Effect of a tart cherry juice supplement on arterial stiffness and inflammation in healthy adults: a randomised controlled trial.

LYNN, Anthony, MATHEW, Shilpa, RUSSELL, Jean, ROBINSON, Emma, SOUMPASI, Vithleem and BARKER, Margo

Published version

LYNN, Anthony, MATHEW, Shilpa, RUSSELL, Jean, ROBINSON, Emma, SOUMPASI, Vithleem and BARKER, Margo (2014). Effect of a tart cherry juice supplement on arterial stiffness and inflammation in healthy adults: a randomised controlled trial. Plant Foods for Human Nutrition, 69 (2), 122-127.

Copyright and re-use policy

Effect of a tart cherry juice supplement on arterial stiffness and inflammation in healthy adults: a randomised controlled trial.

Anthony Lynn[1.], Shilpa Mathew[2.], Chris T Moore[2.], Jean Russell[3.], Emma Robinson[2.], Vithleem Soumpasi[2.], Margo E Barker[2.].

1. *Food and Nutrition Group, Sheffield Business School, Sheffield Hallam University S1 1WB, 2. Human Nutrition Unit, Department of Oncology, School of Medicine, University of Sheffield, S10 2RX* 3. *CICS, University of Sheffield S10 2HB*

Corresponding author: Anthony Lynn T.Lynn@shu.ac.uk; Tel: ++44 (0)114 2252065; fax: ++44 (0)114 2255036.

Abbreviations used: BP, blood pressure; BMI, body mass index; CV, coefficient of variation; CRP, c-reactive protein; DBP, diastolic blood pressure; FRAP, ferric reducing-antioxidant power; HDL, high density lipoprotein; PWV, pulse wave velocity; SBP, systolic blood pressure; SD, standard deviation.

Keywords: cherry, arterial stiffness, inflammation, blood pressure.

Abstract

Tart cherries are a particularly rich source of anthocyanins. Evidence indicates that dietary intake of anthocyanins is inversely associated with arterial stiffness. We conducted an open-label randomised placebo controlled study to determine whether a tart cherry juice concentrate (Cherry Active®) reduced arterial stiffness, inflammation and risk markers for cardiovascular disease in 47 healthy adults (30 – 50 y). Participants consumed 30 ml of cherry concentrate diluted to a volume of 250 ml with water or the same volume of an energy matched control drink daily for 6 weeks. Measurements were taken at baseline and at the end of the intervention. There was no effect of the intervention on arterial stiffness (P=0.218), c-

reactive protein (P=0.220), systolic blood pressure (P=0.163), diastolic blood pressure (P=0.121), total cholesterol (P=0.342) and high density lipoprotein cholesterol (P=0.127). At the end of the intervention, plasma antioxidant capacity (measured as the ferric reducing ability of plasma (FRAP) was significantly higher in the intervention group than the control group (P=0.012). We conclude that a tart cherry juice concentrate rich in anthocyanins has no effect on arterial stiffness, c-reactive protein and risk markers for cardiovascular disease, but evokes a minor increase in antioxidant status in healthy adults.

Introduction

Epidemiological studies indicate that the consumption of foods rich in flavonoids reduces the risk of cardiovascular disease, with some evidence that anthocyanins may be particularly protective [1-3]. Cherries are a rich source of flavonoids, especially anthocyanins [4-5]. In cell culture and animal models, cherry extracts or isolated anthocyanins have been shown to exert a range of potentially cardioprotective effects including, increasing nitric oxide production and antioxidant status, reducing lipid oxidation and inhibiting inflammation [6-9]. Anti-inflammatory effects have also been reported in a limited number of human studies [10-13]. In healthy middle-aged adults, the daily consumption of sweet cherries for 4 weeks reduced several markers of inflammation [10, 11]. Also, supplementation with tart cherry juice reduced exercise-induced inflammation in marathon runners and in adults completing a resistance exercise task [12, 13].

