Capsaicinoids and Vitamin Ci Habanero Chili (Capsicum Chinense) Cultivated in Different Types of Soils from Yucatan Mexico

Rodríguez B Ingrid[1], López D Cindy[2], Morozova Ksenia[3], S Matteo[4] and Ramírez-Sucre Manuel[5]

Keywords: Capsaicinoids, Capsicum chinense, Vitamin C in habanero pepper, Soils from Yucatan

Abstract

Habanero pepper (*Capsicum chinense*)is the main horticultural and commercial speciein the Yucatan Peninsula in Mexico. It is a symbol of pungency withcharacteristics of commercial interest due to its high contents of capsaicinoids thatare believed to vary in conditions of hydric stress.The *Capsicum chinense* plantsgrown in the Yucatan Peninsula obtainedtheappellation of origin based on their unique characteristics due to the particularities of the soils in which they are cultivated. Three main types of soil are used for its cultivation:*K'áankablu'um*, *Box lu'um* or *Ch'ich 'lu'um* (red, black and brown soils, respectively).The interaction of the soil with the plant affects the development of the fruit, since the amount of nutrients, water and salinity have significant effects on the quantity and size of fruit, andin the content of some secondary metabolites. The objective of the present work was to determine the content of capsaicinoids and vitamin C in habanero pepper grown in different types of soils and to evaluate itsrelationship with the ripenessof the pepper. There were significant differences in both, the content of capsaicinoids and vitamin C due to different types of soil and the ripeness of the pepper, the highest content of capsaicinoids were obtained with the orange ripe pepper and red soil.The highest amount of vitamin Cwas found in the red soil in the orange ripe pepper and in those of incomplete ripeness without significant differences between them. The green pepper presented the lowest vitamin C content.

Introduction

Habanero pepper (*Capsicum chinense*) is a symbol of pungency; it hascharacteristics of commercial interest due to its high content of capsaicinoids accumulated in the fruit and is the main horticultural specie commercially exploited in the Yucatan Peninsula in Mexico. The concentration of capsaicinoids in spicy chili varieties varies significantly from each other. They range from 0.003% (dry weight) in lightly spicy varieties to more than 0.3% (dry weight) for heavily spicy varieties.This variation is genetically controlled, but it is also affected by environmental variables such as temperature, light, and soil moisture (Jeeatid et al., 2017; 2018).

The fruits of habanero pepper are also a rich source of vitamin C, reporting changes for this type of fruit ranging from 43 to 247 mg / 100g infresh peppers, reaching a contribution of between 50 to 100% of the daily requirements of this vitamin (Wahyumi et al. 2013). Among other applications of vitamin C we can mention those related to its antioxidant characteristics (Khassaf et al. 2003). The profile and concentration of vitamins of the habanero pepper are influenced by several factors, among them are the amount of light and temperature to which the fruit is subjected, the degree of maturity, the harvesting processes and the type of treatment and storage of the pepper after the harvest (Tamaoki et al. 2003; Chennupati et al. 2011). For *C. chinenese*cultivation three main types of soil are used *K'áankablu'um* (red soils), *Box lu'um* (black soils) or *Ch'ich 'lu'um* (stony soils), all of them are very shallow (< 25 cm deep) and it is a local knowledge that the stony soil is limited in micro and macronutrient contents, as well as poor water retention capacity (Bautista et al., 2005). These soil properties can cause different types of stress to the plants, such as a stress due to potassium (K) deficiency or water stress(Borges et al., 2010; Medina-Lara et al., 2019)

So, the objective of this work was to determine the content of capsaicinoids and vitamin C in the habanero pepper grown in different types of soils and to evaluate the relationship of these contents with the state of maturity of the pepper.

Methods

Determination of capsaicinoids and vitamin C was performed by an Acquity H Class ultra highpressure liquid chromatography equipment (Waters, USA) with a diode array detector (UHPLC-DAD) was usedand an Acquity UPLC HSS C18 column (100 Å, 1.8 µm, 2.1 x 50 mm) (Waters, USA).

