

## Estimating Fruit Phenol Content in Wild and Interspecific Hybrid Tomatoes *Solanum habrochaites* through Leaf Phenol Content Estimation

Mohammad Hasan Dawood<sup>1\*</sup>

### Abstract

The experiment conducted at the Horticulture Department of the University of Kentucky during the spring and summer of 2020 aimed to examine the phenolic content of different types of tomatoes in detail. The plant materials used in the study included open-pollinated tomato varieties called Zaofen-2, Maglia Rosa, and Black Tomato, as well as a wild tomato accession known as *Solanum habrochaites* (WT-LA2329) and interspecific hybrid plants. The results of the experiment revealed that the phenolic content was found to be higher in the fruits compared to the leaves. The fruit samples exhibited a wide range of phenolic content, varying from 200 to 800  $\mu\text{g g}^{-1}$  of fresh weight. On the other hand, the leaves ranged from 75 to 230  $\mu\text{g g}^{-1}$ . According to leaf phenolic content, both the hybrid varieties and the wild variety WT-LA2329 displayed higher concentrations of phenolic compounds in comparison to the commercial varieties. Notably, the interspecific hybrid family IS-N152 exhibited the highest phenolic concentration in the leaves, measuring 353  $\mu\text{g g}^{-1}$ , which significantly surpassed other genotypes. When it came to the fruit samples, the wild variety WT-LA2329 exhibited the highest phenolic concentration, measuring 819  $\mu\text{g g}^{-1}$ . Conversely, the cultivated tomatoes (Zaofen-2, Maglia Rosa, and Black Tomato) displayed the lowest phenolic concentrations, averaging at  $235 \pm 10.0 \mu\text{g g}^{-1}$ . The phenolic concentrations of the hybrid varieties fell within this range, varying from 230  $\mu\text{g g}^{-1}$  to 354  $\mu\text{g g}^{-1}$ . On average, the phenolic content of the fruit in all hybrid families ( $291 \pm 8.2 \mu\text{g g}^{-1}$ ) was slightly higher than that of commercial varieties. Furthermore, the study found a strong positive correlation ( $r=0.80$ ) between the phenolic content of the leaves and fruits, suggesting a potential causal relationship. These findings highlight the significant differences in phenolic content between wild and cultivated tomato species, with interspecific hybrids showing an increase in phenolic content. Further investigation of phenolic content in early hybrid generations was suggested, as it could help identify individuals with higher phenolic concentrations in their fruit, similar to the wild parent. This line of research may contribute to the development of tomato cultivars with higher phenolic content, desirable due to the potential health benefits of phenolic compounds.

**Keywords:** Wild tomato, *Solanum lycopersicum*, *Solanum habrochaites*, Interspecific hybrid, Phenols, Leaf, Fruits

<sup>1\*</sup>Sorumlu Yazar/Corresponding Author: Mohammad Hassan Dawood, University of Telafer, College of Agriculture, Department of Field Crops, Telafer, Iraq.

E-mail: [mohammadh.dawood@uotelafer.edu.iq](mailto:mohammadh.dawood@uotelafer.edu.iq)  ORCID: 0000-0003-2145-3335

Citation: Dawood, M. H. (2026). Estimating fruit phenol content in wild and interspecific hybrid tomatoes *Solanum habrochaites* through leaf phenol content estimation. *Journal of Tekirdag Agricultural Faculty*, 23(2): 329-336.