There is interest in whether diets rich in dietary anthocyanins can reduce arterial stiffness and therefore risk of cardiovascular disease [14]. Arterial stiffness is determined by the structural properties of the arterial wall, blood pressure and endothelial function [15]. Some experimental evidence indicates that anthocyanins can improve endothelial function via induction of endothelial nitric oxide synthase, so by extrapolation anthocyanins may reduce

arterial stiffness [16, 17]. In patients with hypercholestrolaemia, endothelial function was improved by a single dose of anthocyanins (320 mg) and a period of chronic supplementation (320 mg/d x 12 weeks) [17]. In the chronic supplementation study, endothelial function was improved > 12 hours after consumption of the last dose of anthocyanins when intact anthocyanins and their metabolites could not be detected in the plasma of participants. The authors speculated that anthocyanins may have accumulated in tissues [17].

In a cross-sectional study of women from the TwinsUK registry, arterial stiffness was inversely associated with anthocyanin intake, but not with total flavonoid intake [14]. The risk of residual confounding means that casual inference cannot be ascertained from cross-sectional studies, so intervention studies are needed to demonstrate that anthocyanin rich foods can reduce arterial stiffness [14]. In a recent study, daily supplementation with cranberry juice (rich in anthocyanins; 94 mg/d) for 4 weeks reduced arterial stiffness in overweight adults with coronary artery disease [18]. The effect of anthocyanin rich foods on arterial stiffness in healthy adults remains largely unexplored. In the present study we aimed to determine whether a commercial tart cherry juice concentrate rich in anthocyanins reduced arterial stiffness, inflammation and other markers of cardiovascular risk in healthy adults.

METHODS

Participants A total of 47 (29 female and 18 male) apparently healthy, non-smoking volunteers (age 30-50 y) were recruited through University email distribution lists, posters and personal contacts. Exclusion criteria included taking medication for heart disease, hypertension or diabetes, regular consumption of cherries or cherry juice and the use of antioxidant supplements. The study was approved by Sheffield Hallam University Ethics Committee and all volunteers gave written informed consent. The study was conducted between May 2010 and August 2011.

Study design. The study was a 6-week parallel open-label intervention of a daily supplement of cherry juice concentrate (30 ml diluted with 220 ml of water; Cherry Active®) *versus* a control drink of lemonade (250 ml/d; Sprite®). Both drinks were delivered to participants at the start of the intervention; those consuming the cherry juice were instructed to store the juice in their refrigerators before consumption. The concentrated cherry juice was dispensed automatically using a pump-action dispenser from a 950 ml bottle, whilst the lemonade was supplied in individual 250 ml bottles. Participants consumed the drinks during the day, according to their preference.

Participants were stratified by gender and age (30-39 years and > 40 years) and then block randomised to treatment by an investigator who was not involved in recruitment. Concealed envelopes were used to inform the researchers responsible for recruitment of the treatment allocation; this information was not made available until after baseline measurements were completed. Compliance to the intervention was recorded through participants keeping a daily tick-sheet of drinks consumed. It was emphasised to all participants that they should adhere to their usual diet and maintain usual exercise patterns in conjunction with daily consumption of the test drinks.

Our primary outcome variable was change in pulse wave velocity (PWV); our secondary outcome variable was change in c-reactive protein (CRP). Power calculations were based on a 10% change in PWV. A sample size of 50 (25 per arm) was calculated to detect a 10% change in PWV with 80% power and an alpha value of 0.05, using variance estimates of PWV (SD = 1.06, n=57) from a study of PWV (unpublished data).

Tart cherry juice concentrate and placebo beverage

The tart cherry juice concentrate was supplied by Cherry Active, Sunbury UK. A 30 ml serving of tart cherry juice was diluted with 220 ml of water prior to consumption. Each serving was estimated to contain the equivalent of 90-100 Montmorency tart cherries. The

composition of the juice was analysed by an independent laboratory (Atlas Bioscience Inc, Tuscan, AZ, USA). Each 30 ml serving of the concentrate contained 102 kcal, 24.5 g carbohydrate, 1.1 g protein, trace amounts of fat, 2.6 g fibre, 9.72 mg ascorbic acid, 408 μg β-carotene and trace amounts of sodium. The total anthocyanin content per serving was 273.5 mg. The predominant anthocyanins normally present in tart cherries are cyanidin derivatives with smaller amounts of peonidin-3-rutinoside. Other compounds typically present include hydroxycinnamic acids, flavonols and the indoleamine, melatonin [4, 19, 20]. The very distinctive taste of the cherry concentrate made it difficult to blind the study. The placebo beverage (Sprite®, The Coca-Cola Company) was chosen because it closely matched the energy and macronutrient composition of cherry juice (109 kcal, 26.4 g CHO, 0 g fat, 0.1 g sodium per 250 ml) and was devoid of plant compounds, antioxidants and vitamins.

