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A regular lycopene enriched tomato sauce consumption influences antioxidant status of healthy young-subjects: A crossover study

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ABSTRACT

Tomato and tomato products are known as potential factors to decrease oxidative stress biomarkers. Therefore, the objective was to evaluate the effects of consumption of two tomato sauces with different concentrations of lycopene on oxidative stress markers. Thirty healthy subjects (Men/women: 9/21; Aged 39 ± 6 years old; BMI: 24.5 ± 3.3 kg/m^2) were recruited to participate in a double-blind crossover study. Participants had to consume 160 g/day of tomato sauce, while maintaining their usual dietary and physical activity habits.

The regular consumption of the high-lycopene tomato sauce induced a significant reduction in the oxidized-LDL cholesterol levels (−9.27 ± 16.8%; $p < 0.05$). Moreover, total plasma antioxidant capacity tended to increase with the high-lycopene tomato sauce, while it decreased slightly with commercial tomato sauce consumption (2.69 ± 13.4 vs −0.05 ± 0.4; $p = 0.058$). Lipid, glucose profile and C-reactive protein concentrations were stable during both intervention periods, as well as anthropometric and body composition variables.

Thus, the daily consumption of 160 g of a high-lycopene tomato sauce improved oxidized-LDL cholesterol levels, evidencing the putative role of lycopene in combination with other bioactive compounds in the prevention of oxidative stress related diseases.

1. Introduction

Lycopene is a carotenoid with a potent antioxidant activity commonly found in tomato and tomato products (Di Mascio, Kaiser, & Sies, 1989), often regarded as a significant factor in cardiovascular protection and oxidative stress reduction (Agarwal & Rao, 2000; Blum et al., 2005; Das, Otani, Maulik, & Das, 2005). Clinical trials have shown contradictory results about the role of antioxidants. While several studies have revealed no significant improvements in oxidative stress markers (Ellinger, Muller, Stehle, & Ulrich-Merzenich, 2011; Lee et al., 2009; Markovits, Ben Amotz, & Levy, 2009; Martinez-Tomas et al., 2012), others have demonstrated protective effects (Basu & Imrhan, 2007; Bowen et al., 2002; Hooper, Ness, & Smith, 2001; Mackinnon, Rao, Josse, & Rao, 2011; Visioli, Riso, Grande, Galli, & Porrini, 2003). Results from many interventional studies using antioxidants given as supplements have not been concordant with observational and epidemiological studies, where the regular consumption of fruits, vegetables and natural antioxidant foods have been associated

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with lower oxidative stress levels, cardiovascular diseases and atherosclerosis incidence (Hertog, Feskens, Hollman, Katan, & Kromhout, 1993; Mink et al., 2007). Published evidences have shown significant variation in the benefits achieved through the consumption of tomato or derivatives, mainly due to differences in study design, study group and the dose consumed in the trial (Engelhard, Gazer, & Paran, 2006; Fuhrman, Elis, & Aviram, 1997). Furthermore, the bioavailability of lycopene is highly variable depending on food matrix and processing (how food is prepared and consumed) (Reboul et al., 2006). Indeed, prepared products with high lycopene concentration have not shown more effectiveness than natural products, which suggests possible cooperative interactions between lycopene and other naturally occurring bioactive tomato factors (Fuhrman, Volkova, Rosenblat, & Aviram, 2000).

On the other hand, current lifestyle makes the fulfilment of fruits and vegetables recommendations more difficult, rendering the maintenance of an adequate antioxidant status complex. Thus, the increase in antioxidant content naturally occurring in traditional plant foods, instead of the consumption of artificial antioxidant products, may be a good strategy to improve the antioxidant status and decrease the risk of oxidative stress related diseases. In this context, the present study aimed at investigating the effect of consuming two tomato sauces differing in lycopene concentration on oxidative stress markers, lipid profile, glucose metabolism and anthropometric measures in healthy volunteers. The tomato sauces had different lycopene concentrations, which were achieved naturally, without the addition of artificial compounds.

