies have reported on the beneficial health effects of purple grape juices consumption [4–6,21]; however, to our knowledge, this is the first study to assess the effects of WGJ supplements in women. For this purpose, WGJ from 100% of grapes was chosen, without the presence of additives or water. The content of phenolic compounds from the juice that was used in our study was lower than reported in purple grape juices [22]. Despite this, WGJ exhibited significant antioxidant activity, which justifies our study.

Participants were nonsmoking women ages 50 to 67 y and included 11 eutrophic and 14 overweight or obese women. The

Table 3
Anthropometric measurements and biochemical assays before and after supplementation with white grape juice

Variable	Before supplementation			After supplementation			P-Value
	Mean	SD	Median	Mean	SD	Median	
Body mass index (kg/m ²)	25.6	3.8	25.7	25.4	3.7	25.4	<0.001*
Waist circumference (cm)	85.5	9.5	85.0	83.6	8.9	85.0	<0.001*
Abdominal circumference (cm)	90.5	10.0	92.0	88.7	9.4	91.0	<0.001*
Systolic blood pressure (mmHg)	123.6	16.4	118.0	121.8	11.7	124.0	0.5
Diastolic blood pressure (mmHg)	77.7	11.6	79.0	74.5	10.5	75.0	0.07
Total cholesterol (mg/dL)	182.6	30.0	181.5	182.1	23.9	179.8	0.9
HDL cholesterol (mg/dL)	55.9	15.2	52.0	64.2	18.4	62.5	0.05†
LDL cholesterol (mg/dL)	102.0	36.0	102.4	91.8	28.9	95.1	0.2
Triacylglycerols (mg/dL)	128.6	31.2	135.6	130.8	38.6	127.3	0.7
Glycemia (mg/dL)	88.3	20.6	88.5	79.0	13.1	76.0	0.06
Insulin (μU/mL)	5.2	2.9	4.9	5.3	3.4	4.4	0.9
TBARS (nmol MDA/mL)	4.6	0.6	4.6	4.5	0.7	4.5	0.4
Nitric oxide (mmol/L)	27.5	30.2	18.5	33.7	43.0	17.9	0.5
SOD (USOD/mg of protein)‡	89.5	33.9	86.6	93.9	30.9	89.8	0.6

HDL, high-density lipoprotein; LDL, low-density lipoprotein; MDA, malondialdehyde; SD, standard deviation; SOD, superoxide dismutase activity; TBARS, thiobarbituric acid reactive substances; USOD: one unit of superoxide dismutase activity.

Data were expressed in mean ± SD.

* Statistical significance $p < 0.001$.

† Statistical significance $p < 0.05$.

‡ One unit of SOD is defined as the amount of enzyme that is needed to decrease to half the spontaneous adrenochrome formation velocity.

women were instructed to take 7 mL/Kg/d of WGJ for 30 d. To include grape juice in participants' diets, we adjusted the energy consumption without changing the dietary habits. Although WGJ is a caloric drink, we observed a reduction in BMI and waist and abdominal circumference after the intervention. The results of a randomized clinical trial that used white wine and purple grape juice showed that both groups had reduced weight and waist circumference in a similar way [23]. Our results indicate that a

moderate consumption of WGJ has a positive impact on weight and abdominal fat, which is directly associated with cardiovascular disease.

To evaluate the cumulative antioxidant activity of the women's diet, we conducted the DTAC (a concept created by Serafini and Del Rio) [24] before the supplementation. DTAC considers the accumulative and synergistic effects of dietary antioxidants rather than each individual antioxidant action and has been used to provide an integrated parameter rather than the simple sum of each antioxidant that is found in a diet. Previous studies reported that DTAC is inversely associated with stroke incidence in cardiovascular disease [25], cancer susceptibility [26], the development of metabolic syndrome [27], and the frequency of cerebral infarction [28]. In our study, we found a DTAC that oscillated between 488.0 and 2357.1 mg VCE/d, which reflects the diversity in the quantity of antioxidants that were ingested by the volunteers. The mean value of the DTAC (1194.3 mg VCE/d) was 54% higher than that previously found (772.08 mg VCE/d) for women ages 18 to 35 y [29], which is probably due to the concern that older women maintain a diet that is rich in fruits and vegetables.