Measurements Participants attended Sheffield Hallam University on two occasions for vascular measurements, anthropometric measurements and blood sampling. All these were taken in the early morning after an overnight fast. On both occasions, PWV, systolic blood pressure (SBP), diastolic blood pressure (DBP) and body weight were measured and a blood sample was taken. Height was also measured at the baseline visit. Measurements were taken after a 15 min rest in the supine position to allow time for BP, cardiac function and vasomotor tone to reach resting levels.

Brachial-knee PWV was measured in the supine position using a Nicolet Vasoguard Microlight system (VIASYS Healthcare, USA) as previously described [21]. BP and heart rate were measured in triplicate at 2.5 min intervals in the supine position using a semi-automated Accutorr Plus™ sphygmomanometer (Datascope®, USA). The first reading was disregarded to prevent readings being affected by the defence mechanism (the rise in BP associated with anxiety of measurement, that tends to subside with subsequent measurements) [22] and mean SBP, DBP and heart rate were calculated from the second and

third measurements. The Accutorr Plus™ sphygmomanometer was calibrated prior to the start of the study. The device meets the US Association for the Advancement of Medical Instrumentation and British Hypertension Society criteria for accuracy and has been recommended by the European Society of Hypertension [23].

Weight was measured to the nearest 0.1 kg using a SECA 709 mechanical column scale and height was measured to the nearest 0.1 cm with a SECA 220 telescopic measuring rod (SECA, Birmingham, UK).

Fasting capillary blood samples were collected for the determination of total cholesterol, high density lipoprotein (HDL) cholesterol, CRP and total antioxidant activity (ferric reducing ability of plasma; FRAP). Lipid variables were measured on a Reflotron Plus reflectance photometer (Roche Diagnostics Ltd, Burgess Hill, UK). For the analysis of total cholesterol a 30 µl sample of whole blood was collected into a capillary pipette and applied to a Reflotron reagent strip (Inverness Medical, Stockport, UK). The within day precision was 0.8% and the between day precision was 1.2%. For the determination of HDL, a 60 µl sample of whole blood was collected into an EDTA-potassium coated microcentrifuge tube (Sarstedt Ltd, Leicester, UK) and spun at 2000 g x 5 min. Plasma was then extracted and applied to a Reflotron HDL cholesterol strip (Inverness Medical, Stockport, UK) for immediate analysis. The within day precision was 7.0% and between day precision was 8.3%. A 250 µl whole blood sample was also collected into a lithium-heparin coated microcentrifuge tube (Sarstedt Ltd, Leicester, UK) and spun at 2000 **g** for 10 min at 4^{o}C to extract plasma. The plasma was divided into two aliquots. One aliquot was stored at -80^{o}C for the later analysis of CRP and the second aliquot was used for the immediate determination of plasma antioxidant activity (FRAP). FRAP was measured as described by Benzie and Strain [24] on a Cecil Series 1000 UV/Vis spectrophotometer (Cecile Instruments Ltd, Cambridge, UK). The intra-assay coefficient of variation (CV) was 1.4% and the inter-

assay CV was 4.2%. Plasma CRP was measured using a commercially available ELISA kit (MP Biomedicals UK, Cambridge, UK). The intra-assay CV was 11.5% and the inter-assay CV was 12.3%.

