

**Nutritional and antioxidant properties of fresh and processed tomato (*Lycopersicon esculentum*) cultivars from Cuba and Germany.**

**General introduction**

Human nutrition worldwide covers the most important nutritional problems of developing and developed countries and suggests appropriate programs and policies to address them. It provides sound science-based information on food, nutrients, causes of malnutrition, nutritional disorders, and their prevention. It emphasizes three prerequisites of good nutrition: food security, good health and adequate care (FAO, 1997).

The link between diet and prevention of chronic diseases has long been known. Bioactive compounds that have not been historically classified as nutrients have been known to promote optimal human health, especially in areas related with chronic diseases. Recent researches in fruits and vegetables indicate that bioactive compounds have a powerful impact on disease prevention, such as cardiovascular and cerebrovascular diseases, many types of cancer, and ischemic heart disease (Joshipura et al., 2001, Bazzano et al., 2002, Finley, 2005, Ovesen, 2005).

Assuring the presence of nutrients and bioactive compounds in our food supply to foster increased consumption is a challenge and should be a high priority for agriculture producers, food processors, nutritionists, researchers, educators, and consumers. Identifying bioactive compounds and establishing their health effects are active areas of scientific inquiry. An impressive and growing number of bioactive compounds have been identified as having potentially important health benefits. These compounds can act as antioxidants, enzyme inhibitors and inducers, inhibitors of receptor activities, and inducers or inhibitors of gene expression, among other actions. It is evident that much research needs to be done to identify the biology of each important bioactive compound and its effect on health. With the advent of contemporary and powerful methodologies for

conducting applied and basic science, rapid progress can be made in understanding the functional importance of each bioactive compound (Kris-Etherton et al., 2004).

Epidemiological studies suggest that antioxidant capacity is improved by the consumption of tomato products, thereby decreasing the risk of the development of disease related to oxidative stress. As a result of several investigations, it has been proven that tomato and its products are essential not only for nutrition but also for human health, as they provide nutrients and bioactive compounds such as ascorbic acid, lycopene, flavonoids and many others (Giovannucci et al., 2002, Etminan et al., 2004, Levy and Sharoni, 2004). For all these reasons, research is needed to characterize tomato products with regard to their bioactive compounds and antioxidant capacity. Although there is sufficient evidence to recommend consuming food sources rich in bioactive compounds, much scientific research needs to be conducted before we can begin to make science-based dietary recommendations (Kris-Etherton et al., 2002).

This research focuses on some nutritional and antioxidant properties of tomatoes, and their variation during the heating process.

### **Outline of the thesis**

Chapter 1 offers an introduction to the topic, with special emphasis on the nutritional value of tomato, general concept and classification of the bioactive compounds, as well as their presence in tomato and its products, and the effects of processing on these compounds that has been reported in the last years of research.

Chapters 2, 3 and 4 give the results of the experimental work, where:

Chapter 2 deals with the nutritional value of the studied cultivars and processing methods with regard to the content and composition of sugars, organic acids, and amino acids, as well as protein content.

Chapter 3 comprises the results of the determination of some bioactive compounds (ascorbic acid, lycopene and total phenolics) and antioxidant capacity in fresh and processed tomato products in order to evaluate the influence of heating process and the contribution of the single bioactive compounds to the total antioxidant power.

Chapter 4 is an additional characterization of the rheological properties of processed tomato products (puree and ketchup) and its correlation with dry matter and mineral content.

The general conclusions of the thesis as well as the suggestions for future research are given in chapter 5, making a characterization of the cultivars with regard to the analyzed parameters.

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## **Chapter 1. Antioxidant properties and bioactive compounds of vegetables: an introduction**

### **1.1. Introduction**

Nutrition is a major, modifiable, and powerful factor in promoting health, preventing and treating disease, and improving quality of life. The relationship between food, nutrition and health is thus one of the global challenges that developed and developing countries are facing today. Essential nutrients and a range of bioactive compounds found in meat, fish, fruits, vegetables, and cereals are important for optimal nutrition, both in industrial and in developing countries. Epidemiological studies have shown an inverse correlation between increased fruit and vegetable consumption with a reduced risk of chronic diseases including cardiovascular diseases (Mihalev et al., 2004). Fruits and vegetables have received particular attention because they contain high amounts of known antioxidants such as polyphenols, ascorbic acid, tocopherol,  $\beta$ -carotene, lycopene and many others. Due to their potential role in preventing diseases, natural compounds with antioxidant activity have gained the attention of researchers and nutritionists (Lenucci et al., 2006).

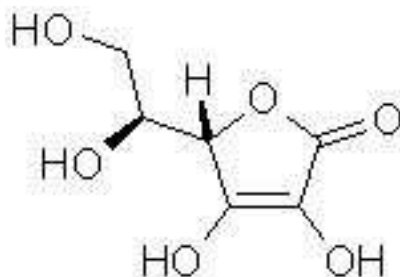
In Cuba, the Executive Committee of the Ministers Council approved the National Program of Health and Life Quality, which includes 10 intervention areas, one of these areas is: non healthy feeding and Alimentary Culture. Due to this, a main policy of the Ministry of Public Health is to develop the Program of Alimentary and Nutritional Education, guided to gradually modify the current alimentary habits, with the rising increment of the vegetables consumption, improving people lifestyle and increasing the population's alimentary culture. This research work is in accordance to this program, as it will contribute to the knowledge of the nutritional and antioxidant properties of tomato and its products.

