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Diet with isolated soy protein reduces oxidative stress and preserves ventricular function in rats with myocardial infarction

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Abstract We investigated the effects of an isolated soy protein (ISP) diet offered over a 9-week period to rats in whom myocardial infarction (MI) had been induced, and a casein diet given as a control. Male Wistar rats were assigned to six groups after infarct size determination ($n = 8$/group): Sham Casein (SC); Infarct Casein $< 25\%$ (IC $< 25\%$); Infarct Casein $> 25\%$ (IC $> 25\%$); Sham Soy (SS); Infarct Soy $< 25\%$ (IS $< 25\%$); and Infarct Soy $> 25\%$ (IS $> 25\%$). MI surgery was performed at the fifth week, and one month later, the animals were hemodynamically assessed to evaluate left ventricular systolic pressure (LVSP), left ventricular end diastolic pressure (LVEDP), contractility and relaxation indexes ($\pm dP/dt$). Lung and liver specimens were also collected for the estimation of organ congestion. Oxidative stress was evaluated in heart homogenates through chemiluminescence (CL), carbonyl groups, and antioxidant enzyme activities of superoxide dismutase (SOD), catalase (CAT), and glutathione peroxidase (GPx). Infarcted groups treated with casein showed cardiac hypertrophy, lung and liver congestion, increased LVEDP and decreased LVSP and $\pm$dP/dt, all typical signals of heart failure. Ventricular dysfunction was correlated with increased myocardial oxidative damage as seen by CL and carbonyl groups data in the groups IC $< 25\%$ and IC $> 25\%$ (3 and 10-fold increase, respectively). The ISP diet was able to improve ventricular

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systolic and diastolic function in the groups IS < 25% and IS > 25% (LVEDP was reduced by 44% and 24%, respectively) and to decrease myocardial oxidative stress. The overall results confirm the preventive role of soy-derived products in terms of post-MI myocardial dysfunction probably by an antioxidant action.

Introduction

Coronary heart disease (CHD) is the leading cause of mortality in the industrialized world, causing over 40% of all deaths in the United States and Western Europe [1]. In the past 30 years, numerous studies have shown that soy consumption improves the plasmatic lipid profile and have suggested that soy components may protect against CHD [2—4]. Well-documented experimental studies have shown beneficial effects of soy in serum lipids, including reduction of low-density lipoprotein (LDL), cholesterol and triglycerides [3], and increased resistance to LDL oxidation [5]. Conversely, other studies found that soy protein had no effect on serum lipid concentrations [6]. Conflicting results may be due to subject selection, varied doses of soy protein and hormonal changes.

The Food and Drug Administration (FDA) in the USA recently approved a health claim for soy since laboratory investigations, clinical trials and epidemiological data indicate that high soy consumption (at least 25 g per day), with low saturated fat intake, reduces the risk of CHD [7]. Soy products, as isolated soy protein (ISP), contain a significant amount of isoflavones, such as genistein and daidzein. Previous studies have indicated that isoflavones exhibit free radical-scavenging action [8].

There is increasing evidence that oxidative stress plays a major role in the development and progression of left ventricular (LV) remodeling and failure after myocardial infarction (MI). The degree of oxidative stress and the severity of the subsequent myocardial damage might depend on the imbalance between excessive production of reactive oxygen species (ROS) and the antioxidant defense within the heart. Increased ROS production can result in myocyte hypertrophy, apoptosis and interstitial fibrosis, which may contribute to depressed cardiac function and heart failure development [9]. Khaper et al. [10] have demonstrated decreased SOD expression in the infarcted rat heart. Other antioxidant defenses, catalase and glutathione peroxidase, were likewise reduced in experimental MI [11].

Since soy is a rich source of antioxidants [8], and oxidative stress is enhanced in the heart after myocardial infarction [11], a soy-enriched diet offered to rats could help to preserve their heart function after myocardial ischemia. This study was designed to test this hypothesis.

