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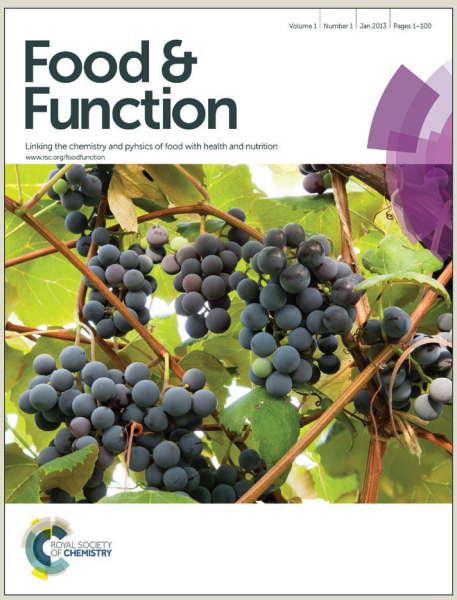

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Comparative effects of red and white grapes on oxidative markers and lipidemic parameters in adult hypercholesterolemic humans

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ABSTRACT

The present study compared the effects of consuming red versus white whole grapes on oxidative and lipidemic indices in people with hypercholesterolemia. Sixty nine patients were randomized into three groups. The two treatment groups consumed 500 g of either Condori red grapes or Shahroodi white grapes daily for 8 weeks, and the third group served as a control. Plasma glucose, triacylglycerol (TG), cholesterol, low-density lipoprotein cholesterol (LDL-C), high-density lipoprotein cholesterol (HDL-C), thiobarbituric acid reactive substances (TBARS) and total antioxidant capacity (TAC) were determined by colorimetric methods at baseline and at the end of the study. Additionally, the polyphenol and fiber content of the two grapes varieties was measured. TBARS was reduced in both study groups compared to the control group, and the reduction was greater in the group that consumed red grapes compared to the white grapes. TAC was increased significantly in both red and white grapes consuming groups compared to the control group. Total cholesterol and LDL-C were decreased in the red grape group compared to the control group. No significant changes in fasting blood glucose, TG or HDL-C were observed among the groups. The results of this study suggest that consumption of the whole fruit of red grapes has more potent anti-oxidative and hypolipidemic effects compared to the white grapes in hyperlipidemic adult humans. Hence, the whole fruit of red grape may be an excellent fruit choice not only to prevent oxidative stress related metabolic disorders but also cholesterol related cardiovascular diseases, particularly for hyperlipidemic adult humans.

Keywords:

Condori red grapes, Shahroodi white grapes, Polyphenols, Lipids, Hypercholesterolemic humans

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1. Introduction

Cardiovascular diseases (CVD) are the major threat to global public health and the leading cause of mortality among patients with chronic non-communicable diseases. Elevated serum total cholesterol, low-density lipoprotein cholesterol (LDL-C) and triglycerides (TG) have been recognized as the most risk factors for cardiovascular and coronary heart diseases.[1] Furthermore, the oxidative modification of LDL-C has been found to be a critical event in triggering the development of atherosclerosis.[2] The "Mediterranean" dietary pattern has been found as one of the most effective types of protection against CVD along with the consumption of adequate amount of fruits and vegetables.[3] In some previous studies, although the cardio-protective properties of fruits and vegetables were attributed to their high level of fiber[4] and phytochemicals,[5-9] extensive epidemiological evidence suggests that the dietary intake of fiber along with phytochemicals reduces the cardiovascular mortality by modulating oxidative status and ameliorating dyslipidemia.[10,11]

Epidemiologic data from World Health Organization (WHO) revealed the discrepancies in cardiovascular mortality among cohorts from 17 western countries compared to a cohort of subjects from Toulouse, France.[12,13] This counterintuitive finding, termed "French paradox", stimulated further research that led to several possible explanations for this discordance. We hypothesized that the increased consumption of grapes (*Vitis vinifera*) and grape products in Mediterranean countries might be one of the reasons for lower death from cardiovascular diseases.