## **1.2. Bioactive compounds and antioxidant capacity**

Bioactive compounds are defined as extra nutritional components of food that influence physiological or cellular activities, resulting in a beneficial health effect. This definition distinguishes these compounds from many others that are bioactive, but have detrimental effects and are considered carcinogens or toxins. Bioactive compounds occur in small quantities in foods, but have more subtle effects than nutrients, for example, they influence cellular activities that modify the risk of disease, rather than prevent deficiency diseases. The primary challenge in this area is to identify bioactive compounds and their associated health effects as well as their underlying biological mechanism of action. An impressive and growing number of bioactive compounds have been identified as having potentially important health benefits. These compounds may have different mechanisms of action. For example, they can act as antioxidants, enzyme inhibitors or inducers, inhibitors of receptor activities, and inducers and inhibitors of gene expression. Demonstration of these activities alone is not sufficient for a compound to be defined as a bioactive compound; it also must have an associated beneficial health effect (Kris-Etherton et al., 2004, Huang, et al., 2005, Prior et al., 2005).

According to Liu (2004), bioactive compounds are divided into several groups depending on their chemical structure and function as follow: carotenoids, phenolics, alkaloids, nitrogen-containing compounds and organosulphur compounds. Some of the most important bioactive compounds are:

**Ascorbic acid: C<sub>6</sub>H<sub>8</sub>O<sub>6</sub>**



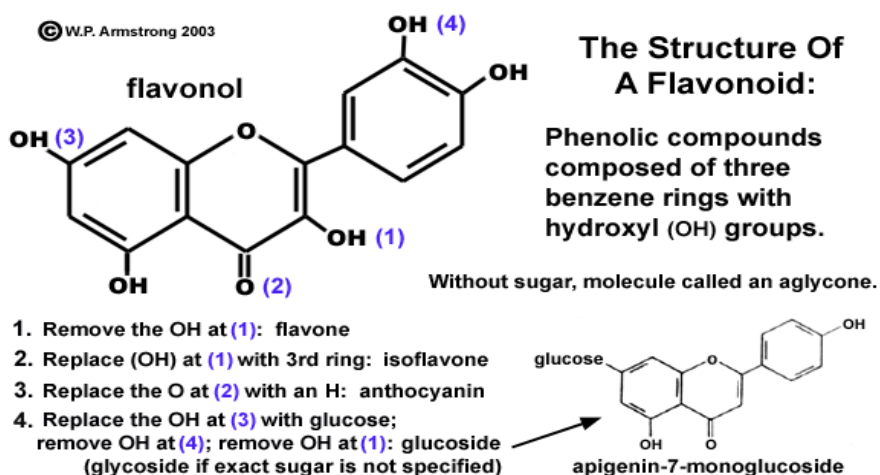
*Source: Landolt Börnstein Organic Index (2006)*

Ascorbic acid is a six-carbon lactone synthesised for the plants from the sugars formed during photosynthesis. In plant and animal systems ascorbic acid interacts enzymatically and non-enzymatically with damaging oxygen radicals and their derivatives, so called reactive oxygen species (ROS). The biological importance of the antioxidant behaviour of ascorbic acid is that unlike other low-molecular-weight antioxidants ( $\alpha$ -tocopherol, uric acid, carotenoids, flavonoids, etc). This compound is able to terminate radical chain reactions by disproportionation to non-toxic, non-radical products (Davey et al., 2000).

**Phenolic compounds:**

Phenolic compounds are naturally-occurring substances in fruit, vegetables, nuts, seeds, flowers and some herb beverages. They are secondary plant metabolites and confer on fruit and vegetables both desirable and undesirable food qualities, and comprise a large group of biologically active ingredients (above 8000 compounds) from simple phenol molecules to polymeric structures with molecular mass above 30000 Da. On the bases of the number of phenol subunits, the modern classification forms two basic groups: simple phenols and polyphenols. The group of simple phenols contains also the so-called “phenolic acids” or phenols with carboxyl group underlying the specificity of their function. Polyphenols contain at least two phenol rings. Phenolics possess a wide spectrum of biochemical activities such as antioxidant, antimutagenic, anticarcinogenic, as well as ability to modify the gene expression (Marinova et al., 2005).

## Flavonoids:



Source: *Chemical Compound Outline* (2003)

Flavonoids are a powerful group of phytonutrients. Chemically they are polyphenolic compounds that are ubiquitous in nature and are categorized, according to chemical structure, into flavonols, flavones, flavanones, isoflavones, catechins, anthocyanidins and chalcones. Over 4000 flavonoids have been identified, many of them occur in fruits, vegetables and beverages (tea, coffee, beer, wine and fruit drinks). The various classes of flavonoids differ in the level of oxidation of the carbon ring of the basic benzo- $\gamma$ -pyrone structure (Amić et al., 2003). The flavonoids have aroused considerable interest recently because of their potential beneficial effects on human health. They have been reported to have antiviral, anti-allergic, antiplatelet, anti-inflammatory, antitumor and antioxidant activities. The vast number of flavonoids and mixtures of their subclasses, including flavonols, flavones, and flavanones, and the variety of agricultural practices that affect their concentration in foods have presented a challenge to the development of adequate food composition databases for these compounds (Graf et al., 2005).