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Effect of an avocado oil-rich diet over an angiotensin II-induced blood pressure response

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Abstract

We studied the effect of an avocado oil-rich diet on (1) the blood pressure response to angiotensin II (AngII) and (2) the fatty acid composition of cardiac and renal membranes on male Wistar rats. The avocado oil-rich diet induced a slightly higher AngII-induced blood pressure response in the rats as compared to the control rats. In cardiac microsomes, avocado oil induced an increase in oleic acid content ($13.18 \pm 0.33\%$ versus $15.46 \pm 0.59\%$), while in renal microsomes, the oil decreased α-linolenic acid content ($0.34 \pm 0.02\%$ versus $0.16 \pm 0.12\%$), but increased the arachidonic acid proportion ($24.02 \pm 0.54\%$ versus $26.25 \pm 0.54\%$), compared to control. In conclusion, avocado oil-rich diet modifies the fatty acid content in cardiac and renal membranes in a tissue-specific manner. The rise in renal arachidonic acid suggests that diet content can be a key factor in vascular responses.

Keywords: Avocado oil; Blood pressure; Membrane fatty acid composition; Arachidonic acid; Angiotensin II

1. Introduction

Persea americana Miller (Lauraceae) or avocado, native to Mexico, is valued due to its nutritional and therapeutic qualities. Avocado fruit and leaves have been used in Mexican folk medicine to treat a wide variety of diseases. Francisco Hernández reported as early as the XVI century, that oil obtained from pressing the seed was useful in the treatment of rashes and scars, had an astringent effect, and could also be used to treat dysentery (Argueta-Villamar et al., 1994). Hot water infusion from the leaves can be taken as an emmenagogue, diuretic, to treat coughs and colds, and diarrhea. An important use of avocado leaves is to treat hypertension, which is not used exclusively by Mexican populations, but people in countries like Brazil, Indonesia, Jamaica, Nigeria and Panama also use it for the same therapeutic benefits (Ross, 1999; Adeboye et al., 1999).

Recent studies carried out among Mexican populations that consume avocados have shown that the avocado decreases serum total cholesterol, LDL-cholesterol and triglycerides, and increases HDL-cholesterol levels compared to the control diet (Alvizouri-Munoz et al., 1992; Lopez-Ledesma et al., 1996).

The consumption of oil from different sources exerts different effects over the lipid composition of the cellular membranes and their function. Therefore, we studied the effect of a diet rich in avocado oil and a control diet, on the blood pressure response to angiotensin II (AngII). In addition, we evaluated the effect of an avocado oil diet on fatty acid composition of cardiac and renal membranes in order to correlate biochemical changes and physiological responses.

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2. Materials and methods

2.1. Experimental animals

Male Wistar rats (230–250 g), bred and raised in our facilities, were placed into metabolic cages 3 days prior to the beginning of the protocol, offered tap water and lab chow ad libitum, and maintained on a 12-h light:12-h dark cycle in a temperature-controlled room. Animals were randomly divided into two experimental groups of five rats each. The control group received lab chow, while the treated group received a 10% (w/w) avocado oil-rich diet for a 2-week period. At the end of the treatment, the rats were anaesthetized with sodium pentobarbital (50 mg/kg, i.p.) and were either prepared for blood pressure measurement, or the heart and kidneys were removed. All procedures were conducted in accordance with Institutional ethical guidelines.

2.2. Diet preparation

The avocado-enriched diet was prepared in bulk in our laboratory by mixing ground lab chow with avocado oil obtained from fresh fruit (10%, w/w). Both the control diet (ground lab chow) and avocado oil-rich diet were partitioned into daily rations packaged in plastic bags, and flushed with nitrogen to minimize oxidation and stored at 4 °C.