Evidence from 6000 years ago recovered from archaeological investigations in Egypt have indicated the medicinal value of grapes.[14] This fruit contains a wide variety of polyphenolic compounds, including flavonoids and non-flavonoid agents with cardio-protective properties.[15] The concentrations of these compounds are varied based on the variety of grapes, climate and light, ripeness, processing and storage condition.[16]

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Several types of grapes have been studied, but some research indicated that darker varieties are more beneficial for humans due to their higher content of phytochemicals.[17] White grape varieties and their cardio-protective effects have not been well studied compared to the darker cultivars.[18] To the best of our knowledge, there is no clinical trial in humans which compared the effect of white grape versus red grape cultivars on lipidemic and oxidative markers. In this study, we evaluated the effect of consuming two Iranian grape cultivars, e.g. Condori red grapes and Shahroodi white grapes, on oxidative markers and lipidemic parameters in hypercholesterolemic subjects. Since polyphenols are mainly distributed in grape skins, stems, leaves and seeds rather than in the juicy pulp,[19] the principal aim of this study was to examine and compare the effects of whole fresh red and white grapes including the seeds and skin on lipidemic and oxidative marks in hypercholesterolemic adult humans. We also analyzed the total polyphenol and fiber content of these two cultivars of grapes.

2. Materials and Methods

2.1 Human subjects and experimental design

One hundred patients with hypercholesterolemia (30 men and 70 women, mean age 52.6 years) have been selected from the outpatient department of the Shohada hospital in Tehran, Iran based on their medical records. A written consent was taken from all patients regarding their participation in this study. First of all, all agreed patients were invited to attend a seminar where the consequences of dyslipidemia and its relation to CVD were explained along with the objectives of the study.

The inclusion and exclusion criteria of patients in this study are shown in Table 1. Out of 100 individuals, 69 satisfied the entry criteria and completed the study. Based on the results of a previous study,[20] the required sample size for our interventional trial with an 8-

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week follow-up period was calculated by using a G-Power software (version 3.1, Informer Technologies, Inc.) since the mean change in cholesterol after grape consumption was achieved after this period of time.

The experimental protocol of the trial was approved by the Shohada Hospital Review Board (DP/8703277/176, 14/5/2008). The ethical aspects of the study were also approved by the Ethics Committee of Shahid Beheshti University of Medical Sciences in May 2008 (Ethical approval no. 18525). The entire study was carried out in accordance with the principles of the Helsinki Declaration as revised in 2000. The participants were instructed not to take any antioxidant supplements from 8 weeks before the study.

2.2 Intervention

Baseline measurements were collected for a 3-week period when all participants consumed their usual diet. They were randomly assigned to one of the 3 groups after stratification by sex, age and body mass index. The participants in group 1 received 500 g of Condori red grapes and those in group 2 received 500 g of Shahroodi white grapes daily in 5 servings of 100 g each for 8 weeks intervention period. The group 3 or control group was used for the stratification of changes in dietary intake or fluctuations in serum lipids related to the summer season when this group similarly consumed 5 servings of other fruits except grapes.[21] The grapes were purchased from Ghazvin province orchards, Ghazvin, Iran which polyphenol and fiber concentrations have been analyzed (Fig. 1).

Participants were instructed not to change their level of physical activity or other lifestyle factors throughout the intervention period. Before the baseline period, written and verbal instructions were provided to the participants by a dietician on how to keep accurate dietary records, including how to weigh or measure foods. A 3-day dietary record (2 weekdays and 1 weekend day) and a lifestyle related questionnaire including history of

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illness, medications and physical activity were completed at baseline and after the intervention period. Physical activities of participants were evaluated by an Epic-Norfolk Physical Activity Questionnaire. Energy consumption from each food, beverage and other nutrients was analyzed by NUNTRITIONIST III software (version 7.0; N-Squared Computing, Salem, OR, USA), which was designed for Iranian foods.