Capsaicinoids(capsaicin and dihydrocapsaicin) quantification method was done with a flow rate of 0.2 min-1;column temperature: 27 ° C; amobile phase A: acetonitrile, andphase B: formic acid (0.1%.). A proportion of 60% A with 40% B was used. An injection volume of 2 µL and wavelength of 280 nm was used.The peak for capsaicin was observed at 1.7 minutes and for dihydrocpasaicin at 2.2 minutes.

Vitamin C (ascorbic acid)method conditions were:flow rate of 0.25 ml min-1; column temperature: 27 ° C; isocratic mobile phase made up of water with 0.1% formic acid and an injection volume of 2 µL and wavelength of 244 nm.The extraction process was carried out with 50 mg of habanero pepper

Rodríguez-Buenfil Ingrid1, López-Domínguez Cindy2, Morozova Ksenia3, Scampicchio Matteo4 and Ramírez-Sucre Manuel5
1Center for Research and Assistance in Technology and Design of the State of Jalisco AC (CIATEJ), Mexico.
2,3,4,5Free University of Bolzano, Italy

powder with 4 ml of acetone-water solution (20:80), this mixture was sonicated for 20 min and centrifuged for 30 minutes and finally filtered with 0.2 micron membranes. The peak for vitamin C was observed at 0.75 minutes.

Results and Discussion

Figure 1 shows the content of capsaicinoids in fruits grown in different types of soil and in three degrees of ripeness. The ripefruits had more capasaicinoids in comparison with the other stages of ripeness, as well as those grown in red soil. The highest value of capsaicinoids was 61 mg / g of dried pepperand was obtained with the ripe pepper grown in red soil. The major capsaicinoid found was capsaicin (sixty percent), whilea thirty percent corresponded to dihydrocpasaicin, these proportions behaveconstant regardless of the degree of ripenessof the pepperand the soil where they grow.

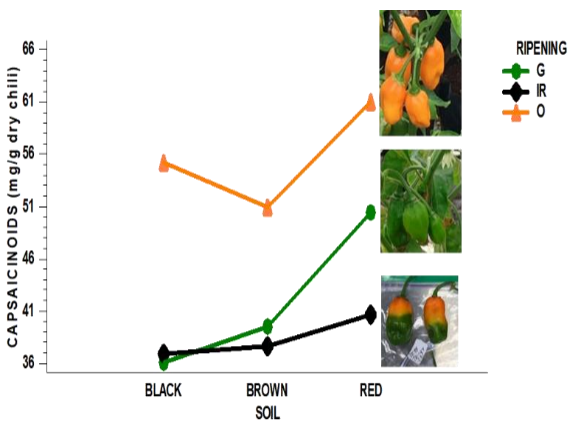

Fig. 1. Capsaicinoids in Habanero pepper grown in different soils and with different degrees of ripeness.IR: Incomplete Ripening; O: Orange or ripe; G: green or immature

Figure 2 shows the content of vitamin C in fruits grown in different types of soil and in three degrees of ripeness. The ripe(O) and incompletely ripe(IR) fruits reachedmore vitamin C in comparison with the immature (G); the lower values appeared in the red soil. The highest value of vitaminC was 0.85mg / g of dried pepperand was obtained with the ripe (O) and incompletely ripe (IR) pepper grown in red soil without differences between them. The green chili presentedthe lowest content of vitamin C.

Fig. 2. Vitamin C in Habanero pepper grown in different soils and with different degrees of ripeness. IR: Incomplete Ripening; O: Orange or ripe; G: green or immature

There was a significant difference in habanero pepper production due to the types of soil.The red soil was the best with almost 14 kilograms of harvested pepper, followed by the brown soil with 6.8 Kg and the black soil with 4.8 Kg.These differences were probably due to the composition in sand (higher in the black soil), clay (higher in the brown soil) and silts (higher in the black soil), and a low availability of nutrients in the brown and black soils due to their high Cation Exchange Capacity (CEC) values, and to differences in nutrient contents (P, N) in soils prior to cultivation. Moreover, the content of capsaicinoids and vitamin C increased when the pepperripefrom green to orange from 51 to 61 mg g-1 of dry chili for capsaicinoids, and from 0.66 to 0.86 61 mg g-1 of dry chili for vitamin C, confirming that both metabolites gradually accumulate in fruits during ripening.

