Nutritional value of conventional, wild and organically produced fruits and vegetables available in Baja California Sur markets
Valor nutricional de frutas y vegetales producidos de manera convencional, silvestre y orgánica disponibles en el mercado de Baja California Sur

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SUMMARY

Consuming fruits and vegetables plays a crucial role in the development of age-related diseases including arthritis, diabetes, cancer, atherosclerosis, vascular diseases and metabolic syndromes caused by oxidative stress. Demand for organic food is on the rise, reflected in a significant 11% growth in the organic food trade in the United States, the world's largest organic market. More farmers are currently producing on more certified organic land, and to date 179 countries have reported activities in organic agriculture. Vegetables analyzed for this study were obtained from commercial shopping centers of the city of La Paz Baja California Sur and were classified into four groups: tomatoes, peppers, citrus fruit and leafy vegetables and subgrouped into conventional, wild and organically produced. The 1,1-diphenyl-2-picrylhydrazyl (DPPH) technique was used to measure the antioxidant activity of the plant extracts. Of the organically produced group, grape tomatoes with 1.273 mg trolox equivalent mg per gram of sample and certified organic bell pepper with 1.119 mg trolox equivalent per gram presented the highest antioxidant power. Of the group of citrus fruits, we found that the wild naranjitas had higher antioxidant power with 1.623 mg trolox equivalent per gram of sample. Finally, of the leafy vegetable group, wild greens (quelites) showed the highest antioxidant power with 1.313 mg trolox equivalent per gram of sample.

Index words: *antioxidants, organic crops, oxidative stress.*

RESUMEN

El consumo de frutas y hortalizas desempeña un papel crucial en el desarrollo de enfermedades relacionadas con la edad como artritis, diabetes, cáncer, aterosclerosis, enfermedades vasculares y síndromes metabólicos causados por el estrés oxidativo. La demanda de alimentos orgánicos está aumentando, y se refleja en el significativo crecimiento de 11% en los alimentos orgánicos en los Estados Unidos, el mercado orgánico más grande del mundo. Más agricultores están produciendo más productos certificados como orgánicos y hasta ahora 179 países informaron actividades relacionadas con la agricultura orgánica. Los vegetales analizados para este estudio se obtuvieron de tiendas comerciales de la ciudad de La Paz Baja California Sur y fueron clasificados en cuatro grupos: tomates, pimientos, cítricos y verduras de hoja; los sistemas de producción evaluados fueron: el sistema convencional, silvestre y producción orgánica certificada. La técnica 1,1-difenil-2-picrylhydrazyl (DPPH) se utilizó para medir la actividad antioxidante de los extractos de plantas. El tomate uva certificado como orgánico presentó el más alto poder antioxidante con 1.273 mg equivalente trolox por gramo de la muestra; así mismo el chile morrón orgánico certificado obtuvo el mayor poder antioxidante con 1.119 mg equivalente

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de trolox gramo de muestra. En relación con el grupo de los cítricos, encontramos que las naranjitas silvestres tenían mayor poder antioxidante con 1.623 mg trolox equivalente por gramo de muestra. Finalmente, dentro del grupo de las hortalizas de hoja, el quelite silvestre mostró el más alto poder antioxidante con 1.313 mg trolox equivalente por gramo de muestra.

Palabras clave: *antioxidantes, cultivos orgánicos, estrés oxidativo.*

INTRODUCTION

In 2000-2011 period, the value of vegetable production in Mexico reached 467 283.5 million pesos. Of the 158 different types of produced vegetables, red tomato, green tomato, white onion, green chili and asparagus made up the largest portion (SAGARPA, 2012). Consumer longevity seems to increase with caloric reduction and high levels of antioxidants in their diets. Antioxidants can reduce mitochondrial degradation, cell metabolism and oxygen consumption. It has been observed that antioxidant levels reduce with aging, mainly in blood and some organs. These degenerative immune system changes can induce development of cataracts, Alzheimer, Parkinson or cardiovascular disorders (Zorrilla, 2002; De La Fuente, 2002). Generally, plants with high antioxidant potential contain phenolic compounds that act as reducing agents, hydrogen donors and reactive oxygen species quenchers (Javanmardi *et al*., 2003). Consuming fruits and vegetables is of great importance in the treatment and prevention of aging, cancer, chronic-degenerative diseases, among other disorders caused by oxidative stress which generates reactive oxygen species (ROS) in the body. ROS action is quenched by the content and capacity of antioxidant compounds through donation of one of their own electrons, protecting cells from oxidative damage (Soto *et al*., 2012). ROS are mainly formed endogenously in cellular respiration (mitochondria) and, due to the effect of pollutants, exogenously. These molecules react quickly and damage other biomolecules, competing for electrons in order to reach stability (Figure 1) (Rodríguez *et al*., 2006).