Body weight and height of all participants were measured with a digital scale and non-stretchable measuring tape. Body weight, changes in physical activity and medication, and any illnesses were recorded weekly during baseline and at week 2, 4, 6 and at the end of the intervention period.

2.3 Biochemical measurements

Fasting blood samples were taken at baseline and at the end of the 8-week intervention period. All samples were promptly centrifuged at 3000 × g for 15 min at 4 °C. Immediately after centrifugation the plasma samples were separated and analyses were carried out with a Selectra 2 Auto Analyzer (Vital Scientific, Spankeren, The Netherlands). Plasma glucose was determined with a glucose analyzer (YSI, Yellow Springs, OH). Serum TG was measured with glycerol-3 phosphate oxidase phenol aminoantipyrine in an automated Technicon Axon Analyzer. Total HDL-C levels (after precipitation with magnesium chloride) were measured with enzymatic techniques (Pars Azmun, Tehran, Iran). The LDL-C level was calculated with the Friedewald formula[22] as follows:

$$\text{LDL-cholesterol} = [\text{Total cholesterol} - (\text{HDL-cholesterol} + \text{TG}/5)]$$

where, TG/5 is equivalent to the concentration of VLDL-cholesterol

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Total plasma antioxidant capacity (TAC) was determined by the generation of colored 2,2'-azinobis-(3-ethylbenzothiazoline-6-sulfonic acid radical cation method) (Randox Inc. Antrium, Northern Ireland, UK).[23]

The lipid peroxidation rate as a marker of oxidation was estimated by measuring thiobarbituric acid reactive substances (TBARS), and was reported as the malondealdehyde equivalent (MDAE).[24]

2.4 Samples for fiber and polyphenol measurements

All samples of grapes were harvested from vines grown in Ghazvin province, Iran. The red and white grape orchards were divided into six equal areas and 100 berries were collected from each area. Grape berries were placed in polyethylene bags and transported under refrigerated conditions to the Faculty of Nutrition, Department of Biochemistry, Shahid Beheshti Medical University, Tehran, Iran. The aqueous extract of each sample of grape berries was obtained by boiling the dried part of grapes for 30 min in distilled water at a ratio of 1:100 (w/v), and incubated overnight at 40 °C with slow shaking on an orbital shaker (Stuart Scientific Orbital Shaker, Staffordshire, UK). The water-soluble fraction was centrifuged at 6000 × g for 10 min and the insoluble precipitate was discarded. The supernatant was filtered with Whatman No. 1 filter paper. The filtrate was concentrated under reduced pressure at 40 °C with a rotary evaporator (Laborota 4000, Heildolph, Germany) and finally freeze-dried to obtain the grape extract. The resulting sample was powdered and sealed in plastic bag for subsequent use.

2.5 Measurement of polyphenols

The amount of total polyphenols in grape extract was determined with a modified pharmacopeia colorimetric method.[25] The freeze-dried extract was dissolved in an

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ammonium chloride and methanol mixture (20 mg/mL) and further dilutions were done to obtain readings within the standard solution curve at different concentrations of 24, 32, 48, 56, 64 µg/mL. The samples were kept in the dark for 40 min and absorbance was then read at 415 nm. The results were expressed as milligrams of polyphenol per gram of dried extract.

2.6 Measurement of fiber

Total fiber content of the grapes was determined by measuring the parts of defatted grapes remaining after boiling with sulfuric acid and sodium hydroxide, with methods approved by the American Association of Cereal Chemists.[26]

2.7 Statistical analysis

The distribution of variables was studied with probability plots and the Shapiro-Wilks test. Baseline demographic and biochemical values were compared between the groups with one-way ANOVA. Bonferroni correction was used wherever there was a major effect. The differences between the groups in serum TBARS, TAC and serum glycemic and lipidemic parameters were analyzed by one way ANOVA, with an adjustment for age, body weight and sex. Unpaired *t*-tests were used wherever there was a major effect.

