Original

Use of cereal bars with quinoa (*Chenopodium quinoa* W.) to reduce risk factors related to cardiovascular diseases

Consumo de barras de cereais com quinoa (Chenopodium quinoa W.) para reduzir fatores de risco de doenças cardiovasculares

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Abstract

Quinoa is considered a pseudocereal with proteins of high biological value, carbohydrates of low glycemic index, phytosteroids, and omega-3 and 6 fatty acids that bring benefits to the human health. The purpose of this study was to investigate the effects of quinoa on the biochemical and anthropometric profile and blood pressure in humans, parameters for measuring risk of cardiovascular diseases. Twenty-two 18 to 45-year-old students were treated daily for 30 days with quinoa in the form of a cereal bar. Blood samples were collected before and after 30 days of treatment to determine glycemic and biochemical profile of the group. The results indicated that quinoa had beneficial effects on part of the population studied since the levels of total cholesterol, triglycerides, and LDL-c showed reduction. It can be concluded that the use of quinoa in diet can be considered beneficial in the prevention and treatment of risk factors related to cardiovascular diseases that are among the leading causes of death in today's globalized world. However, further studies are needed to prove the benefits observed.
Keywords: *quinoa; cardiovascular diseases; cereal bar.*

Resumo

A quinoa é considerada um pseudocereal com proteínas de alto valor biológico, carboidratos de baixo índice glicêmico, fitosteróis e ácidos graxos ômega 3 e 6. O objetivo deste trabalho foi verificar os efeitos da quinoa no perfil bioquímico e antropométrico e pressão arterial em humanos, parâmetros dos fatores de risco para doenças cardiovasculares. Vinte e dois estudantes com 18 a 45 anos de idade foram tratados diariamente, por 30 dias, com quinoa sob a forma de barra de cereal. As amostras de sangue foram coletadas antes e após os 30 dias do tratamento para determinar o perfil glicêmico e bioquímico do grupo. Os resultados mostraram efeitos positivos do uso da quinoa já que se observou redução significativa nos valores de colesterol total, triglicerídeos e LDL-c. Conclui-se que o uso da quinoa na alimentação pode ser considerado benéfico na prevenção e tratamento de fatores de risco de doenças cardiovasculares que estão entre a principais causas de morte no mundo globalizado, embora sejam necessários mais estudos para comprovação dos benefícios observados.
Palavras-chave: *quinoa; doenças cardiovasculares; barra de cereal.*

1 Introduction

The category of snacks, defined as fast foods that can be eaten between main meals, is growing significantly in relation to other types of food products (PAIVA, 2008). These trends are tied to the increased search for products that are beneficial to health or that represent a reduction in risk factors for the development of future disorders, such as cardiovascular diseases (SANTOS et al., 2006). Therefore, recently, there has been a search for alternatives that are easier to obtain and can act as supporting factors in the treatment of the risk indicators, such as obesity, dyslipidemia, and high blood pressure. As a result, dietary alterations associated with economic, social and demographic changes and their effects on human health have been observed in several developing countries (HOENIG et al., 2008). The increasing substitution of fresh foods rich in fibers, vitamins, and minerals for industrialized products, allied to a sedentary lifestyle favored by changes in the work structure and technological advances, represents one of the major etiological factors in obesity associated with systemic arterial hypertension, dyslipidemias, cardiovascular diseases and metabolic syndrome.

However, adequate nutrition allied to other modifications in the lifestyle contributes to the improved control of these associated risk factors preventing complications and increasing quality of life (BLONDE, 2010; DONIN et al., 2010). Accordingly, cereal bars emerged about a decade ago and represent an alternative food that is easy to consume while simultaneously possessing functional properties (SILVA et al., 2009; BARBOSA, 2007).

Since the consumption of cereals has expanded from the breakfast table to any time of the day, these products have become an excellent vehicle for the inclusion of functional ingredients in the consumers' diet. Cereals have been playing an increasingly vital role in modern lifestyles thanks to their varied uses including ready-to-eat products, instant products, cereal bars, and energy bars (FREITAS; MORETTI, 2006).