Statistical analysis For each variable, analysis was restricted to participants for whom baseline and end of study data were available (see Table 2 for *n* values). The effect of treatment on post-intervention measures was analysed by a one way ANCOVA, with adjustment for baseline [25]. The residuals from the model were tested for normality using the Shapiro-Wilk test and log transformation was used when there was deviation from normality. The criterion for significance was a $P<0.05$. All analyses were conducted using SPSS version 20.0 (SPSS UK Ltd. Woking, UK).

Results

Baseline characteristics, retention and compliance Anthropometric, biochemical and vascular measures were similar in randomisation groups at baseline (Table 1 & 2) and the groups were balanced for sex and age. One participant withdrew from the study because they did not like the taste of the cherry juice; all other participants completed the intervention without report of adverse effects. Compliance to the intervention was good with 97% of drinks consumed by the cherry juice group and 98% of drinks consumed by the placebo group.

Effect of intervention There was no significant difference between the groups for the primary outcome variable of PWV (Table 2). Cherry juice did not have any effect on CRP, SBP, DBP, total cholesterol or HDL cholesterol relative to the placebo drink (Table 2). Antioxidant status was significantly elevated at the end of the intervention in the cherry juice group compared to the placebo group ($P=0.012$). In comparison to the cherry juice group

there was a weak trend towards an increase in bodyweight in the placebo group (adjusted mean difference 0.69 (95% CI -0.07, 1.15) kg; *P*=0.073).

Discussion

There is some evidence from dietary observational studies that anthocyanin intake is associated with PWV – a large study of 1872 women from the TwinsUK registry reported that women with a high intake of dietary anthocyanins had lower PWV [14]. The present study was designed to test the hypothesis that short-term dietary intervention with anthocyanins supplied as tart cherry juice would reduce PWV and a range of other risk markers for CVD in healthy adults. To our knowledge no other study has investigated the effect of tart cherry juice on PWV. However, Dohadwala et al. [18] reported that a 4-week intervention with double strength cranberry juice (supplying 94 mg/d of anthocyanins) reduced carotid-femoral PWV (by approximately 0.5 m/s) in overweight adults with coronary artery disease. Despite providing approximately 3 times the quantity of anthocyanins to our participants we failed to observe a reduction in PWV. Differences in study design may explain this discrepancy. Dohadwala et al. [18] studied a group of overweight adults with elevated risk markers for cardiovascular disease, whereas our volunteers had a normal body mass index (BMI) (approx. 24 kg/m^2) and were seemingly healthy. It is possible that in healthy individuals, arterial stiffness is less responsive to a short-term increase in the intake of anthocyanins. Moreover we measured brachial-knee PWV, which because it includes segments of peripheral muscular arteries may be less amenable to dietary intervention than carotid-femoral PWV. It is also possible that constituents of cranberry juice other than anthocyanins may have driven the reduction in PWV observed by Dohadwala et al. [18]. The influence of supplementation with drinks rich in other polyphenolic compounds such as green tea (rich in flavanols) [26] and pomegranate juice (rich in elagitannins but also a source

of anthocyanins) have also shown no effect on arterial stiffness [21], whilst supplementation with isolated clover isoflavone over a 6-week period lowered PWV in postmenopausal women and older men [27].

Cherry juice appeared to have no influence on BP in our sample of apparently healthy middle-aged men and women. There are no directly comparable studies, and those testing purified anthocyanins and extracts/juices rich in anthocyanins are inconsistent. A 4-wk intervention with a twice-daily supplement of 320 mg of purified anthocyanins failed to alter BP in middle-aged men with raised baseline BP [28]. Similarly, in elderly women supplementation with an elderberry extract (500 mg/d of anthocyanins) for 12 weeks failed to alter BP [29]. However, Chong et al [30] suggested that chokeberries may have hypotensive effects based on a single intervention study in patients with cardiovascular disease.