Paired *t*-tests were used to compare variables within groups. The Man–Whitney U test was used to determine differences between groups in polyphenol and fiber content. A value of $p<0.05$ was accepted as significant. All statistical analyses were done with an IBM computer using the SPSS 18 statistical software package (SPSS Inc., Chicago, IL, USA).

Sample size was estimated by the F test with G-Power statistical software, version 3.1, based on a two-sided type I error of 5% and 84.5% power. The significance level was set at $p<0.05$.

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3. Results

Out of 100 participants screened, 69 satisfied the entry criteria and completed the study. The characteristics of the patients confirmed that the groups were well matched for all entry criteria (Table 2). There were no significant differences between the groups in total energy intake, micro- and macronutrient intake or body weight at baseline. Physical activity was unchanged during the intervention in all groups (data not shown).

After an 8-week intervention period, the concentrations of TBARS were decreased by 23% (p<0.001) and 6% (p=0.02) in Condori red and Shahroodi white grapes consuming group, respectively (Table 3). Analysis of covariance between groups showed a significantly higher reduction in TBARS in the red grape group than the white grape and control groups (Table 4). Total antioxidant capacity (TAC) was significantly increased (p<0.001) in the red grape and white grape groups (Table 3) compared to the base line data (Table 2). The induction of TAC was significantly higher in the red grape and white grape groups compared to the control group (p<0.001), when no significant difference was found between the red grape and white grape consuming groups (Table 4).

At the end of the study, the total cholesterol concentration was 9% (p= 0.001) and 8% lower (p=0.005) in the red grape and white grape consuming groups respectively compared to the baseline (Table 3). The reduction of total cholesterol was significant (p=0.04) in the red grape group but not in the white grape group compared to the control group (Table 4).

The level of LDL-C was 14% lower (p=0.001) in the red grape group and 10% lower (p=0.04) in the white grape group after the intervention (Table 3) when the reduction was significant only for the red grape group compared to the control group (p=0.01) (Table 4).

No significant changes in fasting blood glucose, TG or HDL-C were observed within or between the groups after the intervention (Table 3). No significant changes in dietary energy, total fat, cholesterol, saturated fatty acids, monounsaturated fatty acids,

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polyunsaturated fatty acids, carbohydrates, vitamin C, vitamin E and selenium content were observed between the groups during this study (Table 4).

4. Discussion

The principal aim of the present study was to examine and compare the effects of whole fresh red and white grapes including the seeds and skin on lipidemic and oxidative marks in hypercholesterolemic adult humans. A number of previous studies reported that the total polyphenol content of fruits and vegetables is closely linked with the lower lipid peroxidation and higher TAC. Although a higher amounts of polyphenols such as 800 mg[27] and 1400 mg[28] were supplied per day in order to achieve significant effects on cardiovascular disease related biomarkers in humans, according to a recent meta-analysis, 5 serving of fruits and vegetables (5 x 100 g = 500 g) in Mediterranean diet have been found as one of the major indicators for the reduction of cardiovascular and cerebrovascular risks.[29] Hence, in our study, 500 g of grapes were supplied in 5 servings as 100 g per serving per day. Although the amount of polyphenol received from 500 g of grapes per day in our study was significantly lower (312 mg) than the above-mentioned studies,[27,28] the antoxidative as well hypolipidemic effect of polyphenols may be different among the grape varieties due to their different compositions of polyphenols. In a recent study, Anastasiadi *et al.*[30] reported that total polyphenol content as well as anti-oxidative properties of Mandilaria red grape cultivar is significantly higher than the Aidani white grape cultivar.[30] In addition, several studies have reported significant reduction in TBARS after the administration the seeds,[10] skins[11] and the pulp of whole red grapes[31] in human and animal models. However, few studies have investigated the effect of white grape cultivars on TBARS and no study compared the effects of whole red and white grapes consumption either in humans or in experimental animals. The results of the present study showed a significantly higher reduction in serum TBARS concentration in individuals