Material and methods

Animals and experimental groups

The experimental protocol was in accordance with the Guide for Care and Use of Laboratory Animals (NIH Publication No. 85-23, revised 1996). Twenty one day old male Wistar rats were obtained from the Central Animal House of the Federal University of Rio Grande do Sul. Housed in metabolic cages (one animal each), they received food *ad libitum* and were maintained under standard laboratory conditions (controlled temperature of 21 °C, and 12 h light/dark cycle). The animals were maintained on a specific diet (with ISP or casein as a protein source) for nine weeks and they were weighed weekly. Food intake was measured three times a week.

Diet

Diet composition was formulated according to the specifications of the AIN-93G [12] and contained similar amounts of protein, fat, carbohydrates, minerals and vitamins, except for the protein source: casein or ISP (Samprosoy 90LH — a concentrated product containing 92% protein) which was a gift from Bunge Alimentos (now The Solae Company) (Table 1). The isoflavones content in ISP (analysis was performed at the Physical Chemistry Laboratory of the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Paraná, Brazil) was reported to be 189 mg/100 g of ISP; 67% of the isoflavones were in the aglycone form that is more easily absorbed.

Surgical procedure

Five weeks after the beginning of diet treatment, myocardial infarction (MI) was induced by the occlusion of the left

Table 1 Diets composition

Ingredients	Casein (g/kg)	Isolated soy protein (g/kg)
Casein (86.7% protein)[a]	211	—
Isolated soy protein (92% protein)[a]	—	206
Cornstarch	520	527.5
Sucrose	100	100
Soybean oil	70	70
Fiber	50	50
Mineral mixture (AIN-93G-MX)	35	35
Vitamin mixture (AIN-93-VX)	10	10
L-Methionine	1.5	1.5
Choline bitartrate	2.5	2.5
Tert-butyl hydroquinone (TBHQ)	0.014	0.014

Diets compositions were measured in grams per kilograms, based on AIN-93G diet [12].

[a] Content analysis was performed at the Physical Chemistry Laboratory of the Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Paraná, Brazil.

coronary artery according to a technique described previously [13]. The animals were submitted to a surgical procedure of ligature of the descending anterior branches of the left coronary artery, or to a sham operation in which all surgical procedures were performed except the suture around the coronary artery.

Hemodynamic assessment

Four weeks after surgery, the animals were weighed and anesthetized with ketamine (90 mg/kg i.p.) and xylazine (10 mg/kg i.p.). A polyethylene catheter (PE 50), connected to a pressure transducer (Strain-Gauge-Narco Biosystem Transducer RP-155, Houston, Texas, USA) and coupled to a signal amplifier (Pressure Amplifier HP 8805C), was inserted into the right carotid artery and then advanced into the left ventricle cavity. Left ventricular end diastolic pressure (LVEDP), left ventricular systolic pressure (LVSP), contractility index ($+dP/dt$) and relaxation index ($-dP/dt$) were recorded using an automatic acquisition system (AT/MCA CODAS, DATAQ Instruments, Inc., Akron, Ohio, USA), with a sampling frequency of 2 kHz.

Determination of infarct size

At the end of the hemodynamic measurements, the animals were sacrificed by decapitation and the hearts were rapidly excised. After blood washout, the ventricular chambers were dissected, blotted and weighed. The presence of infarction was easily confirmed by gross visualization of the fibrous scar on the anterolateral region of the left ventricle. Since the heart was used for biochemical analysis, the infarct size was determined by planimetry. The scar tissue was separated from the remaining left ventricular myocardium in the infarcted heart under a microscope. Both fragments were blotted and their outlines were drawn on graph paper to estimate the respective areas. Infarct size was calculated and reported as a percentage of the ventricular endocardial area covered with scar tissue [14].

After infarct size analysis, the animals were assigned into six groups: sham-operated, fed with casein (SC); infarct size less than 25%, fed with casein (IC $<$ 25%); infarct size larger than 25%, fed with casein (IC $>$ 25%); sham-operated, fed with ISP (SS); infarct size less than 25%, fed with ISP (IS $<$ 25%); and infarct size larger than 25%, fed with ISP (IS $>$ 25%).