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Some cereals and pseudocereals have been widely included in food products to meet consumer demand due to their physiological and metabolic properties. Corn, rice, potatoes, and grains such as quinoa (*Chenopodium quinoa* W.) are grown primarily in the Andes Mountains. Quinoa, which is considered a pseudocereal (ROMERO et al., 1998) which can be consumed by humans (ABUGOCH JAMES, 2009; VILLARROEL et al., 2009; RUALES; NAIR, 1992) is particularly adapted to the climatic and geographic conditions of these regions (REPO-CARRASCO; HOYOS, 1993; RUALES; NAIR, 1992). It has some functional (technological) properties such as solubility, water-holding capacity (WHC), gelation, emulsifying, and foaming that allow diversified uses (ABUGOCH JAMES, 2009). It is an important source of proteins of high biological value, carbohydrates with low glycemic index, vitamins (thiamine, riboflavin, niacin, and vitamin E), and minerals (magnesium, potassium, zinc, and manganese). It is also rich in phytosteroids such as soy , omega-3, and 6 fatty acids. In addition to these characteristics, it can also be consumed by people with celiac disease since it is gluten free (ABUGOCH JAMES et al., 2008; ABUGOCH JAMES, 2009; INSTITUTO…, 1997; RUALES; NAIR, 1994).

Quinoa can be found in the form of flakes, grains, and flours, as well as in products such as noodles and energy bars, and its grains can be cooked in hot water prior to consumption (SEMINÁRIO INTERNACIONAL, 2006). There are several developments with quinoa flour at a smaller scale such as bread, muffins, pasta, snacks, drinks, flakes, baby foods, beer, and extrudates (ABUGOCH JAMES, 2009; DOGAN; KARWE, 2003).

The literature does not report data showing the effect of quinoa on the biochemical profile of animals. Therefore, the aim of this study was to investigate the effects of quinoa on the biochemical and anthropometric profiles and arterial blood pressure of humans based on its use in cereal bar formulations.

2 Subjects and methods

2.1 Study location and population

This work was developed at the "Estudante Rafael Almeida Camarinha" Faculty of Technology in Marília, state of São Paulo, Brazil. The study population comprised twenty-two students between 18 and 45 years old, 9 males and 13 females, from different terms chosen randomly to participate in the project.

2.2 Anthropometric evaluation

Weight and stature were measured, respectively, on an electronic balance (*Filizola*) with a capacity for 180 kg and a stadiometer (SANNY) with millimetric precision. The anthropometric measuring techniques presented below were based on Heyward (2000).

3 Biochemical measurements

Glycemia, total cholesterol, HDL-c (high density lipoprotein cholesterol), LDL-c (low density lipoprotein cholesterol), triacylglycerides, AST (aspartate transaminase), ALT (alanine transaminase), and urea were measured before and after treatment (30 days) with cereal bar according to the methodology adopted by the Marília Municipal Foundation for Higher Education at its Clinical Pathology Laboratory. Blood collection was performed in the same period of the day from individuals after an 8- to 10-hour fast. The subjects were instructed to follow a normal diet without changes during the treatment period. The results were interpreted according to SBD – Brazilian Diabetes Society (2010). Blood pressure measures followed the V Brazilian Guidance of Blood Pressure (2007).

3.1 Legal ethical aspects

Ethical approval was given by the Research Ethics Committee of FAMEMA (Marília Faculty of Medicine), under Protocol Nº 698 of November 5, 2007. All individuals signed a Consent Form before participating in the study. (Resolution 196/10 of October 1996 – National Health Council).