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who consumed red grapes compared to those who consumed white grapes and the control group (Table 3, 4). Serum TAC also increased after red grape consumption, although the value after the intervention period did not differ significantly between the two treatment groups. These results indicate a robust antioxidant property of red grapes compared to the white grapes. The significantly higher total polyphenol content in the red grape cultivar than the white grape cultivar might be the reason for lower serum TABRS concentration and higher TAC in the red compared to the white grape consuming group.

The difference in the anti-oxidative characteristics of Condori red grapes and Shahroodi white grapes are also likely related to differences in the chemical compositions of the two cultivars, particularly with regard to polyphenols. The most obvious difference between these cultivars is the color of the berries, which reflects the presence of different types of polyphenolic compounds. It has been reported that white grapes are evolutionarily derived from red varieties as a result of mutations in two regulatory genes and deactivation of the production of anthocyanins, which are responsible for the dark color of red grapes.[32] Some studies found at least 25 times more athocyanins in red grapes than in white grapes.[33] Among fruit pigments, anthocyanins have been recognized as a potent antioxidant polyphenol. In this connection, serum anthocyanin concentration is directly related to serum total antioxidant capacity. Mazza *et al.*[34] and Choi *et al.*[35] have suggested that anthocyanins likely to play an important role in the activation of NADPH oxidase, which leads to an increase in circulating TAC.[34,35] Delphinidin, the major subset of anthocyanins in dark grapes, has been reported to exert an anti-atherosclerotic action by protecting vascular endothelial cells against oxidized LDL-induced endothelial dysfunction.[36] According to the results of the above-mentioned studies, some of these mechanisms might be involved in showing lower lipid peroxidation (TBARS) and higher TAC of red grapes compared to the white grapes in our study.

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On the other hand, the β-carotene content of white grapes is responsible for their bright color.[37] Several studies have reported a pro-oxidant role for β–carotene in humans.[38-40] Rozenberg *et al.*[40] found that white grape consumption by mice made diabetic resulted in a 22% increase in macrophage total peroxide levels and a 45% decrease in cellular glutathione content.[40] Consequently, the lack of anthocyanins accompanied by augmented β-carotene content in white grapes might be another reason for the lower antioxidant capacity compared to the red varieties which has been further proved by the effects of grapes on some other parameters such as serum lipid profile.

It has been reported that the consumption of raisins (red variety), which contain ample amounts of dietary fiber[4] and polyphenols,[41] lowered LDL-C in patients with hypercholesterolemia. It has been also reported that grape fiber interferes with entero-hepatic bile circulation, which results in increased bile acid excretion.[42] Additionally, polyphenols interfere with cholesterol synthesis via microsomal transport protein inhibition, which is responsible for lipid transfer to Apo B, and its inhibition increases the susceptibility of Apo B to degradation and consequently decreases the section of very low density lipoprotein and circulating LDL-C.[43-46] Zern *et al.*[46] also concluded that grape polyphenols, like fiber, can interfere with cholesterol absorption.[46] Therefore, despite the high fiber content of Shahroodi white grapes, their low polyphenol content is likely to be responsible for the null effect on serum cholesterol levels compared to the control group. In contrast, significantly lower serum total cholesterol as well as LDL-C in the red grape consuming group compared to white grapes consuming and control groups (Table 4) might be due to higher polyphenol content.