2.3. Fatty acid methyl esters analysis

Cardiac and renal microsomes were obtained as described by Garg and co-workers (1988) in a homogenizing buffer containing: 250 mM sucrose, 0.1 mM etilenediamino tetraacetic acid (EDTA), 62 mM potassium phosphate, 150 mM potassium chloride, 5 mM magnesium chloride, and 1 mM dithiothreitol (DTT), at pH 7.4. The microsomes, containing butylated hydroxy toluene (BHT, 0.02%), were stored at −70 °C until processed. The lipids were extracted as described by Folch et al. (1957). The lipid extracts were trans-esterified to their fatty acid methyl esters as described by Christie (1989), separated and identified by gas–liquid chromatography in a Carlo Erba Fratovap 2300 chromatograph, fitted with a 25 m × 0.25 mm i.d. fussed-silica capillary column, coated with CP-Sil 88 (film thickness, 0.25 μm). The analysis was carried out at an isotherm temperature of 195 °C, using helium gas as a carrier at a flow rate of 1 ml/min.

2.4. Angiotensin II-induced increase of blood pressure

At the end of the 2-week treatment, both control rats and rats fed with avocado oil-rich diet were anaesthetized and we performed intra-artery measurement of the blood pressure as described by Adeboye et al. (1999). AngII (100, 300, and 1000 ng/kg, i.v.) was administered and the basal- and AngII-induced blood pressure changes were measured with a Blood Pressure monitor (BP Monitor, WPI, USA).

2.5. Statistical analysis

Data were expressed as mean ± S.E.M. Statistical evaluation of the data was performed using Student's *t*-test for unpaired comparisons; $p < 0.05$ was considered statistically significant.

3. Results

3.1. Effect on body weight

Two weeks of an avocado oil-rich diet had no significant influence on the rat's body weight. Body weight of control rats was 247.5 ± 1.4 g, while in the avocado oil-rich diet was 249.1 ± 1.7 g.

3.2. Effect on AngII-induced change in blood pressure

Basal systolic blood pressure for control and avocado oil-rich diet rats was: 95 ± 3.1 and 97 ± 2.6 mmHg, respectively. The administration of AngII (100, 300, and 1000 ng/kg, i.v.) induced an increase in blood pressure in both control rats and rats fed with avocado oil-rich diet; however, this increment was slightly higher in the rats fed with avocado oil-rich diet, as compared to the control rats (Fig. 1).

3.3. Effect on fatty acid composition

Avocado oil-rich diet induced an increase in oleic acid proportion in cardiac microsomes (15.46 ± 0.5% of total) compared to those from control rats (13.18 ± 0.3%, $p < 0.05$). In renal microsomes, avocado oil-rich diet elicited a decrease in α-linolenic acid (0.34 ± 0.02 and 0.16 ± 0.12% of total, for control and avocado oil-treated rats, respectively, $p < 0.05$); as well as an increase in arachidonic acid proportion: for control,

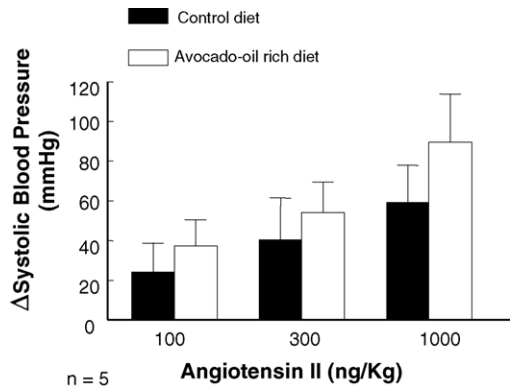

Fig. 1. Effect of angiotensin II-stimulation on blood pressure response in rats fed a control and avocado oil-rich diet. AngII (100, 300, and 1000 ng/kg, i.v.) was administered to rats fed control diet (■), and avocado oil-rich diet (10%, w/w, □) for 2 weeks. The bars represent the mean ± S.E. of five different experiments.

