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THE TASTE-OF-THE-PAST FROM ANCIENT LANDRACES. HOW MODERN NON-ORGANIC BREEDING HAS AFFECTED AROMA QUALITY IN PEPPERS AND TOMATOES

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Abstract: Organic production in many areas of the world are mainly based in modern F1 varieties, particularly vegetables, which have been bred for more intensive, high input production systems, instead to more sustainable/organic systems. In addition, these varieties have been mainly bred for yield, resistances and uniformity, to the detriment of quality and increasing genetic erosion due to the loss of agrobiodiversity. However, nowadays there is an opportunity for ancient landraces and for small and medium farmers in the frame of organic productions systems, as they are expected to show a better adaptation to low-input conditions like organic systems than modern varieties, but also as they may also provide the “taste-of-the-past” that modern varieties lack. In this regard, some studies have revealed that sugars and acids have been lost in most modern varieties of vegetables, but there is not much knowledge about what happened with the volatile fraction, responsible of both aroma and whole flavour during mastication. In the present work we compared the volatile fraction of several varieties of ancient landraces and modern varieties from Oxheart tomatoes and Jalapeno and Numex peppers. Our results indicate that within each varietal type modern breeding has provoked a remarkable loss of volatiles at both qualitative and quantitative levels, which indicates that the tastier flavour and more intense aroma of ancient landraces is mainly due to a richer volatile fraction.

Introduction: Nowadays, most production of vegetables in the Mediterranean area is based in modern F1 hybrids selected for intensive production. High yields, uniformity, resistance to diseases, slow ripening/long lasting traits (for export markets) has provoked the predominance of these varieties in production systems, even in many “organic” export-oriented production systems. However, such predominance has been to the detriment of a plethora of ancient landraces and consequently increased the genetic erosion of such heritage of agrobiodiversity. Luckily, in the last years, most consumers, particularly those committed with local, sustainable and organic production systems, are searching for healthier and tastier products. Even more, they are looking at ancient landraces as some way to recover the taste-of-the-past that they remember in fruits and vegetables decades ago. In addition, most traditional varieties have evolved (and

were bred) under low-input conditions, more similar to the current truly organic production systems. All this offer to landraces: i) the opportunity of being offered to consumers and other value chain agents as high-added value products, ii) to contribute to preserve biodiversity by promoting their use and consumption and iii) to diversify production and increasing social justice by providing local small-medium farmers with highly appreciated varieties. Some works have been done to demonstrate that heirlooms encompass a remarkable diversity in terms of bioactive compounds, particularly in organic systems and also some others have reported a high quality in terms of taste compounds like sugars and acids (Figás et al. 2016, Ribes-Moya et al. 2018). However, the knowledge on the volatile fraction is very scarce. This factor, responsible for aroma, is also essential for “taste” (actually flavor) perception during mastication (i.e. volatiles detected at the retronasal area). Some studies in the last decade have revealed a considerable interspecific and intraspecific diversity in terms of the volatile composition in vegetables like peppers (Rodríguez-Burruezo et al. 2010). By contrast, the knowledge on intra-varietal diversity is still scarce and particularly the impact of modern breeding. In this work we present the results of exhaustive studies on the volatile fraction of traditional versions of tomato and peppers varieties against modern forms of them in order to assess whether modern intensive breeding has affected this flavor-factor and therefore whether the better flavor of ancient varieties is also due to the presence of a volatile quality lost in modern varieties.

Material and methods: A collection of modern, ancient and intermediate cultivars from Oxheart tomatoes (10, *Solanum lycopersicon*) and from Jalapeno (8) and Numex (8) peppers (*Capsicum annuum*) were grown under organic in Marxal dels Moros (Sagunto, Valencia, Spain) in 2018. Fruits were harvested at the most common commercial stages of each type, i.e. fully ripe stage in tomatoes and green ripe stage in peppers. Three samples per cultivar (by mixing 2x2 mm cut pieces from 5 fruits each) were prepared and analysed. The volatile fraction was isolated by means of head space solid phase microextraction (HS/SPME) and analysed through gas chromatography-mass spectrometry (GC-MS), according to the protocols from Rodríguez-Burruezo et al. (2010). The main volatiles were identified by means of their mass spectra and reference compounds and they were quantified by integrating the corresponding GC million peak area units (p.a.u.). A semi-trained panel of 5 persons was also included to assess the whole aroma quality and intensity of the samples. To avoid varietal type bias, the different varietal types were assessed in three different days.

Results: A total of fifty volatiles were found among the oxheart tomato varieties studied, being terpenoids the most predominant (>20), followed by a range of esters (12), aldehydes, and alcohols. Regarding Capsicum peppers, forty volatile compounds were identified among the varieties studied, including twenty terpenoids, ten esters and another ten compounds, including aldehydes, lipoxygenase-derived compounds like the bell pepper pyrazine, methyl salicylate, etc. A considerable qualitative and quantitative differences were found among the studied materials within each species and varietal type. Thus, within tomatoes the highest levels of total volatiles corresponded to ancient oxheart varieties from Valencia, Andalusia, France and Italy, with values ranging from 550 to 6810 p.a.u., while modern F1 only ranged between 53 to 180 p.a.u. In addition, ancient landraces showed a higher number of volatiles, ranging from 25 to 50 compounds, while modern varieties ranged from 15 to 30.

Among peppers, jalapenos showed the most complex and abundant volatile profiles in comparison to Numex peppers, although within each varietal type the results were similar to those observed in tomatoes. Thus, the total amount of volatiles in jalapeno espinalteco landraces was comprised between 645×106 and 8180×106 GC p.a.u. In contrast, the lowest levels in total volatiles were found in modern Jalapeno F1 (Delicias and Jalapa), comprised between 40 and 80 p.a.u., while Jalapeno M, a traditional open pollinated jalapeno, and the semi-wild ancestor Serrano showed intermediate levels, 250-585 p.a.u. Also, the volatile fractions of espinalteco jalapenos included 25 to 40 compounds, while modern F1 showed < 25. A similar trend was observed in Numex peppers, although at a lesser extent than Jalapenos, with ancient

Big Jim Heritage and Conquistador cultivars showing the most complex and quantitatively abundant profiles. This behavior was also found considering the main groups of volatiles and also many individual compounds, like those particularly relevant for the aroma and flavor of unripe peppers, i.e. several terpenoids (3-carene, a-longipinene, a-copaene, b-caryophyllene, a- and b-himachalene), esters (4-methylpentyl-3-methylbutanoate, hexyl 2-methylbutanoate, 4-methylphenyl pentanoate), anad the bell pepper pyrazine and methyl salycilate.

Regarding the taste panels, all panellists detected remarkable differences between most ancient varieties and modern varieties in terms of whole aroma intensity as well as fruity and green/grassy notes, more intense and persistent in the former ones.

Discussion: Our findings have showed that most ancient landraces, within each specific varietal type, usually show more diverse and quantitatively richer composition in volatiles than modern varieties. And this fact has been exhaustively found in two different vegetable species, tomatoes and peppers. These findings reveal that modern breeding has been to the detriment of fruit quality in vegetables, not only in sugars and acids as usually expected, but also in the volatile fraction. This suggest that the “taste-of-the-past” loss in modern F1 is not only a result of lower amounts of sugars and acids due to modern breeding but also particularly due to a remarkable loss of aroma and flavor active volatiles, which are mainly perceived in ancient landraces. Such results reinforce the feeling that ancient landraces are usually tastier and that a range of aroma and flavor notes lie in this biodiversity heritage, offering to small and medium farmers a tool to differentiate their organic production in terms of flavor quality.

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