©Bu çalışma Tekirdağ Namık Kemal Üniversitesi tarafından Creative Commons Lisansı (<https://creativecommons.org/licenses/by-nc/4.0/>) kapsamında yayınlanmıştır. Tekirdağ 2026

## 1. Introduction

The tomato, scientifically known as *Solanum lycopersicum*, is one of the most widely produced vegetables globally. According to recent data from the Food and Agriculture Organization (FAO) of the United Nations (FAOSTAT, 2023), the total worldwide tomato production exceeded 186 million tons in 2023. China remains the largest producer, followed by India, Turkey, and the United States (FAOSTAT, 2023). As the global population continues to grow, tomato consumption is also on the rise, with significant variations in per capita consumption across countries (Mrabet, 2023). As the global population grows, tomato consumption is increasing, and the amount consumed per person varies greatly across countries. From an agricultural standpoint, tomatoes are widely regarded as the second most significant vegetable crop, following potatoes. They have a versatile growth habit and can be cultivated in various environments, including both greenhouses and open fields. This adaptability contributes to their widespread cultivation and popularity among farmers. Tomatoes are valued for their nutritional benefits, culinary versatility, and economic importance in the agricultural sector (Çinkılıç et al., 2014; Turhan and Özmen, 2021; USDA, 2022).

Phenolic compounds, including flavonoids, phenolic acids, and tannins, represent a prominent group of bioactive constituents and secondary metabolites present in fruits, vegetables, and grains. These compounds exhibit widespread distribution in plants and have garnered significant attention due to their remarkable antioxidant properties (Balasundram et al., 2006; Garcia-Salas et al., 2010; Keskin et al., 2020). Apart from lycopene, the red pigment found in tomatoes, various other phenolic acids possess antioxidant capabilities and serve as essential components of the human diet (Bahorun et al., 2004; Naczki and Shahidi, 2006). Furthermore, phenolics hold potential roles in plant development, reproduction, and defense against diseases (Aktaş and Aydın, 2022; Lattanzio et al., 2006).

While the phenolic composition of tomato fruits in Mauritius has been previously explored (Bahorun et al., 2004), and extensive studies exist on phenolics in cultivated tomatoes (Buta and Spaulding, 1997; Martínez-Valverde et al., 2002), no research has systematically investigated interspecific hybrid tomatoes—particularly the relationship between leaf and fruit phenolic content. This gap is critical because leaves, as metabolically active tissues, may serve as early indicators of fruit phenolic accumulation (Dadáková et al., 2020). Understanding this linkage could accelerate breeding programs aiming to enhance phenolic content, which is associated with improved nutritional and stress-resistant traits (Chaudhary et al., 2019). Mauritius was selected due to its unique agroclimatic conditions, which influence secondary metabolite production (Gahukar, 2018). By comparing phenolic profiles of interspecific hybrids (e.g., wild introgressions like *S. habrochaites*) with commercial cultivars, this study provides insights into whether hybrids better retain high phenolic levels under tropical cultivation—a key consideration for developing climate-resilient, nutrient-dense tomatoes (Felföldi et al., 2021).

## 2. Materials and Methods

### 2.1. Plant materials

The spring and summer of 2020 witnessed the execution of an experiment at the Horticulture Department of the University of Kentucky. The study incorporated various plant materials, including open-pollinated tomato varieties such as Zaofen-2, Maglia Rosa, and Black Tomato. Additionally, a wild tomato accession known as *S. habrochaites* (WT-LA2329), and interspecific hybrid plants were also utilized. The interspecific hybrid population was created by crossing the wild tomato relative WT-LA2329, which possessed green fruits and insect resistance, with Zaofen-2. Specifically, the interspecific hybrid plants employed in this experiment were carefully selected from five BC4F3 families (IS-N122, IS-IS-N152, IS-N166, IS-O35, and IS-O37) and one BC3F3 family (IS-F55). The seeds of all these lines were germinated in an incubator on moist filter paper, maintaining a temperature of 26°C. After the emergence of radicles, the seeds were planted in 72-cell trays filled with ProMix BX. Subsequently, after six weeks, the seedlings were transplanted into a field of Maury silt loam at the Horticulture Research Farm in Lexington, Kentucky, USA. The transplanting and field production procedures adhered to the recommended cultural methods outlined in ID-36 (University of Kentucky Cooperative Extension Service, 2019). On August 30, 2020, leaflet tissue and fruit samples were collected for analysis. The selection of fruits was based on their ripeness. The selection of leaf tissue samples was based on the variation in the concentration of a specific sesquiterpene hydrocarbon, 7-epizingiberene, which was categorized as high, medium, or low. The presence and abundance of this compound are linked to resistance against insects and spider mites in this particular tomato population, which is being bred based on findings from our previous

experiment (Dawood and Snyder, 2021).