We also observed no change in CRP as a result of cherry juice supplementation. CRP is a recognised biomarker of systemic inflammation and a risk marker for cardiovascular events [31]. This lack of effect on CRP contrasts with the studies of Kelley et al. [10, 11] who reported that 280 g/d of sweet cherries (supplying approx. 100 mg/d anthocyanins) reduced CRP by 8% after 2 weeks of supplementation and by 25% after four weeks of supplementation. Although these changes in CRP seem to indicate that sweet cherries elicit a reduction in inflammation, the study lacked a control group so interpretation must be cautious. Our results also contrast with studies demonstrating that tart cherry juice attenuates the inflammatory response to marathon running and resistance exercise [12, 13]. This discrepancy may be explained by differences in dosing schedule (1 serving/d v 2 servings/d) or indicate that in healthy adults, tart cherry juice attenuates the response to an inflammatory challenge, but does not modulate baseline levels of inflammation.

Cherry juice has potent antioxidant effects [4, 32]. At the end of the current intervention, plasma antioxidant status (measured by the FRAP assay) was modestly elevated

in the tart cherry group in comparison to the control group, however, this was largely driven by a fall in antioxidant status in the control group. This may reflect the displacement of antioxidant containing beverages by the placebo drink. The FRAP assay probably has limited sensitivity to detect an increase in antioxidant status in response to the tart cherry juice. The main determinants of plasma FRAP are uric acid, which may be lowered by cherries and ascorbate which is only present in low amounts in tart cherry juice [24, 33]. The contribution of polyphenols to plasma FRAP activity is likely to be low [24].

The inertia in response of total and HDL cholesterol concurs with one short-term intervention study using sweet cherries [10]. A lack of impact on blood lipids has also been noted in relation to diet intervention with other anthocyanin-rich berries [30].

The current study has several limitations. It would have been informative to have checked compliance to the intervention through measurement of plasma or urinary anthocyanins. As an adjunct to this, a detailed dietary record would have been informative as to any dietary displacement effects. We narrowly failed to meet our recruitment target of 25 participants in each arm. This slightly reduced the power of the study to identify a change in PWV. For CRP, the low sensitivity of the assay (CV 11.5%) may have masked a small anti-inflammatory effect. All biochemical measures were performed in capillary samples collected by finger prick. Limited blood volume meant that we failed to collect complete data for some analytes; this may have contributed to our null effect. It is also possible that our null effect arose because participants may have been too healthy to detect a beneficial effect of cherry juice. We cannot rule out the possibility that cherry juice may be more effective in individuals with existing hypertension or cardio-metabolic disease.

In conclusion our study provides no evidence that a short-term intervention with tart cherry juice reduces arterial stiffness or improves other markers of cardiovascular risk in

apparently healthy adults. Confirmation of this null effect is needed, perhaps using longer intervention periods and examining individuals at high risk of cardiovascular disease.

ACKNOWLEDGEMENTS

AL and MEB designed the study and wrote the manuscript. JR carried out the statistical analysis. SM, CTM, ER and VS were responsible for data collection. All authors read and approved the final manuscript. We thank Cherry Active, Sunbury UK for supplying the cherry juice. We are grateful to all our volunteers for their time and commitment.

The study was funded by Sheffield Hallam University and the University of Sheffield. The authors declare that they have no conflict of interest.

References

1. Huxley RR, Neil HA (2003) the relation between dietary flavonol intake and coronary heart disease mortality: a meta-analysis of prospective cohort studies. Eur J Clin Nutr 57: 904-908
2. Mink PJ, Scrafford CG, Barraj LM et al (2007) Flavonoid intake and cardiovascular disease mortality: a prospective study in post-menopausal women. Am J Clin Nutr 85: 895-909
3. Cassidy A, Mukamal KJ, Lui L et al (2013) High anthocyanin intake is associated with a reduced risk of myocradial infarction in young and middle-aged women. Circulation 127: 188-96
4. Kirakosyan A, Seymour EM, Llanes DE et al (2009) Chemical profile and antioxidant capacities of tart cherry products. Food Chem 115: 20-25
5. Yao LH, Jiang YM, Shi J et al (2004) Flavonoids in food and their health benefits. Plant Foods for Hum Nutr 59: 113–122