3.2 Preparation of cereal bars

Cereal bars were prepared following the methodology described by Freitas and Moretti (2006) with ingredients obtained from the local market (Table 1). The quinoa used was imported from Bolivia and marketed by the Vitao manufacturing company. The agglutinating syrup was prepared in a stainless steel container to melt and dissolve the sugars, followed by the addition of pre-dissolved maltodextrin, vegetable fat, and lecithin. The ingredients were kept under constant stirring, and the content of total soluble solids was checked periodically with a bench top refractometer until syrup with 86 °Brix was obtained.

The dry ingredients were incorporated into the agglutination syrup at a temperature of approximately 95 °C, and the mass was kept under constant stirring until it was completely homogenized. Using a stainless steel cylinder, the mass was then laminated in a stainless steel mold to a thickness of 1 cm cooled to a temperature of 9 °C for 10 minutes, and cut into rectangular bars, each weighing 25 g and having a standard size (10 × 3 × 1 cm), which were then unmolded and wrapped in flexible film.

The cereal bars were administered daily, including weekends. The students consumed two bars per day, at a total concentration of 19.5 g of quinoa (9.75 g quinoa/bar).

Table 1. Formulation of the cereal bars for the treated group.

Agglutination syrup ingredients (%)	
Crystal sugar	14
Glucose syrup	26
Maltodextrin	6
Vegetable fat	4
Soybean lecithin	2.5
Water	2.5
Dry ingredients (%)	
Quinoa flakes	39
Rice flakes	6

3.3 Statistical methodology

The data were described using Descriptive Statistics and analyzed using a Student's *t*-test comparing the two stages of the study.

4 Results

The initial collection of biochemical data revealed that 19.04% of the participants had a total cholesterol level above 200 mg.dL^{-1}, 14.28% had triglyceride concentrations exceeding 150 mg.dL^{-1}, and 33.33% had HDL-c concentrations below 45 mg.dL^{-1}. The anthropometric measurements indicated that 52.38% of the study population had a body mass index (BMI) exceeding 25.

After the 30-day treatment, it was observed significant reduction (Table 2) in the cholesterol levels as well as in triglycerides and LDL-c levels (67.5% of the subjects showed a reduction in total cholesterol, 55.9% in triglycerides concentrations and 66% showed a reduction in LDL-c). Although not significant differences in glycemic index, weight, and BP were observed, when these parameters were evaluated in terms of percentage (data not shown), it was observed that 56.7% of the subjects showed reduction in blood glucose levels, 42.2% of them showed reduction in body weight, and 40.7% showed reduction in BP.

Based on the findings, a parallel was drawn between the genders (male and female) and the stage of treatment (pre- and post-treatment), as indicated in Table 3. A significant decrease was found in total cholesterol among the women but not among the men studied. However, the latter showed a statistical tendency for the reduction in this index. Both women and men showed a significant decrease in the LDL-c concentrations. Post-treatment glucose levels were lowered significantly in men, but not in women. For the hepatic enzymes, no significant difference was found in ALT (alanine transaminase) values in either sex, but both sexes showed a decrease in AST (aspartate transaminase) values. Women showed significantly lower post-treatment concentrations of triglycerides and urea, which was not the case among men. Neither sex showed a significant difference in pre- and post-treatment blood pressure or body weight.

Table 2. Biochemical parameters (mg.dL^{-1}), blood pressure (mmHg), and weight (kg) from 22 individuals from Marilia, SP, before and after 30 days consumption of quinoa bars.

Variables	Moment		p-value
	Pre-treatment	Post-treatment	
Glycemia	87.32 ± 8.17	85.24 ± 6.36	0.4223
Total cholesterol	175.76 ± 28.41	158.28 ± 19.03	0.0006*
Triglycerides	101.83 ± 84.07	89.31 ± 43.26	0.0471*
LDL-c	152.65 ± 39.97	121.31 ± 43.11	0.0002*
HDL-c	46.37 ± 10.40	47.44 ± 10.81	0.4223
Urea	30.59 ± 7.16	28.27 ± 6.96	0.0141*
AST (U.L^{-1})	25.00 ± 6.71	21.23 ± 5.72	0.0014*
ALT (U.L^{-1})	38.00 ± 13.25	38.85 ± 9.77	0.3518
BPmax	113.95 ± 15.62	112.41 ± 8.75	0.3703
BPmin	75.71 ± 8.70	75.88 ± 7.12	0.5000
Weight	71.90 ± 14.14	70.70 ± 14.11	0.3948