Consumer demand for organic products is increasing and is reflected in a significant increment of 11% in the USA market, the largest organic market in the world. Farmers are producing organically on more organic certified land and 179 countries report organic agriculture (Willer and Lernoud, 2017). This study has the objective of determining the nutritional value, through the antioxidant capacity, of four groups of vegetables available to Baja California Sur consumers: tomatoes, peppers, citrus fruits and leafy vegetables.

MATERIALS AND METHODS

This study was carried out in May 2018 at Universidad Autónoma de Baja California Sur (UABCS), located in La Paz, Baja California Sur, Mexico. According to Robles (1998[1]), the city of

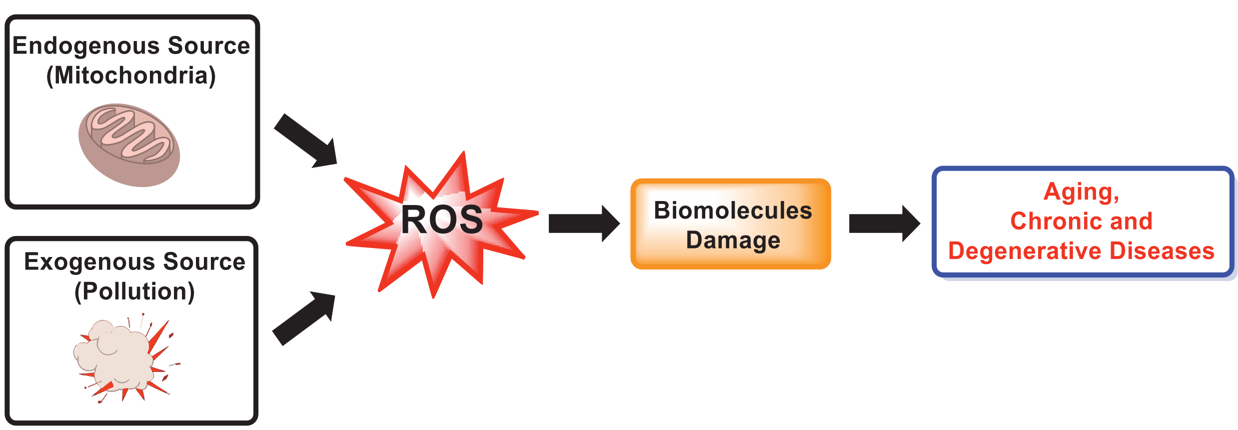

Figure 1. Oxidative stress effects on human health.

[1] Robles Gil-Mestre, S. 1998. El clima de la Ciudad de La Paz, B.C.S. Tesis de Maestría. UNAM, México, D. F. 233 pp.

La Paz is located at the northeastern tip of the La Paz Valley 24° 10’ N and 110° 19’ W at 18.5 m altitude. The fruits and vegetables analyzed were obtained from local markets of the city and were organized into four groups: tomatoes, peppers, citrus and leafy vegetables and subgrouped into conventional, wild and organically produced. The obtained tomatoes were round (conventional, hydroponic), cherry (conventional), saladette (conventional), grape (organic). The obtained peppers were California (conventional), güerito (conventional), poblano (conventional), habanero (conventional), jalapeño (conventional) and bell (organic). The citrus fruits obtained were naranjita (wild), orange (conventional), grapefruit (conventional) and lime (conventional). Finally, the leafy vegetables obtained were lettuce (conventional), spinach (conventional), chard (conventional), purslane (conventional) and quelite (wild).

The evaluated parameter was the antioxidant power of leaves, stem and fruits of the samples mentioned above (*vide supra*). One-hundred grams of the sample were finely ground with 100 mL of distilled water and then carefully vacuum filtered in order to obtain a clear mixture. The obtained mixture was used for measurement of total soluble solids (ºBrix) using a digital refractometer (Hanna, HI 96801). Likewise, the mixture was used to measure pH and electric conductivity using a pH/EC/TDS/Temp tester (Hanna, HI98130). To measure antioxidant capacity, 1 mL serial dilutions of the juice were prepared in methanol. These dilutions were then mixed with 1 mL of a DPPH solution in methanol at 4 mg 100 mL^{-1} concentration. The mixture was then left to stand for 30 min in the dark, and absorbance was obtained in a spectrophotometer (ThermoFisher Scientific, Genesys 10S) at 517 nm (Xie and Schaich, 2014).