6. Wang H, Nair MG, Strasburg GM et al (1999) Antioxidant and antiinflammatory activities of anthocyanins and their aglycon, cyanidin, from tart cherries. J Nat Prod 62: 294-29
7. Seeram NP, Momin RA, Nair MG, Bourquin LD (2001) Cyclooxygenase inhibitory and antioxidant cyanidin glycosides in cherries and berries. Phytomedicine 8: 362–36
8. Xu JW, Ikeda K, Yamon Y (2004) Upregulation of endothelial nitric oxide synthase by cyanidin-3-glucoside, a typical anthocyanin pigment. Hypertension 44: 217-22
9. Saric A, Saobacanec S, Balog T et al. (2009) Improved antioxidant and anti-inflammatory potential in mice consuming sour cherry juice (Prunus Cerasus cv. Maraska). Plant Foods for Hum Nutr 64: 231-237
10. Kelley DS, Rasooly R, Jacob RA et al (2006) Consumption of Bing sweet cherries lowers circulating concentrations of inflammation markers in healthy men and women. J Nutr 136: 981-986
11. Kelley DS, Adkins Y, Reddy A et al (2013) Sweet Bing cherries lower circulating concentrations of markers for chronic inflammatory diseases in healthy humans. J Nutr 143: 340-344
12. Connolly DA, McHugh MP, Padilla-Zakour OI et al (2006) Efficacy of a tart cherry juice blend in preventing symptoms of muscle damage. B J Sports Med 40: 679-683
13. Howatson G, McHugh MP, Hill JA et al (2010) Influence of tart cherry juice on indices of recovery following marathon running. Scand J Med Sci Sports 20: 843-852
14. Jennings A, Welch AA, Fairweather-Tait SJ et al (2012) Higher anthocyanin intake is associated with lower arterial stiffness and central blood pressure in women. Am J Clin Nutr 96: 781-788

15. McEniery CM, Wallace S, Mackenzie IS et al (2006) Endothelial function is associated with pulse pressure, pulse wave velocity, and augmentation index in healthy humans. Hypertension 48: 602-8
16. Bell DR & Gochenaur K (2006) Direct vasoactive and vasoprotective properties of anthocyanin-rich extracts. J Appl Physiol 110: 1164-1170
17. Zhu Y, Xia M, Yang Y et al (2011) Purified anthocyanin supplementation improves endothelial function via NO-cGMP activation in hypercholesterolemic individuals. Clin Chem 57: 1524-1533
18. Dohadwala MM, Holbrook M, Hamburg NM et al (2011) Effects of cranberry juice consumption on vascular function in patients with coronary artery disease. Am J Clin Nutr 93: 934-940
19. Bonerz D, Wurth K, Dietrich H, Will F (2007) Anthocyanin characterisation and impact of ageing on anthocyanin composition and degradation in juices from five sour cherry cultivars. European Food Research and Technology 224: 355-364
20. Howatson G, Bell PG, Tallent J et al (2012) Effect of tart cherry juice (Prunus cerasus) on melatonin levels and enhanced sleep quality. Eur J Nutr 51: 909-916
21. Lynn A, Hamadeh H, Leung WC et al (2012) Effects of pomegranate juice supplementation on pulse wave velocity and blood pressure in healthy young and middle-aged men and women. Plant Foods Hum Nutr 67: 309-314
22. Naismith DJ & Braschi A (2003) The effect of low-dose potassium supplementation on blood pressure in apparently healthy volunteers. B J Nut 90: 53–6
23. O'Brien E, Waeber B, Parati G et al (2001) Blood pressure measuring devices: recommendations of the European Society of Hypertension. BMJ 322: 531-536.
24. Benzie IF & Strain JJ (1999) Ferric reducing/antioxidant power assay: direct measure of total antioxidant activity of biological fluids and modified version for simultaneous

measurement of total antioxidant power and ascorbic acid concentration. Methods Enzymol 299: 15-27