The three beverages that contributed to the increase in the volunteers' DTAC were mate (a typical drink of the southern region of Brazil), coffee, and tea. Before supplementation, purple grape juice ranked eighth among the 10 food and drinks that were responsible for maintaining women's DTAC. Phenolic compounds appeared more closely associated with the DTAC than vitamin C because there was a positive correlation between the content of phenolic compounds and DTAC, as previously demonstrated [30–32].

In our study, there was no change in the blood pressure of the volunteers who supplemented with WGJ. Similar results were observed with the supplementation of purple grape juice in healthy women and individuals with high blood pressure [33]. However, in another study, purple grape juice reduced the blood pressure of hypertensive individuals [5].

HDL cholesterol is an important predictor of risk of cardiovascular diseases. Data from a meta-analysis showed that with an increase of 2% of serum levels of HDL cholesterol, the incidence of coronary heart disease is reduced by 2% in men and 3% in women [34]. Studies have demonstrated that purple grape juice can increase HDL cholesterol after 1 month of supplementation with

Table 4
Levels of nutrient and energy intake and correlations with DTAC

Nutrient	Mean	SD	Median	DTAC	
				r*	P-value
Total energy intake (Kcal)	1645.00	338.8	593.25	0.05	0.82
Carbohydrate (% TEI)	55.70	6.4	54.70	0.48	0.02†
Protein (% TEI)	17.92	4.1	17.50	0.07	0.74
Fat (% TEI)	26.18	5.1	26.00	−0.62	0.001‡
Total fiber (g)	21.21	6.4	18.50	0.06	0.77
Calcium (mg)	771.58	406.04	722.73	0.06	0.78
Iodine (μg)	122.56	113.72	95.06	−0.03	0.89
Iron (mg)	9.20	3.20	8.40	0.11	0.61
Magnesium (mg)	260.70	120.03	248.06	−0.06	0.78
Potassium (mg)	2377.76	783.21	2391.85	0.10	0.61
Selenium (μg)	27.10	28.76	21.05	−0.23	0.53
Sodium (mg)	1920.93	1394.10	1377.12	−0.18	0.38
Zinc (mg)	8.10	3.70	7.10	0.07	0.72
Folate (μg)	149.62	76.74	137.9	0.45	0.03†
Vitamin A (μg)	4419.09	5636.71	2669.82	−0.31	0.14
Vitamin B1 (mg)	1.30	1.44	0.89	−0.16	0.44
Vitamin B6 (mg)	0.89	0.26	0.83	0.23	0.27
Vitamin B12 (μg)	2.16	1.90	2.00	0.25	0.23
Vitamin C (mg)	120.00	50.80	118.10	0.21	0.32
Vitamin D (μg)	3.77	4.33	2.67	0.06	0.78
Vitamin E (mg)	5.13	4.73	3.79	−0.27	0.19
Polyphenols (mg GAE)	1806.60	923.20	2069.60	0.74	<0.001‡
β-Carotene (μg)	137.44	131.33	87.38	0.14	0.52
DTAC (mg VCE/d)	1194.30	563.60	1101.70	—	—

DTAC, dietary total antioxidant capacity; GAE, gallic Acid equivalent; SD, standard deviation; TEI, total energy intake.

Data expressed with mean ± SD mean.

* Spearman correlation with; Spearman correlation with statistical significance.

† $P < 0.05$.

‡ $P < 0.001$.