HDL-c (high density lipoprotein cholesterol); LDL-c (low density lipoprotein cholesterol); AST (aspartate transaminase); ALT (alanine transaminase); BP (blood pressure). Mean, standard deviation, and results of the statistical analysis of the biochemical variables; (*) p-value significant.

5 Discussion

Some studies have suggested that the vegetables and cereals widely consumed by the population have active compounds that were proven to have physiological and metabolic properties. These studies include soybeans, eggplant, and oats, which have been exhaustively investigated with respect to their beneficial effects on dyslipidemias. Other studies have focused on plants such as *Glycine Max* (L.), *Mentha piperita*, *Cassia esculenta*, *Curcuma* sp., *Ananas comosus*, green tea, amaranth and others (BARBALHO; FARINAZZI-MACHADO, 2011; BARBALHO et al., 2011; RANILLA et al., 2010; QI et al., 2010; BAÑOS; PÉREZ-TORRES; EL HAFIDI, 2008; GRASSI et al., 2008; ALUKO, 2008; MARTIROSYAN et al., 2007; XIE et al., 2005; KUO et al., 2005).

Some studies have shown that the consumption of dietary fiber may reduce the risk of diseases and can prevent hyperlipidemias, cardiovascular diseases, diabetes, and obesity (DEVALARAJA; JAIN; YADA, 2011; PAPATHANASOPOULOS, CAMILLERI, 2010; PAIVA, 2008). The ingestion of dietary grains and fibers has been associated with diminished risk for obesity and diabetes (QI et al., 2010; JANG et al., 2010; ASLAM et al., 2009; GRASSI et al., 2008). Berti et al. (2005) related that carbohydrates from quinoa, including insoluble and soluble fiber, can be considered as nutraceuticals because they can help reduce glucose, triglyceride, and free fat acids levels in the blood. The results obtained in the present study corroborate the data reported in the literature indicating that quinoa can be used in plasma lipids and glycemic control.

There are plants that may contribute to the reduction of the body mass index (BMI) and show beneficial effects on the control of arterial blood pressure, such as Matico (*Piper angustifolium R.),* Guascas (*Galinsoga parviflora*), cocoa (*Theobroma cacao*), chickpea (*Cicer arietinum* L.), pea (*Pisum sativum* L.), fruits of Embelia ribes Burm, soy (*Glycine max* L.), and psyllium (*Plantago psyllium* L.) (RANILLA et al., 2010; SHIN et al., 2010; GRASSI et al., 2008; ALUKO, 2008; BHANDARI; ANSARI; ISLAM, 2008; MASKARINE et al., 2008; CICERO et al., 2007). In this study, after 30 days using quinoa cereal bar, 42.2% of the individuals showed reduced blood pressure and 40.7% showed reduced body weight.

After 30 days, the use of quinoa did not lead to hepatic or kidney damages, as observed by the AST, ALT and urea levels.

Quinoa contains considerably high vitamin E, iron, zinc and magnesium contents (RUALES; NAIR, 1992), as well as saponins and phytosteroids (KULJANABHAGAVAD et al., 2008; INSTITUTO…, 1997). These substances have shown hypocholesterolemic effects and increased postprandial sensitivity and release of plasma insulin (KWON et al., 2008;

Table 3. Means, standard deviation, and results of the statistical analysis of the biochemical parameters ($mg.dL^{-1}$), blood pressure (mmHg), and anthropometric (kg) variables regarding gender and stage of treatment.