25. Vickers AJ, Altman DJ (2001) Analysing controlled trials with baseline and follow up measurements. BMJ 323: 1123–1124
26. Ryu OH, Lee J, Lee KW et al (2006) Effects of green tea consumption on inflammation, insulin resistance and pulse wave velocity in type 2 diabetes patients. Diabetes Res Clin Pract 71:356-8
27. Teede HJ, McGrath BP, DeSilva L et al (2003) Isoflavones reduce arterial stiffness: A placebo-controlled study in men and postmenopausal women. Arterioscler Thromb Vasc Biol 23:1066-71
28. Hasselhund SS, Flaa A, Sandvik L et al (2012) Effects of anthocyanins on blood pressure and stress reactivity: a double-blind randomized placebo-controlled crossover study. J Hum Hypertens 26: 396-404
29. Curtis PJ, Kroon PA, Hollands WJ et al (2009) Cardiovascular disease risk biomarkers and liver and kidney function are not altered in postmenopausal women after ingesting an elderberry extract rich in anthocyanins for 12 Weeks. J. Nutr 139: 2266–2271
30. Chong MFF, MacDonald R, Lovegrove JA (2010) Fruit polyphenols and CVD risk: a review of human intervention studies. B J Nutr 104: S28-S39
31. Ridker PM, Hennekens CH,Buring JE, Rifai N (2000) C-reactive protein and other markers of inflammation in the prediction of cardiovascular disease in women, N Eng J Med 342: 836-842
32. Damar I, Eksi A (2012) Antioxidant capacity and anthocyanin profile of sour cherry (Prunus cerasus L.) juice. Food Chem 135: 2910-2914
33. Jacob RA, Spinozzi GM, Simon VA et al. (2003) Consumption of cherries lowers plasma urate in healthy women. J. Nutr. 133: 1826–1829

Table 1 Participant characteristics according to randomisation group at study inclusion (means and SDs)

	Cherry juice (n=25)	Placebo (n=21)
Age (years)	38.3 (6.16)	37.2 (5.78)
Weight (kg)	70.4 (12.75)	69.2 (14.55)
BMI (kg/m^2)	24.6 (3.63)	23.5 (3.00)
Sex (Female/Male)	16/9	13/8

Table 2 Change in outcome variables in the tart cherry juice and control groups over the 6 week intervention period

	Cherry juice		Placebo		Adjusted	
	Baseline (mean (SD))	End (mean (SD))	Baseline (mean (SD))	End (mean (SD))	difference# (95% CI)	
PWV (m/s)	8.22 (1.69)	8.18 (1.60)	7.98 (1.21)	7.74 (1.06)	0.243	*F* (1, 43) =1.564
n	25		21		(-0.149, 0.634)	*P*= 0.218

hsCRP (mg/L)*	1.13 (0.92, 1.38)	1.13 (0.93, 1.03)	1.14 (0.91, 1.43)	1.26 (1.01, 1.59)	-10%**	*F* (1, 36) = 1.559
n	22		17		(-14%, 7%)	*P* = 0.220
SBP (mm Hg)	110.5 (14.38)	110.2 (12.58)	110.43 (12.28)	113.36 (11.88)	-3.21	F (1, 43) = 2.019
n	25		21		(-7.763, 1.346)	*P* = 0.163
DBP (mm Hg)	70.3 (10.04)	69.2 (9.86)	67.4 (8.28)	69.9 (7.62)	-2.814	F (1, 43) = 2.496
n	25		21		(-6.406, 0.778)	*P* = 0.121
Cholesterol (mmol/L)						
Total	4.25 (0.79)	4.22 (0.77)	3.76 (0.67)	4.12 (0.67)	-0.183	F (1, 40) = 0.926
n	24		19		(-0.569, 0.202)	*P* = 0.342
HDL*	0.96 (0.87, 1.05)	1.09 (1.02, 1.16)	1.37 (0.92, 1.15)	1.04 (0.97, 1.11)	7%**	*F* (1, 36) = 2.436
n	22		17		(-2%, 16%)	*P* = 0.127
FRAP (µM)	1205 (339.45)	1294 (269.03)	1298 (323.05)	1165 (255.55)	173.58	*F* (1, 39) = 6.909
n	23		19		(40.002, 307.159)	*P* = 0.012

[#]Effect of intervention was assessed by ANCOVA adjusted for baseline. *Data was log transformed prior to analysis so baseline and end of study data is expressed as geometric mean and 95% CI. **Adjusted mean difference for log transformed data is expressed as a percentage (Bland 2000).