## 2.2. The quantification of overall phenolic content in the foliage and fruits of tomato plants.

Leaf samples were collected by carefully excising tissue measuring 10 cm<sup>2</sup> from the central part of three leaflets located at the third and/or fourth positions on each plant. The samples were taken from plants at the onset of the flowering stage to ensure consistency in developmental maturity. To maintain uniformity, leaflets were selected from the upper half of the plant, deliberately avoiding very young or fully mature leaves, as these could introduce variability in phenolic concentrations. The collected tissue was then weighed and transferred into a 20 mL scintillation vial. Subsequently, a 4 mL 80% ethanol (v/v) was added to the vial. To facilitate mixing, the vials were shaken vigorously for one minute using a vortex mixer. After the thorough mixing process, the vials were stored in a refrigerator for 24 hours to minimize oxidation. To determine the overall phenolic content, the assessment was performed using the Folin-Ciocalteu Reagent, following the methodology outlined by. For precise quantification of phenolic compounds, a standard curve of tannic acid was employed. Moving on to the analysis of phenolic content in the tomato fruits, a total of fifteen fully ripe fruits were collected from each of the five to seven plants within the corresponding family. The collected fruits were weighed and meticulously rinsed with distilled water. Subsequently, the tomato fruits were diced and blended for exactly one minute using an Oster® Blender. From the resulting mixture, 50 mL was filtered through Whatman No. 4 filter paper. The evaluation of phenolic content in the fruit samples followed the same procedure as that used for analyzing the leaf tissue. For consistency, 2–3 ripe fruits were carefully collected from each replicate, ensuring uniformity in size and ripeness to minimize variability. The fruits were sampled from the central region of each plant, with priority given to those at the same developmental stage, as this directly influences phenolic concentrations (de Sena Fernandes et al., 2014; Rigano et al., 2016).

## 2.3. Data analysis

The data collected was subjected to statistical analysis using two software tools, Microsoft Excel 2019, and SAS software (version 9.4; SAS Institute, Cary, NC). To determine the relationship between the total phenolic content of leaves and fruits, Pearson correlation coefficients were calculated. Additionally, an analysis of variance (ANOVA) was performed to compare the phenolic content of fruits and leaves in both interspecific-hybrids and commercial tomato varieties. This allowed for a comprehensive examination of the phenolic content in different parts of the tomato plant, considering the influence of tomato variety.

## 3. Results and Discussion

### 3.1. Phenolic content in leaves

The results presented in *Figure 1* provide a comprehensive overview of the total phenolic content in the leaves of various tomato genotypes, including commercial varieties (Cul), interspecific hybrids (IS), and wild tomatoes (WT). The data reveal significant differences in phenolic content among these genotypes, highlighting the influence of genetic background on secondary metabolite production.