Morphometric evaluation

After hemodynamic recordings, the animals were weighed and measured by the naso-anal length to determine the Lee index, an easy method to determine obesity and to evaluate the nutritive status [15]. The Lee index is calculated by dividing the cube root of the body weight by the naso-anal length. A value of about 0.300 is considered normal. Immediately after the sacrifice, the heart, lungs and livers were rapidly excised, freed from adhering tissues and weighed. The right and left ventricles (plus septum) were dissected and weighed. Ventricular hypertrophy was evaluated by the chamber weight to body weight ratio. Pulmonary and liver congestions were estimated by the wet weight/body weight ratio [16].

Tissue preparation

Tissue from both the ventricles (including the scar) was homogenized as described by Llesuy et al. [17] and was frozen at $-80\,^{\circ}C$, for further evaluations.

Carbonyl assay

Carbonyl assay was performed using the method of Reznick and Packer [18] and data were expressed as nanomoles per milligram of protein of the homogenates.

Tert-butyl hydroperoxide-initiated chemiluminescence

Chemiluminescence (CL) was measured using the method of Gonzalez-Flecha et al. [19] and data were expressed as counts per second per milligram of protein of the homogenates (cps/mg protein).

Antioxidant enzyme activities

Superoxide dismutase (SOD) activity, expressed as units per milligram of protein, was measured using the method of Marklund [20]. Catalase (CAT) activity was determined using the method of Aebi [21] and expressed as picomoles of H_2O_2 reduced per minute per milligram of protein. Glutathione peroxidase (GPx) activity expressed as nanomoles of peroxide/hydroperoxide reduced per minute per milligram of protein was measured as described by Flohé and Gunzler [22].

Protein determination

Protein was measured using the method of Lowry et al. [23].

Statistical analysis

Data were expressed as mean $\pm$ standard deviation (SD) and were compared by one-way analysis of variance. The Student—Newman—Keuls post-hoc test was used to determine significant differences among individual groups. Mortality rate was evaluated by the chi-square test. The correlation between two variables was analyzed by Pearson's correlation. Values of $P < 0.05$ were considered significant. The GraphPad InStat 3.0 software (San Diego, California, USA) was used.

Results

The mean daily food intake of the group on the casein diet during the 9-week experimental period was 20.5 g/day while it was 18 g/day in the ISP diet group. Considering mean values of food intake during the treatment, the animals on the ISP diet received about 7 mg of isoflavones/day.

A total of 158 rats were used in this study: 69 receiving the ISP diet (31 sham and 38 MI) and 89 receiving the casein diet (31 sham and 58 MI). The mortality rate due to myocardial infarction was 49% in the casein group and 33% in the ISP group. However, the overall mortality was similar in the two diet groups ($X^2 = 1.86$; $P = 0.17$). Also,

the log-rank test showed that there was no difference between the survival curves in the two groups ($P = 0.316$).

After isolation of the scar from the heart tissue, it was observed that the infarct size areas varied from 8% to 46% of the left ventricle (LV) mass. The median of the infarct size areas was 25% of the LV surface. Accordingly, infarcted animals were subdivided into two groups: less than 25% of infarct size ($n = 8$ for the ISP group and $n = 16$ for the casein group) and more than 25% of infarct size ($n = 12$ for the ISP group and $n = 9$ for the casein group). Therefore, the lowest number of animals in each of the six groups was eight.

Morphometric analysis

Table 2 shows morphometric indexes of the six groups. The Lee index was similar in the six groups. The lung to body weight ratio increased significantly in the groups IC < 25% and IC > 25%, suggesting the development of lung edema. Liver congestion was also observed in the casein diet animals and was prevented (IS < 25%), and attenuated significantly in the group IS > 25% compared to their respective controls. Cardiac hypertrophy was observed in both infarcted groups on the casein diet. In the group fed with ISP, rats presenting small infarcts (IS < 25%) did not develop cardiac hypertrophy, which only appeared in the group with large infarcts (IS > 25%).