The obtained measurements were then compared to a trolox calibration curve constructed using the same DPPH solution mention above and trolox solutions at different concentrations (Figure 2). Results are expressed in milligrams of trolox equivalent g^{-1} fresh fruit or vegetable biomass.

A randomized blocks experimental assay was used and multiple mean comparisons were performed using Tukey HSD $P = 0.05$. The statistical analysis was carried out using a statistics program from the Agronomy Department at the Universidad Autónoma de Nuevo León (Olivares, 2012).

RESULTS AND DISCUSSION

DPPH is a stable free radical, commonly used to evaluate the antioxidant potential of foods (Floegel *et al*., 2011). The higher the ability of a fruit or vegetable sample to turn DPPH purple color to yellow, due to the formation of 1,1-Diphenyl-2-picrylhydrazine, the higher its antioxidant power (Figure 3).

As shown in Table 1, among the group of tomatoes, certified organic grape tomatoes had the highest antioxidant capacity with 1.273 mg trolox equivalents g^{-1} fresh biomass. Round and saladette tomatoes grown conventionally had the lowest antioxidant capacity.

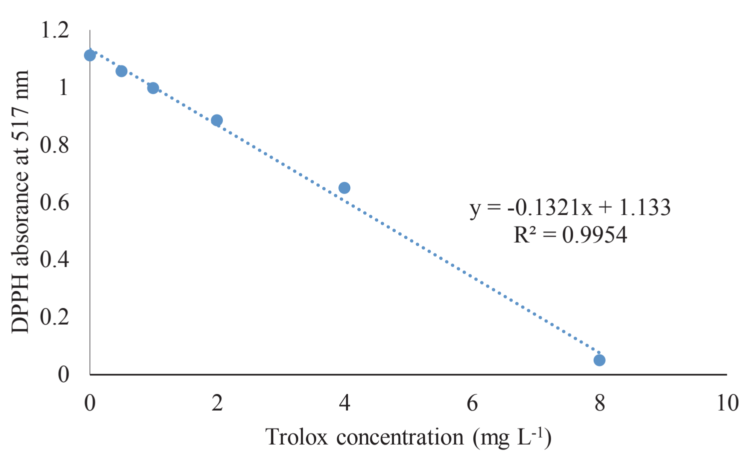

Figure 2. Trolox calibration curve.

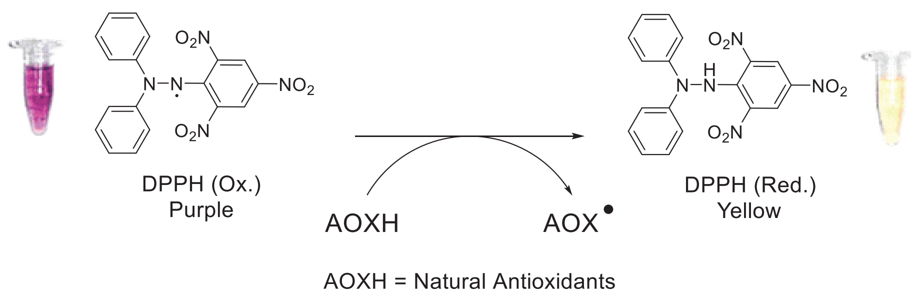

Figure 3. DPPH reaction with natural antioxidants.

Table 1. Antioxidant capacity of four groups of vegetables.