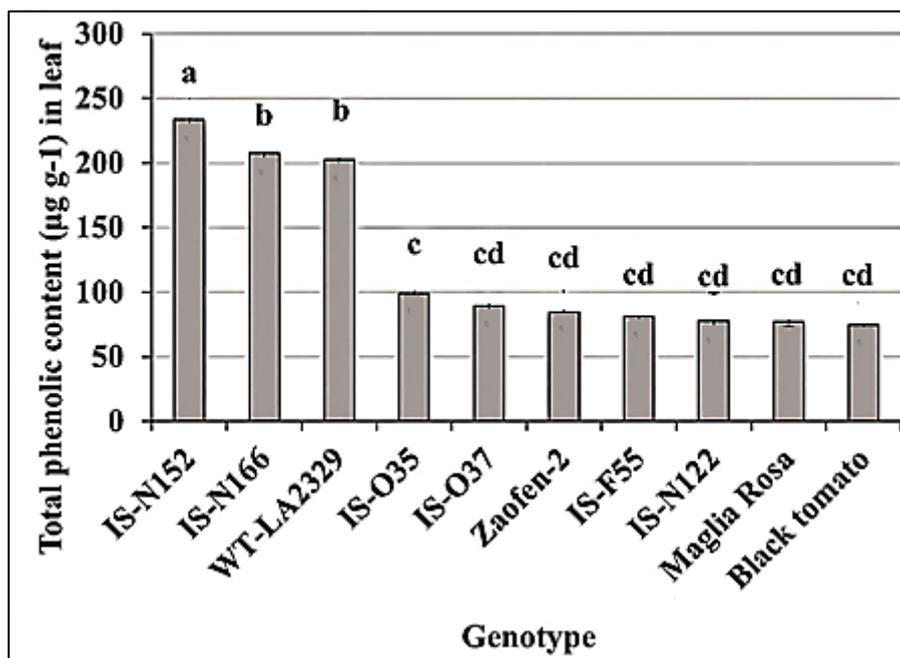
In *Figure 1*, the total phenolic content is expressed as  $\mu\text{g g}^{-1}$  dry weight of leaf tissue. The genotype IS-N152, an interspecific hybrid derived from crossing a wild tomato (WT-LA2329) with a cultivated tomato (Zaofen-2), showed the highest average phenolic content, measuring  $233.58 \mu\text{g g}^{-1}$ . This suggests that IS-N152 possesses a robust capacity for synthesizing phenolic compounds, likely due to its genetic makeup inherited from both wild and cultivated parents. Closely following IS-N152 is another interspecific hybrid, IS-N166, which demonstrated an average phenolic content of  $207.67 \mu\text{g g}^{-1}$ . These high phenolic levels in interspecific hybrids indicate that crossbreeding can enhance the accumulation of beneficial secondary metabolites.

The wild tomato genotype, WT-LA2329, also showed a relatively high phenolic content, averaging  $202.47 \mu\text{g g}^{-1}$ . This result supports with the general understanding that wild plants often accumulate higher levels of secondary metabolites as part of their natural defence mechanisms against environmental stressors such as pests, pathogens, and UV radiation. In contrast, some interspecific hybrids displayed considerably lower phenolic contents. For example, IS-O35 and IS-O37 had average phenolic contents of  $98.9 \mu\text{g g}^{-1}$  and  $89.49 \mu\text{g g}^{-1}$ , respectively. These lower values suggest that certain combinations of parental genes may not favor the efficient biosynthesis or accumulation of phenolic compounds.

Among the commercial varieties, Zaofen-2 showed an average phenolic content of 84.39  $\mu\text{g g}^{-1}$ , which was notably lower than that of the interspecific hybrids and wild tomato. This outcome emphasises the potential trade-offs between agronomic traits (e.g., yield, fruit quality) and secondary metabolite production in cultivated varieties, as breeding programs often prioritize traits like disease resistance and productivity over secondary metabolite accumulation.

Interestingly, several other interspecific hybrids, including IS-F55, IS-N122, Maglia Rosa, and Black Tomato, displayed relatively similar and low average phenolic contents, ranging from 81.22  $\mu\text{g g}^{-1}$  to 74.9  $\mu\text{g g}^{-1}$ . These results highlight the variability in phenolic accumulation even among hybrids derived from the same parental crosses, suggesting that specific genetic interactions or environmental factors may play a role in modulating phenolic biosynthesis.