In present study, we instructed the participants to consume whole grape berries, including the seeds. A meta-analysis of nine randomized controlled trials (N=390) on the lipid-lowering effect of grape seed extract in humans failed to find significant results,[47] whereas studies of the effect of whole grape berries on lipidemic parameters reported

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significant outcomes.[20] There is a consensus that the hypolipidemic effect of grapes may be the result of the synergic effects of several compounds rather than a single compound.[48] A potential strength of the present study over previous studies was that grape berries (both red and white) were consumed as a whole fruit including the seeds and skin. It was emphasized that the seeds should be chewed well before swallowing .This made it possible to investigate the synergic effects of several compounds found in different parts of grape on lipidemic and oxidative markers. Grape seeds contain high levels of phytosterols and tocopherols (vitamin E), polyunsaturated fatty acids such as linoleic acid, oleic acid and alpha-linolenic acid, which are assumed to enhance the anti-oxidative and hypo-lipidemic properties of grapes.[49]

5. Conclusion

The results of this study suggest that consumption of the whole fruit of Condori red grapes has more potent anti-oxidative and hypo-lipidemic effects compared to the whole fruit of Shahroodi white grapes in hyperlipidemic adult humans. Hence, the whole fruit of Condori red grape may be an excellent fruit choice not only to prevent oxidative stress related metabolic disorders but also to cholesterol related cardiovascular diseases, particularly for hyperlipidemic adult humans.

Declaration of interest

The authors report no conflict of interest.

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TABLES

Table 1 The inclusion and exclusion criteria of the study

Parameters	Inclusion criteria	Exclusion criteria
Age (years)	>20 but <70	>70
Serum cholesterol (mg/dl)	> 200 mg/dl	
BMI (kg/m^2)	>19.8 but < 35	
Medicine		Use of anti-inflammatory , lipid-lowering, beta-adrenergic antagonist, and thiazide diuretic medications
Diseases		Previous medical history of diabetes, thyroid, liver, renal and chronic inflammatory diseases (plasma creatinine >1.47 mg/dl), heart disease, angina, or major surgery; had a recent history (within 6 months) of myocardial infarction or stroke.
Diet		Special diet
Supplements		Fish oil or omega-3, vitamin E, C, selenium, lipoic acid supplements.

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Table 2 Baseline characteristics of the participants (n=69). Means ±SD

Characteristic	Red grape	White grape	Control	P value
Number	22	24	23	NS
Male	4	6	4	NS
Female	18	18	19	NS
Age (years)	50.5 ± 10.6	50.6 ± 9.0	52.5 ± 11.5	NS
Weight (kg)	71.4 ± 14.4	72.3 ± 16.2	69.0 ± 10.7	NS
BMI (kg/m^2)	27.5 ± 7.5	28.5 ± 5.2	27.8 ± 4.1	NS
Biochemical markers				
TBARS(MDAE, µmol/L)	2.15 ± 0.01	2.12 ± 0.02	2.17 ± 0.01	NS
TAC (m mol/L)	1.51 ± 0.01	1.51 ± 0.02	1.60 ± 0.01	NS
FBG (mg/dL)	84.60 ± 10.23	86.45 ± 12.35	89.31 ± 13.22	NS
Cholesterol(mg/dL)	242.61 ± 4.97	230.45 ± 30.54	231.57 ± 27.03	NS
LDL-C (mg/dL)	164.90 ± 20.92	147.22 ± 37.68	149.02 ± 29.10	NS
HDL-C (mg/dL	44.54 ± 7.91	46.72 ± 11.52	39.07 ± 8.24	0.01

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TG (mg/dL)	180.09 ± 72.48	182.95 ± 103.83	209.77 ± 87.93	NS
Dietary intake				
Energy(Calories)	1741 ± 341	1698 ± 502	1471 ± 411	0.09
Total fat(g/day)	53.20 ± 12.60	52.09 ± 18.88	50.20 ± 23.54	NS
SFA(g/day)	16.33 ± 4.36	16.55 ± 6.76	17.05 ± 11.90	NS
MUFA(g/day)	17.89 ± 5.65	16.99 ± 7.98	16.90 ± 8.43	NS
PUFA(g/day)	14.02 ± 5.10	14.07 ± 4.72	12.29 ± 5.68	NS
Cholesterol(mg/day)	169.17 ± 90.97	178.30 ± 119.25	173.70 ± 89.14	NS
Carbohydrate(g/day)	266.66 ± 66.95	264.29 ± 77.17	214.04 ± 56.67	NS
Vitamin C(mg/day)	120.49 ± 79.99	113.60 ± 68.23	115.14 ± 65.48	NS
Vitamin E(mg/day)	11.45 ± 6.12	11.45 ± 5.19	10.46 ± 4.46	NS
Selenium(mg/day)	75.42 ± 23.08	78.31 ± 20.30	77.2136 ± 21.41	NS