Hemodynamic parameters

Table 2 depicts the hemodynamic values recorded in anesthetized animals. Typical signals of heart failure (increase in the LVEDP and decrease of $\pm dP/dt$ max, as well as a decrease in arterial pressure) were observed in the infarcted animals on the casein diet, mainly in the IC > 25% group. Thus, LVEDP increased by 174% and 286% in the groups IC < 25% and IC > 25%, respectively, compared to the SC group. The hemodynamic impairment of left ventricle diastolic and systolic functions was significantly attenuated in the infarcted groups fed with soy protein. In the groups IS < 25% and IS > 25%, LVEDP increased by 70% and 225%, respectively, compared to its respective control. These values were 104% and 61% smaller than those measured in the casein groups. The contractility index ($+dP/dt$ max) was decreased by 22% in the group IC > 25% and only by 9% in the group IS > 25% compared to their respective controls. The decrease in the relaxation index ($-dP/dt$ max) was by 16% in the group IC > 25% and only by 6.4% in the group IS > 25% compared to their respective controls.

Myocardial oxidative stress

In terms of enzymatic antioxidant defense, it is noteworthy that it increased significantly in the uninfarcted rats fed with ISP (SS). In this group, SOD activity increased by 72%, and both CAT and GPx by 24% compared to the SC group (Table 3). MI decreased the activity of these enzymes. SOD activity in the groups IS < 25% and IS > 25% was higher (96% and 61%, respectively) than the IC < 25% and IC > 25% groups. Similar results were observed in relation to CAT activity since it increased by 43% and 39% respectively in the soy infarcted groups as compared to the casein ones. GPx activity increased by 12% and 25% respectively in the soy infarcted groups compared to the casein ones.

A huge enhancement of protein oxidative damage, evaluated by the concentration of carbonyls, was observed

Table 2 Morphometric and hemodynamic parameters of the experimental groups after 9 weeks of treatment

Parameter	SC	IC < 25%	IC > 25%	SS	IS < 25%	IS > 25%
Body weight gain (g)	282 ± 11	264 ± 16	257 ± 6.6[a]	248 ± 11[a]	247 ± 5.0[a]	232 ± 8.0[a]
Heart weight/BW × 10^3 (mg/g)	2.8 ± 0.3	3.3 ± 0.33[b]	3.3 ± 0.11[b]	2.8 ± 0.2	2.9 ± 0.13[c]	3.4 ± 0.3[d]
Lee index	0.29 ± 0.001	0.29 ± 0.001	0.29 ± 0.001	0.29 ± 0.001	0.29 ± 0.001	0.29 ± 0.001
Lung wet weight/BW (mg/g)	6.6 ± 1.3	8.2 ± 0.7[e]	11.6 ± 2.6[f]	6.01 ± 0.6	5.9 ± 0.8[c,e]	6.9 ± 0.6[e]
Liver wet weight/BW mg/g)	31.4 ± 2.2	36.3 ± 3.2[f]	37.7 ± 0.6[f]	31.6 ± 1.4	32.7 ± 1.2[c,e]	35.2 ± 1.0[g]
LVSP (mmHg)	148 ± 7.3	116 ± 9.9[a]	90 ± 7.8[a,b]	142 ± 7.5	128 ± 7.9[a,c]	110 ± 4.8[c,d,f]
LVEDP (mmHg)	5.7 ± 0.6	15.6 ± 0.5[a]	22.0 ± 0.9[a,h]	5.1 ± 0.5	8.7 ± 1.2[f,h]	16.6 ± 1.2[c,d,f]
$+dP/dt$ (mmHg/s)	7181 ± 687	6061 ± 267[a]	5611 ± 751[a,h]	7186 ± 493	7013 ± 141[i]	6570 ± 276[h]
$-dP/dt$ (mmHg/s)	−5610 ± 254	−5009 ± 103[a]	−4693 ± 99[a]	−5433 ± 344	−5253 ± 196	−5085 ± 125[f,h]
MAP (mmHg)	121 ± 13	104 ± 12[h]	86 ± 9[a,f]	122 ± 8	106 ± 4[f,i]	96 ± 8[i]