Conclusion

There was a significant effect of the factors tested; soil type and ripening, as well as their interactions on the content of capsaicinoids and vitamin C.The red soil was the best to produce habanero pepper and the highest content of capsaicinoids and vitamin C.The ripe habanero pepper (orange) had the highest content of capsaicinoids and vitamin C regardless of the soil in which it was grown.

Rodríguez-Buenfil Ingrid1, López-Domínguez Cindy2, Morozova Ksenia3, Scampicchio Matteo4 and Ramírez-Sucre Manuel5
1Center for Research and Assistance in Technology and Design of the State of Jalisco AC (CIATEJ), Mexico.
2,3,4,5Free University of Bolzano, Italy

References

- Bautista F, Díaz-Garrido S, Castillo-González M, Zinck JA (2005) Spatial Heterogeneity of the Soil Cover in the Yucatán Karst: Comparison of Mayan, WRB, and Numerical Classifications. Eurasian Soil Science 38(1): S81-S88.
- Borges-Gómez L, Moo-Kauil C, Ruíz-Novelo J, Osalde-Balam M, González Valencia C., Yam Chimal C., Can-Puc F. (2014) Soils used for habanero chili production in Yucatán: predominant physical and chemical characteristics. Agrociencia 48(4): 347-359.
- Chennupati, P., Seguin, P., Liu, W. (2011) Effects of High Temperature Stress at Different Development Stages on Soybean Isoflavone and Tocopherol Concentrations. J. Agric. Food Chem. 59, 24, 13081-13088.
- Jeeatid, N., Suriharn, B., Techawongstien, S., Chanthai, S., Bosland, P. W., & Techawongstien, S. (2018). Evaluation of the effect of genotype-by-environment interaction on capsaicinoid production in hot pepper hybrids (*Capsicum chinense* Jacq.) under controlled environment. Scientia horticulturae, 235, 334-339.
- Jeeatid, N., Techawongstien, S., Suriharn, B., Bosland, P. W., & Techawongstien, S. (2017). Light intensity affects capsaicinoid accumulation in hot pepper (*Capsicum chinense* Jacq.) cultivars. Horticulture, Environment, and Biotechnology, 58(2), 103-110.
- Khassaf, M., McArdle, A., Esanu, C., Vasilaki, A., McArdle, F., Griffiths, R. D., Brodie, D.A., Jackson, M. J. (2003). Effect of Vitamin C Supplements on Antioxidant Defence and Stress Proteins in Human Lymphocytes and Skeletal Muscle. The Journal of Physiology, 549(2), 645 – 652.
- Medina-Lara F., Souza-Perera R., Martínez-Estévez M., Ramírez-Sucre M.O., Rodríguez-Buenfil I.M. and Echevarría Machado Ileana. (2019). Red and Brown Soils Increase the Development and Content of Nutrients in Habanero Pepper Subjected to Irrigation Water with High Electrical Conductivity. HortScience: 54(11):2039-2049.
- Wahyumi, Y., Ballester, A.R., Sudarmonowati, E., Bino, R.J., Bovy, A. G. (2013) Secondary Metabolites of Capsicum Species and Their Importance in the Human Diet. Journal of Natural Products. 76, 783 – 793.

Rodríguez-Buenfil Ingrid1, López-Domínguez Cindy2, Morozova Ksenia3, Scampicchio Matteo4 and Ramírez-Sucre Manuel5
1Center for Research and Assistance in Technology and Design of the State of Jalisco AC (CIATEJ), Mexico.
2,3,4,5Free University of Bolzano, Italy