2. Materials and methods

The study was designed in line with the consolidated standards of reporting trials (CONSORT) guidelines (Schulz, Altman, & Moher, 2010). This investigation conforms to the principles outlined in the Declaration of Helsinki, was approved by the research ethics committee of the University of Navarra (080/2009), and each participant gave written informed consent to the study.

2.1. *Experimental tomato sauces*

The two tested tomato sauces were supplied and coded by Industrias Alimentarias de Navarra-Grupo IAN (CARRETILLA). The different lycopene content of tomato sauces was achieved using different varieties of tomatoes and different harvest times based on previous data. Thus, tomatoes used in the production of the high-lycopene tomato sauce were riper than those used in the production of the commercial tomato sauce. The nutritional composition of both sauces was analyzed using National Centre for Food Safety and Technology criteria (Table 1). The lycopene content was determined by a UV/VIS spectrometer (Lambda Bio 40 UV/VIS PerkinElmer, Waltham, Massachusetts, USA) by using the methodology and absorbance values described elsewhere (Barrie & Soderstrom, 1989; Pedro & Ferreira, 2005). The total antioxidant capacity of each tomato sauce was analyzed following the Photochem® antioxidant analyzer instructions (Photochem, Analytik Jena, Bath, UK). The Photochem apparatus uses the photochemiluminescence principle, combining very fast photochemical radical generation with highly sensitive luminometric detection (Pegg, 2007). Superoxide anion free radicals are produced in the instrument by optical excitation of a photosensitiser, added in standardised volumes to the sample to be measured. The anti-oxidative capacity of the sample is quantified by comparison with a calibration curve created using standards of Trolox or ascorbic acid for lipid- and water-soluble antioxidants, respectively.

2.2. *Study design*

The present study was designed as a double-blind crossover nutritional intervention, with two experimental periods of 4 weeks separated by a 2-week washout period. Two experimental groups were organized and subjects were randomly assigned to each subgroup using the random function in excel (Microsoft Office Excel 2003). The tomato sauces were coded (A and B). Thus, while one subgroup started with the tomato sauce A and continued with B, during the first and second intervention periods, respectively, the other subgroup followed the inverse order. Tomatoes, tomato derivatives and foods or preparations rich in lycopene were avoided during the whole intervention. The daily portion of sauce was established according to Spanish dietary habits (160 g/day). Subjects had to include the product while keeping their usual dietary and physical activity habits. Participants had to fill out weighed food records (72 h) to facilitate the assessment of energy intake and macronutrient proportions before and during each experimental period. All participants were instructed by a trained dietician who gave them several recipes and ideas to facilitate the consumption of tomato sauces. Dietary options included the combination of sauces with pasta, rice, poultry, fish, ham, etc. and also emphasized the importance of cooking them. Finally, each participant filled out a small notebook, showing the daily consumption of the tomato sauce. Anthropometric, body composition and blood pressure variables were assessed at the beginning and at the end of experimental periods. Blood samples were drawn at the same time with participants in a fasting state (12 hours). Lycopene compliance was assessed by identification and quantification of 1H NMR chemical shift region signals in the lycopene methyl groups (Frohlich, Conrad, Schmid, Breithaupt, & Bohm, 2007) with aqueous, lipid and phospholipidic extracts of serum samples. Lipid extractions were previously carried out following the method of Folch et al., (1957) .

2.3. *Study population*

Advertisements in the university boards and in the local newspaper concerning the study were placed. Prior to the beginning of the study, subjects interested in participating attended the University of Navarra facilities, where they were informed in detail about the study conditions. Once subjects had agreed to participate in the study, they signed the written informed consent and were examined by a physician who carried out a clinical history, medical examination and fasting blood profile to exclude subjects with evidence of diabetes, hypertension as well as other clinical disorders that could interfere with the study. Then, an interview concerning their