Data expressed as mean ± SD of eight animals/group. BW, body weight; LVEDP, left ventricular end diastolic pressure (mmHg); LVSP, left ventricular systolic pressure (mmHg); $\pm dP/dt$, derivative of left ventricular pressure (mmHg/s); MAP, mean aortic pressure (mmHg). Sham Casein (SC), sham-operated, fed with casein; Infarct Casein < 25% (IC < 25%), infarct size less than 25%, fed with casein; Infarct Casein > 25% (IC > 25%), infarct size greater than 25%, fed with casein; Sham Soy (SS), sham-operated, fed with ISP; Infarct Soy < 25% (IS < 25%), infarct size less than 25%, fed with ISP; and Infarct Soy > 25% (IS > 25%), infarct size greater than 25%, fed with ISP.

[a] Different from SC ($P < 0.01$).
[b] Different from IC < 25% ($P < 0.001$).
[c] Different from SS ($P < 0.05$).
[d] Different from IC > 25% ($P < 0.001$).
[e] Different from IS < 25% ($P < 0.001$).
[f] Different from IC < 25% ($P < 0.05$).
[g] Different from IC > 25% ($P < 0.05$).
[h] Different from SC ($P < 0.05$).
[i] Different from SS ($P < 0.01$).

Table 3 Antioxidant enzyme activities of SOD, CAT and GPx in cardiac muscle homogenates from the different groups after 9 weeks of diet treatment

Parameter	SC	IC < 25%	IC > 25%	SS	IS < 25%	IS > 25%
SOD (U/mg prot)	22.6 ± 3.0	13.7 ± 3.1[a]	12.8 ± 1.1[a]	38.9 ± 3.8[a]	26.9 ± 2.4[b]	20.6 ± 2.3[c,d]
CAT (pmol/mg prot)	76.6 ± 7.6	52.3 ± 6.7[a]	37.4 ± 5.7[a]	94.7 ± 11.4[a]	75.1 ± 4.7[b]	51.9 ± 4.0[c,d,e,f]
GPx (nmol/min/mg prot)	14.6 ± 2.3	11.1 ± 1.8[a]	7.5 ± 1.7[a,g]	18.1 ± 1.9[a]	12.4 ± 1.2[f]	9.4 ± 1.7[f,h]

Data expressed as mean ± SD of 6–8 animals/group. The legends groups are in Table 2.
[a] Different from SC ($P < 0.001$).
[b] Different from SS and IC < 25% ($P < 0.001$).
[c] Different from SS and IC > 25% ($P < 0.001$).
[d] Different from IS < 25% ($P < 0.01$).
[e] Different from IC > 25% ($P < 0.01$).
[f] Different from SS ($P < 0.001$).
[g] Different from IC < 25% ($P < 0.01$).
[h] Different from IS < 25% ($P < 0.05$).

in the casein groups with large infarcts (Fig. 1A). This increase, however, was importantly attenuated in the infarcted group fed with ISP (IS > 25%) compared to the casein fed rats (IC > 25%). No significant difference was found in this parameter in the groups with small infarcts compared to their controls.

Lipid peroxidation (LPO), estimated by tert-butyl-initiated chemiluminescence (CL), was significantly reduced in the group of sham-operated animals fed with ISP (4.600 ± 900 cps/mg protein) compared to the controls (SC group = 5.900 ± 700 cps/mg protein; $P < 0.001$). CL increased significantly in both diet groups as the infarct size increased. However, CL was significantly attenuated in the infarcted rats fed with ISP (Fig. 1B). Thus, LPO was increased by 149% in the group IC > 25% compared to SC, and only by 54% in the group IS > 25% when compared to SS. LVEDP was positively correlated with CL in casein fed animals ($r = 0.95$; $P = 0.04$). This correlation, however, was not significant in the animals fed with ISP. LVEDP was also positively correlated with carbonyl groups ($r = 0.89$; $P = 0.01$) in both casein and ISP fed animals and negatively correlated with catalase activity ($r = -0.97$; $P = 0.001$) and GPx activity ($r = -0.93$; $P = 0.007$). In Fig. 2, we individually plotted catalase as a biochemical parameter (Fig. 2A), and one hemodynamic parameter, LVEDP (Fig. 2B) as a function of infarct size in the individual animals. It can be seen that soy treated animals scored better in terms of catalase regardless of the infarct size area. In terms of LVEDP, the beneficial effect of soy treatment only appeared in infarcted animals, preventing a more pronounced ventricular dysfunction.