No significant differences were found between groups in baseline variables except for HDL-C. BMI = Body mass index; TBARS = Thiobarbituric acid reactive substances, MDAE = Malondialdehyde equivalent; TAC = Total antioxidant capacity; FBG = Fasting blood glucose; LDL-C = Low density lipoprotein cholesterol; HDL-C = High density lipoprotein cholesterol; TG = Triacylglycerol; SFA = Saturated fatty acids MUFA = Monounsaturated fatty acids; PUFA = Polyunsaturated fatty acids.

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Table 3 Changes in each group after the dietary intervention

Serum parameters	Red grapes		White grapes		Control group	
	Before	After	Before	After	Before	After
TBARS (MDAE, ηmol/L)	2.15±0.01	1.65±0.05 *	2.12±0.02	1.99±0.02 #	2.17±0.01	2.09±0.01*
TAC (mmol/L)	1.51±0.01	1.56±0.02 *	1.51±0.01	1.56±0.02*	1.60±.013	1.57±0.03*
FBG (mg/dL)	84.60±10.23	84.681±7.99039	86.454±12.350	92.568±12.496	89.310±13.229	87.00±12.48
Chol. (mg/dL)	242.61±4.97	220.857±7.209 *	230.45± 30.54	211.40±33.73 *	231.57±27.03	228.71±28.72
LDL-C (mg/dL)	164.90±20.92	140.613±32.365*	147.227±37.681	132.95±35.43 #	149.02±29.10	153.20±28.04
HDL-C (mg/dL)	44.54±7.91	41.72±9.40583	46.72±11.52	43.42±10.54	39.07±8.24	36.53±8.10
TG (mg/dL)	180.09±72.48	178.90±90.18	182.95 ±103.83	175.13 ±94.38	209.77 ±87.93	198.95 ±69.86

All data are presented as mean ± SD.

*Significantly different from baseline (by paired t-test): $p < 0.01$.

#significantly different from baseline (by paired t-test): $p < 0.05$.

MDAE = Malondialdehyde equivalent; TBARS = Thiobarbituric acid reactive substances; TAC2008 = Total antioxidant capacity; FBG = Fasting blood glucose; Chol. = Cholesterol; LDL-C = Low density lipoprotein cholesterol; HDL-C2008 = High density lipoprotein cholesterol; TG = Triacylglycerol.

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Table 4 Differences between groups after the dietary intervention

Group/Characteristics	Red grape	white grape	Control
TBARS (MDAE, ηmol/L)	-0.50±0.051 # *	-0.13±0.0001*	-0.07±0.01
TAC (mmol/L)	0.04±0.02*	0.05±0.007*	-0.02±0.03
FBG (mg/dL)	.0773±9.97	6.11±15.54	-2.31±13.44
TG (mg/dL)	-1.18±53.73	-7.81±53.28	-10.82±69.17
Cholesterol (mg/dL)	-24.22±29.95*	-19.04±28.46	-2.85±28.00
LDL-C(mg/dL)	-24.29±28.42*	-14.27±31.32	4.18±33.90
HDL-C(mg/dL)	-2.81±7.35	-3.30±10.87	-2.54±6.26
Dietary intake			
Energy (Calories)	-28.76±542.9	-7.00±408.39	124.04±395.6
Carbohydrate (g/day)	-15.9048±91.06	-12.1667±65.69	.8636±69.82
Total fat (g/day)	5.30±21.42	5.23±19.10	6.97±21.86
Cholesterol (mg/day)	81.58±112.38	73.82±145.80	56.20±99.03
SFA (g/day)	1.63±7.07	2.24±9.49	1.45±11.23
MUFA (g/day)	2.61±11.20	2.71±8.53	3.18±7.79
PUFA (gm/day)	1.13±7.32	2.00±8.29	1.30±6.04