Variables	Gender			
	Female		Male	
	Pre-treatment	Post-treatment	Pre-treatment	Post-treatment
Glycemia	85.38 ± 7.11^{Aa}	86.83 ± 6.29^{Ab}	88.33 ± 10.31^{Ba}	81.40 ± 5.18^{Aa}
Total cholesterol	169.69 ± 25.48^{Ba}	$155.69 \pm 18.89^{A1\ a2}$	185.63 ± 31.84^{Aa}	165.00 ± 19.79^{Aa}
Triglycerides	95.27 ± 61.70^{Ba}	76.50 ± 47.45^{Aa}	112.14 ± 41.65^{Aa}	110.67 ± 26.23^{Aa}
LDL-c	149.12 ± 45.40^{Ba}	127.69 ± 41.24^{Aa}	158.38 ± 31.13^{Ba}	109.46 ± 47.25^{Aa}
HDL-c	47.70 ± 11.11^{Aa}	50.60 ± 11.91^{Aa}	45.63 ± 10.43^{Aa}	43.50 ± 8.33^{Aa}
Urea	27.62 ± 7.04^{Bb}	24.38 ± 5.64^{Ab}	34.89 ± 5.01^{Aa}	33.89 ± 4.40^{Aa}
AST ($U.L^{-1}$)	22.62 ± 3.69^{Bb}	19.62 ± 3.48^{Ab}	28.44 ± 8.68^{Ba}	23.56 ± 7.58^{Aa}
ALT ($U.L^{-1}$)	36.69 ± 15.62^{Aa}	36.31 ± 9.70^{Ab}	40.43 ± 7.59^{Aa}	43.57 ± 8.62^{Aa}
BPmax	109.23 ± 14.41^{Aa}	109.11 ± 7.87^{Aa}	121.63 ± 15.25^{Ab}	116.13 ± 8.63^{Ab}
BPmin	73.85 ± 7.68^{Aa}	73.33 ± 7.07^{Aa}	78.75 ± 9.91^{Aa}	78.75 ± 6.41^{Aa}
Weight	63.98 ± 11.82^{Aa}	62.37 ± 10.03^{Aa}	83.34 ± 8.14^{Ab}	83.19 ± 9.23^{Ab}

1) Mean values followed by at least one same upper-case letter do not differ statistically from each other regarding gender (comparison by stage of treatment). 2) Mean values followed by at least one same lower-case letter do not differ statistically from each other regarding stage of treatment (comparison by gender). LDL-c (low density lipoprotein cholesterol); HDL-c (high density lipoprotein cholesterol); AST (aspartate transaminase); ALT (alanine transaminase); BP (blood pressure).

YIN; ZHANG; YE, 2008; CICERO et al., 2007). Abugoch James (2009) found antioxidants capacity compounds such as polyphenols, phytosterols, and flavonoids in grains of quinoa. These substances may be related with the effects of reduction in plasma lipids and glucose levels in the individuals tested. Matsuo (2005) demonstrated that the use of this grain can also be beneficial for increasing the production of liver antioxidant enzymes. The increase of these enzymes is related with the reduction of harmful effects caused by free radicals on the human body, which it leads to a reduced endothelial alterations (endothelial dysfunction) and decreased oxidation of LDL-c molecules, and hence, reduces the risks for vascular diseases (ADLER et al., 2010; NERI et al., 2010; KUSIRISIN et al., 2009; GHIBU et al., 2008; JI et al., 2008). The present study also demonstrated that this pseudocereal positively influenced the various risk factors for the development of diabetes and vascular diseases, which are the most frequent diseases today.

6 Conclusions

Based on the data obtained in this study, it can be concluded that the use of quinoa in the composition of a cereal bar may help reduce risk factors related to cardiovascular diseases that are among the major causes of death in today's globalized world although further studies are needed to prove the benefits observed. Quinoa flakes can be used in cereal bars or can be added in food products such as cookies, breakfast cereals, and diet supplements.

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