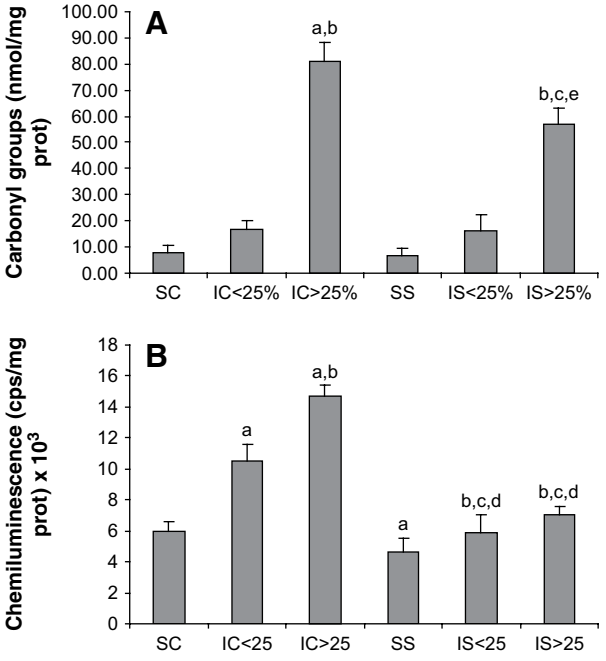

Figure 1 Effects of 9 weeks of diet treatment on oxidative damage in cardiac muscle homogenates from the different groups. (A) Oxidative damage on proteins — radical mediated protein oxidation as indicated by carbonyl groups. (B) Oxidative damage on lipids — tert-butyl hydroperoxide-induced chemiluminescence. Data expressed as mean ± SD of eight animals/group. The groups are the same as in Table 2. (a) different from SC ($P < 0.001$); (b) different from IC < 25% ($P < 0.001$); (c) different from SC ($P < 0.01$); (d) different from IC > 25% ($P < 0.001$).

Discussion

Despite the remarkable improvements in strategies for treating acute MI and subsequent heart failure, understanding of the pathogenesis of heart failure remains a problem. In clinical and experimental studies, the occurrence of antioxidant deficit has been reported as one of the mechanisms for the development of heart failure which cannot entirely explain the complexity of post-ischemic LV remodeling [24–26]. A growing body of evidence suggests that ROS play a major role in the development and progression of LV remodeling and failure after MI. Additionally, chronic supplementation with antioxidants has been previously reported [27], and has been shown to exert beneficial effects in experimental heart failure [10,11]. Soy protein intake has been associated with reduced CHD risk factors, and previous studies have suggested that isoflavones are the cardioprotective component of soy.

Myocardial infarction (MI) in rats has been used as a model to study heart failure. It is worth remembering

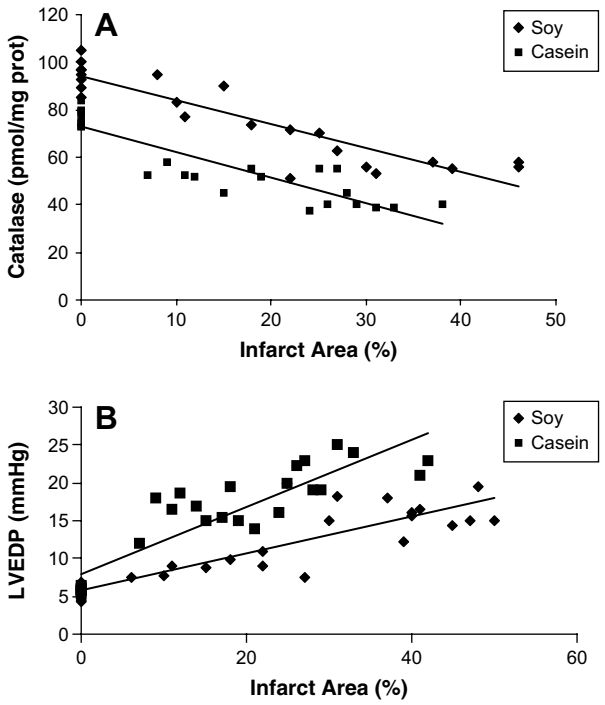

Figure 2 Correlation graph between (A) catalase and infarct size area, and (B) LVEDP and infarct size area in heart homogenates for all experimental groups.