Table 1
Effect of an avocado oil-rich diet over the fatty acid composition of cardiac and renal microsomes

Fatty acid	Heart		Kidney	
	Control (% of total)	Avocado oil (% of total)	Control (% of total)	Avocado oil (% of total)
Palmitic	19.36 ± 0.11	18.54 ± 0.44	26.55 ± 0.48	25.27 ± 0.44
Palmitoleic	1.41 ± 0.38	1.83 ± 0.61	1.40 ± 0.20	1.03 ± 0.16
Margaric	0.95 ± 0.29	0.46 ± 0.04	0.29 ± 0.10	0.51 ± 0.05
Stearic	23.90 ± 1.09	23.62 ± 0.62	18.25 ± 0.58	19.53 ± 0.23
Oleic	13.18 ± 0.33	15.46 ± 0.59*	13.61 ± 0.68	11.77 ± 0.80
Linoleic	14.56 ± 0.28	12.79 ± 0.71	10.42 ± 0.23	10.92 ± 0.36
Gamma-linolenic	2.48 ± 1.44	0.86 ± 0.14	1.52 ± 0.18	0.86 ± 0.26
Alfa-linolenic	0.43 ± 0.01	0.83 ± 0.32	0.34 ± 0.02	0.16 ± 0.12*
Eicosanoic	1.26 ± 0.45	1.05 ± 0.26	0.95 ± 0.02	0.92 ± 0.06
Di-homo-gamma-linolenic	0.45 ± 0.04	0.41 ± 0.03	0.94 ± 0.07	0.93 ± 0.03
Arachidonic	19.08 ± 1.08	20.98 ± 0.95	24.02 ± 0.54	26.25 ± 0.54*
Eicosapentaenoic	0.33 ± 0.01	0.29 ± 0.03	0.81 ± 0.04	0.86 ± 0.25
Docosa-pentaenoic	0.29 ± 0.1	0.31 ± 0.1	0.13 ± 0.03	0.17 ± 0.06
Docosa-hexaenoic	2.11 ± 0.25	2.48 ± 0.13	0.47 ± 0.04	0.53 ± 0.11

The data represent the mean ± S.E. of five different experiments.
* $p < 0.05$.

24.02 ± 0.5%, and for avocado oil-treated rats, 26.25 ± 0.5%; $p < 0.05$ (Table 1).

4. Discussion and conclusions

In this present study, we found that an avocado oil-rich diet administered for 2 weeks to Wistar rat, induced a higher AngII-induced blood pressure response, and modified the fatty acid composition of cardiac and renal microsomes.

The fatty acid composition of cardiac membranes is sensitive to modification through dietary factors (Pepe and McLennan, 2002). It has been reported that the level and nature of polyunsaturated fatty acids (PUFA) incorporated in cardiac membranes is related to the dietary *n*-3 PUFA. In their data, Sergiel et al. (1998) reported that rats given a diet rich in docosahexaenoic acid (DHA) had a decrease in the arachidonic acid content of the cardiac membranes, and that DHA constituted almost the only membrane *n*-3 PUFA, suggesting a very low level of retroconversion. Our data show that avocado oil induces an increase in the proportion of oleic acid in the heart microsomes and thus can modify the structure and function of the membrane, including the biosynthesis of prostaglandins involved in the regulation of the vascular function. Indeed, oleic acid has been shown to exert a pressor effect in rats, when administered intravenously (Grekin et al., 1995). However, this pattern is different in renal microsomes, where we found not only a lack of differences in oleic acid content, but a decrease in α-linolenic acid and an increase in arachidonic acid content. The tendency to a higher increase in Ang II-induced blood pressure may be partially explained by these renal modifications. It has been reported that enhanced dietary intake of α-linolenic acid decreased blood pressure in spontaneously hypertensive rats and increased prostaglandin formation (Rupp et al., 1996).

Upon AngII-stimulation, AA is released from the membrane phospholipids and metabolized in a cell/tissue-specific manner (Croft et al., 2000). Since the avocado oil-rich diet increased the renal content of AA, and we observed a higher increase in AngII-induced blood pressure, it is possible to postulate that the production of metabolites with vasoconstrictor properties is increased.

The use of avocado (fresh fruit and leaves) in folk medicine has shown to be effective. However, our results show that the favorable effects for the cardiovascular system cannot be attributed to the components of the oil and suggests that other active substances present in fresh fruit and leaves may be responsible. Further studies are required to establish the ratio of hypocholesterolemic/cardiovascular benefits, when avocado oil is consumed as well as the component(s) responsible. In conclusion, avocado oil-rich diet modifies the fatty acid content in cardiac and renal membranes in a tissue-specific manner. The rise in renal AA content suggests that diet is a key factor in vascular responses.

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