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Vitamin C (mg/day)	-44.73±108.45	-25.26±83.39	-66.56±123.14
Vitamin E (mg/day)	0.91±4.92	0.03±9.15	-0.58±7.05
Selenium (mg/day)	-23.73±39.71	-26.81±59.16	-20.89±197.87

Data are presented as mean ± SD. One-way ANOVA was used to assess the treatment effects between the groups. Unpaired t-test was used to compare the significant effect between two groups.

*Significantly different in each of the two treatment groups compared to the control group $p<0.05$).

[#] Significantly different for the red grape group compared to the white grape group ($p<0.05$).

MDAE = Malondialdehyde equivalent; TBARS= Thiobarbituric acid reactive substances;

TAC = Total antioxidant capacity; FBG = Fasting blood glucose;

TG = Triacylglycerol; LDL-C =Low density lipoprotein cholesterol; HDL-C = High density lipoprotein cholesterol;

SFA = Saturated fatty acids; MUFA = Monounsaturated fatty acids; PUFA = Polyunsaturated fatty acids.

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FIGURES

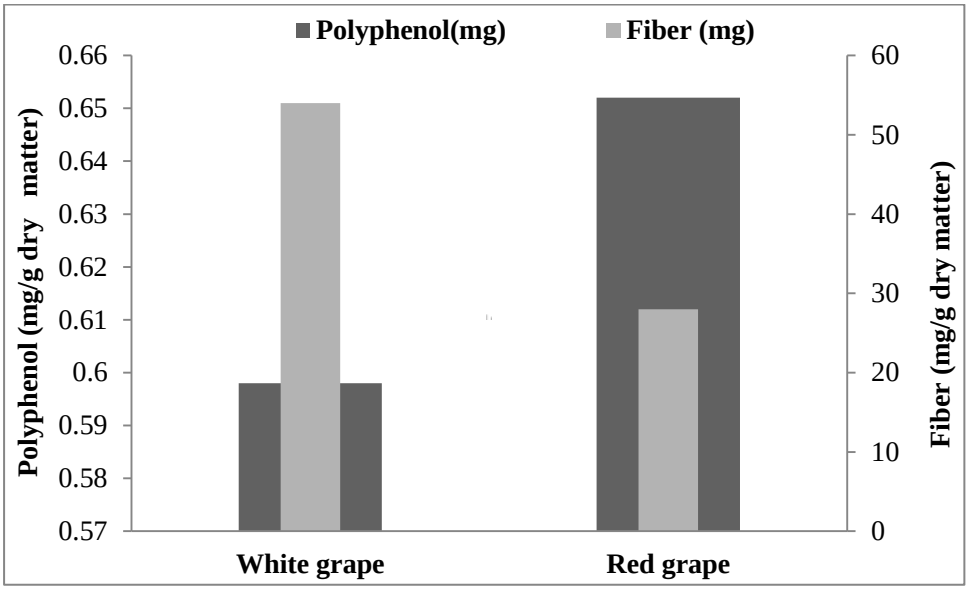

Fig. 1 Average of total polyphenol and fibre content of grapes per gram dried matter: The polyphenol content in the red grape cultivar was significantly higher than the white grape cultivar (0.652± 0.23 vs. 0.598±0.18 mg/g). The fiber content of the white grape cultivar was significantly higher than the red grape cultivar (54±2.3 vs. 28± 1.9 mg/g).

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