Group	Variety	Electric conductivity	pH	Total soluble solids or °Bx	Antioxidant capacity mg equivalents of trolox per gram
		dS m^{-1}			
Tomatoes					
	Round (conventional)	2.67 c	4.03 a	4.30 d	0.392 c
	Round (conventional hydroponic)	2.39 cd	3.84 ab	5.35 c	0.459 c
	Cherry (conventional)	3.84 b	3.33 d	9.75 a	0.836 b
	Saladette (conventional)	1.86 d	3.63 bc	4.40 d	0.566 c
	Grape (organic)	4.84 a	3.39 cd	6.70 b	1.273 a
Citrus fruits					
	Naranjita (wild)	7.45 a	2.03 a	17.77 a	1.623 a
	Grapefruit (conventional)	3.81 c	3.03 c	12.80 c	1.376 b
	Orange (conventional)	4.20 c	3.31 b	14.27 b	1.446 b
	Lime (conventional)	5.24 b	2.01 d	8.850 d	1.092 c
Peppers					
	California (conventional)	2.89 a	5.77 a	5.05 d	0.299 b
	Güerito (conventional)	3.18 a	5.82 a	4.65 e	0.217 b
	Poblano (conventional)	3.11 a	5.47 b	8.20 b	0.358 b
	Habanero (conventional)	2.67 a	5.38 b	5.20 d	0.268 b
	Jalapeño (conventional)	2.42 a	5.59 ab	6.15 c	0.288 b
	Bell (organic)	2.64 a	4.98 c	9.70 a	1.119 a
Leafy vegetables					
	Quelite (wild)	15.04 b	5.318 cd	7.57 a	1.313 a
	Lettuce (conventional)	2.42 d	5.360 c	1.40 c	0.291 c
	Spinach (conventional)	7.085 d	5.280 d	3.28 b	0.573 b
	Chard (conventional)	8.095 c	5.763 a	3.93 b	0.288 c
	Purslane (conventional)	17.43 a	5.493 b	2.15 c	0.522 b

Values with the same letter in a given column per group are statistically equivalent (Tukey, 0.05).

Regarding the group of peppers, certified organic bell pepper showed the highest antioxidant capacity with 1.119 mg trolox equivalents per g fresh biomass. All other tested peppers (güerito, California, habanero, poblano and jalapeño) showed similar antioxidant capacity that was lower than the organically produced bell pepper. From the citrus group, wild naranjita had 1.623 mg trolox equivalents per gram of fresh biomass, and lime showed the lowest antioxidant capacity. Finally, among the leafy vegetables wild quelite had the highest antioxidant capacity with 1.313 mg trolox equivalents per gram of fresh biomass. Chard and purslane obtained conventionally showed the lowest antioxidant power. All data obtained agree with the studies carried out by De Oliveira *et al.* (2016), who found that organic crops contain higher amounts of phenolic compounds and higher antioxidant capacity than conventional crops.

Interestingly, the content if soluble solids of a given group correlates with the antioxidant capacity, possibly because of water soluble antioxidants like vitamin C (Thaipong *et al.*, 2006). However, among tomato group, the organic grape variety shows higher antioxidant power than conventional cherry which has more total soluble solids. This case could be an example of vegetables with other more potent antioxidants like distinctive phenolic compounds and carotenoids (Lindsay and Astley, 2002). A healthy and balanced diet based on fruits and vegetables that contain high amounts of compounds with antioxidant properties can help reduce cell death in sick patients (Terry *et al.*, 2001) and most importantly, consumption of these fruits and vegetables can prevent development of chronic-degenerative diseases (Hu, 2003; McCullough *et al.*, 2003). A study carried out by Baudry *et al.* (2018) showed an important decrease in cancer risk of French participants that had higher consumption of organic food. This study conducted from 2009 to 2016 considered nearly 70 000 people. An important fact to consider is that organic products are pesticide and synthetic fertilizer free; therefore, consumers are not exposed to possible carcinogenic chemicals such as malathion, parathion, etc., which have been linked to increased cancer risk (Gray *et al*., 2017; Mostafalou and Abdollahi, 2013).

CONCLUSIONS

- Organic certified grape tomato with 1.273 mg trolox equivalent per g of sample presented the highest antioxidant power. Additionally, certified organic bell pepper had the highest antioxidant power with 1.119 mg trolox equivalent per g of sample. Regarding the group of citrus fruits, we found that wild naranjitas had higher antioxidant power with 1.623 mg trolox equivalent per g of sample. Finally, as far as the leafy vegetables group, wild quelites showed the highest antioxidant power with 1.313 mg trolox equivalent per g of sample.
- The results obtained in this study give evidence that the production method has a very important effect on nutritional value. Wild and organic production increases antioxidant capacity of fruits and vegetables as shown the analysis performed in this investigation. Wild production is an interesting source of fruits and vegetables, especially those from regions where stressful climate conditions promote metabolic changes in plants, which protect themselves by producing antioxidant compounds. Agriculture practiced in extreme conditions, such as those in Baja California Sur, could be a strategy to increase the nutritional value of fruits and vegetables. Consumption of these products is undoubtedly a natural strategy that can help to reduce problems related to aging and chronic-degenerative diseases.

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