Table 5
Vitamin C and total polyphenol content of the 10 foods and drinks that most contributed to increasing the DTAC

Ranking	Food/drink	Percentage of contribution*	Vitamin C (mg/100 g) [†]	Polyphenols (mg GAE/100 g) [‡]
1	Mate (<i>Ilex paraguariensis</i>)	16.37	0.00	380.30
2	Coffee (<i>Coffea arabica</i> L.)	14.38	0.00	50.60
3	Tea (<i>Camelia sinensis</i>)	11.13	0.00	63.70
4	Apple (<i>Malus domestica</i>)	10.71	2.40	127.10
5	Orange (<i>Citrus aurantium</i>)	10.21	34.70	143.10
6	Banana (<i>Musa sp.</i>)	9.86	21.60	96.50
7	Purple wine (<i>Vitis vinifera</i> L.)	6.16	0.00	200.10
8	Grape juice (<i>Vitis labrusca</i> L.)	5.06	21.00	26.79
9	Papaya (<i>Carica papaya</i> L.)	4.77	60.90	57.60
10	Orange juice (<i>Citrus sinensis</i>)	3.17	73.30	73.30

DTAC, dietary total antioxidant capacity; GAE: Gallic acid equivalent.

* The percentage of the contribution of each food and beverage to the DTAC was based on the sum of all DTACs of the volunteers.

† The values of vitamin C listed in the Brazilian Food Composition Table [42].

‡ The values of polyphenols listed by Floegel et al. [16], except for mate and grape juice (performed by our group).

150 mL twice a day [35]. In a similar way, unripe purple grape juice improved HDL levels in healthy individuals [21]. To our knowledge, this is the first study to show that WGJ also increases HDL cholesterol levels. Here, we demonstrated that the consumption of 7 mL/Kg weight/d of WGJ during 30 d increased HDL levels by 16%, which may contribute to the minimization of the risk of cardiovascular diseases.

Although grape juice has glucose and fructose in its composition, an increase in glycemic or insulin levels was not observed in our study. These findings are in accordance with the results of previous studies that used purple juices [36] and is an important factor to consider, mainly for the supervised use of WGJ by diabetic patients. This fact could be explained by the presence of polyphenols in WGJ (mainly resveratrol), which was already described as able to reduce fasting glucose in healthy individuals [37]. Likewise, resveratrol improved insulin sensitivity and postmeal plasma glucose in older individuals with impaired glucose tolerance [38].

In addition, no changes were observed in NO levels after supplementation with WGJ as previously described for purple grape juice in both men and women [39]. The results on the effect of purple grape juice on lipid peroxidation and SOD activity are controversial. Yuan et al. [40] found a reduction in TBARS levels after supplementation with 300 mL/d during 15 d of purple grape juice in healthy men and women. On the other hand, Toscano et al. [41] did not find any differences in the levels of TBARS after supplementation with 10 mL/Kg /d for 28 d of purple grape juice in athletes who run, which confirms the data obtained in our study.

With regard to SOD activity, a previous study [36] reported an increase in SOD activity in patients with coronary artery disease who consumed 7 mL/Kg/d of purple grape juice for 14 d. In our study, no differences were found in SOD activity, as well as already described in healthy individuals (both sexes) supplemented with 300 mL/d of purple grape juice for 15 d [40]. The divergence of results may be due to variations in the composition of the grape juice, the quantity and duration of the supplementation, and the population studied. Further studies are necessary to confirm the effect of grape juice supplementation in both men and women.

While interpreting our results, the limitations of our methods are important to discuss. First, we did not include a placebo-controlled supplementation methodology once our focus was the investigation of pre- and post-supplementation in the same interventional group (n = 25). Nevertheless, our study yielded very reproducible results that can be attributed to the supplementation. Furthermore, the subjects were advised to avoid the consumption of any grape derivative during the intervention as well as keep

their usual food intake and lifestyle. Second, we defined only 30 d of supplementation, which could be responsible for the lack of response on the antioxidant parameters examined in this study. Future long-term studies should be conducted in healthy subjects to fully understand WGJ mechanisms on redox parameters.

Conclusions

Although studies on purple grape juice already exist, this is, to our knowledge, the first study to evaluate the effect of WGJ supplementation in humans. The results showed that the ingestion of 7 mL/Kg/d for 30 d does not alter blood glucose or insulin levels but decreases BMI and waist and abdominal circumference. No differences were observed in NO levels or markers of oxidative damage. In addition, there was an increase of 16% in HDL cholesterol levels in women, which can contribute to the minimization of the risk of cardiometabolic syndromes that are associated with cholesterol transport.

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Supplementary data

Supplementary data related to this article can be found at doi:10.1016/j.nut.2018.05.026.

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