that after left coronary artery ligation, some animals developed extensive infarcts, while others showed small infarcts, and some others developed no infarct at all. Consistent with previous studies [28], we observed a variation in the infarct size from 8% to 46% of the left ventricular endocardial circumference, being divided into two groups with infarct size smaller than 25% and larger than 25%. Separation of the groups according to the infarct size in this study was necessary because this parameter is the main determinant of heart failure development [13].

Infarcted animals treated with casein showed cardiac hypertrophy. This process reflects an adaptive response of the myocardium as part of the ventricular remodeling after MI. An ISP diet prevented cardiac hypertrophy in group IS $<$ 25%. Since ventricular hypertrophy is well known to predict morbidity and mortality after infarction in the general population [29], this result suggests a cardioprotective effect of an ISP diet in this condition.

The infarcted groups fed with casein were characterized by lung and liver congestion compared to the soy groups. These results suggest that these animals are in a stage of congestive heart failure. The ISP diet completely prevented lung congestion in all the infarcted animals, and liver congestion in the group IS $<$ 25%, suggesting a better cardiac pump function.

Cardiac catheterization data reinforce this affirmation since the ISP diet promoted an improvement in systolic and diastolic LV function in the infarcted animals. Myocardial infarction in casein fed rats produced a pronounced increase in LVEDP, which denotes an augmented residual volume. Accordingly, a decrease in the relaxation index ($-$dP/dt) in the infarcted animals was demonstrated. These changes are similar to those previously reported indicating that rats are in heart failure [11]. The ISP diet was able to modulate these changes in such a way that they appear only in the group IS $>$ 25%, these parameters being comparable to those in group IC $<$ 25%. Systolic function (evaluated by LVSP and $+$dP/dt) was also depressed in the MI groups; however in soy infarcted groups the left ventricle function was not so impaired. The overall hemodynamic results demonstrate that ISP treatment avoids the progression of MI to a stage of severe heart failure, suggesting that ISP treated animals are in a stage of mild heart failure.

As previously reported [11], heart failure subsequent to MI in rats is associated with a decrease in antioxidant enzyme activities as well as an increase in oxidative stress. The present study showed that a depressed left ventricular function in infarcted rats was also correlated with a decrease in the antioxidant enzyme activities, and demonstrated that an ISP diet has improved antioxidant activity when compared to a casein diet. SOD and CAT activities were higher in the ISP group than in the casein group, in both infarct sizes. These data strongly suggest that an increase in myocardial antioxidants contributes to sustaining cardiac function subsequent to MI. The depressed cardiac function was associated with an increase in oxidative damage, as shown by a significant positive correlation between CL and the carbonyl groups and LVEDP, as well as an inverse correlation between LVEDP and catalase activity in the casein infarcted groups. These data are in accordance with other studies that emphasize the augmented ROS production during MI, leading to myocardial oxidative damage [11,30]. It is important to highlight that lipid peroxidation is correlated to an elevation in LVEDP only in casein fed rats. When ISP was included in the diet this correlation was not seen.

Another noteworthy result is the reduction in oxidative stress observed in uninfarcted rats fed with ISP as compared to rats fed with casein. This result reinforces the preventive role of ISP against oxidative stress and its prescription to healthy subjects.

Thus, the major outcome of this study is to demonstrate, for the first time, an improvement in ventricular function after MI avoiding the progression to severe heart failure through ISP use as a food supplement. The overall results confirm the preventive role of soy-derived products in terms of post-MI myocardial dysfunction and our results give support to the conclusion that this beneficial effect is likely to be secondary to the antioxidant action of soy protein.

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