These outcomes suggest that there are variations in the leaf phenolic content within different tomato genotypes (Scarano et al., 2020). The interspecific hybrids (IS) and wild tomatoes (WT) demonstrated relatively higher phenolic content compared to the commercial varieties (Cul). This indicates that genetic factors and the presence of wild tomato ancestors might contribute to the variation in phenolic content observed among the tested genotypes (Rosa-Martínez et al., 2023). Further discussions and investigations could focus on understanding the underlying genetic mechanisms responsible for these variations in phenolic content, as well as exploring the potential health benefits and agricultural implications of higher phenolic content in tomato leaves. The domestication process in plants, including tomatoes, has been shown to significantly alter phenolic content, often resulting in reduced levels compared to wild relatives due to selection for traits like yield and size (Pesaresi et al., 2014). For instance, studies indicate that wild tomato species (*Solanum pimpinellifolium*) contain higher concentrations of phenolics than cultivated varieties (*Solanum lycopersicum*), which may be linked to their enhanced stress resistance (Tieman et al., 2017). Further discussions and investigations could focus on understanding the underlying genetic mechanisms responsible for these variations in phenolic content, as well as exploring the potential health benefits and agricultural implications of higher phenolic content in tomato leaves. This includes examining how specific genes regulating secondary metabolite pathways are affected during domestication (Liu et al., 2019) and assessing whether breeding programs can reintroduce desirable traits without compromising productivity. Additionally, research into the antioxidant properties of phenolics highlights their role in human health, suggesting opportunities to develop nutrient-rich crops (Pérez-Jiménez et al., 2010).



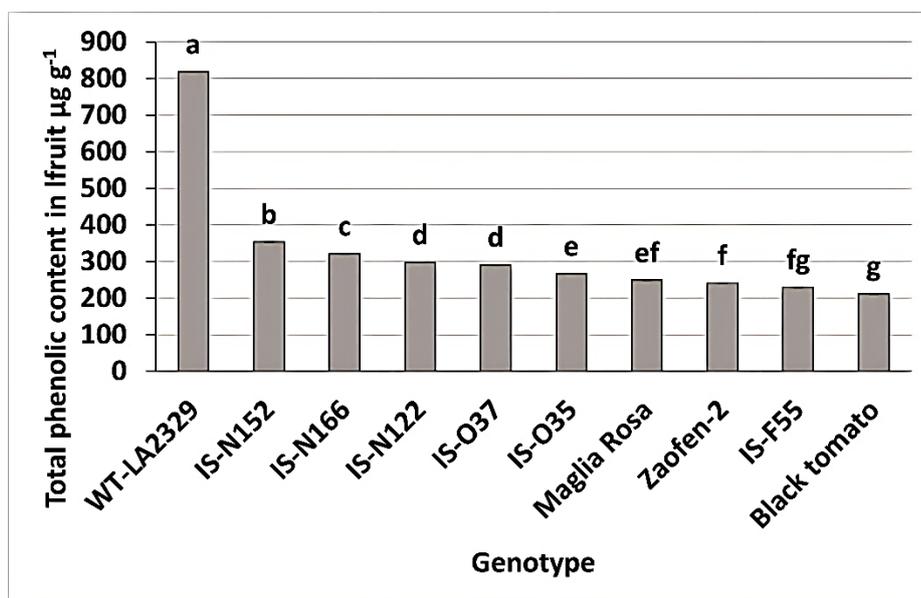
**Figure 1.** Phenolic Content in leaflet of three open-pollinated tomato varieties (Zaofen-2, Maglia Rosa, and Black Tomato) and six interspecific hybrids (IS-N122, IS-IS-N152, IS-N166, IS-O35, IS-O37, and IS-F55) derived from crossing a wild tomato (WT-LA2329) and cultivated tomato (Zaofen-2)

### 3.2. Phenolic content in fruits

In Figure 2, the wild tomato genotype WT-LA2329 showed the highest average phenolic content in fruits, measuring  $818.54 \mu\text{g g}^{-1}$ . This result suggests that WT-LA2329 possesses a significantly higher concentration of phenolic compounds compared to the other genotypes studied. Among the interspecific hybrids, IS-N152 showed the next highest average phenolic content ( $353.82 \mu\text{g g}^{-1}$ ), next to IS-N166 ( $321.58 \mu\text{g g}^{-1}$ ), IS-N122 ( $297.72 \mu\text{g g}^{-1}$ ), IS-O37 ( $291.06 \mu\text{g g}^{-1}$ ), and IS-O35 ( $266.7 \mu\text{g g}^{-1}$ ). These results indicate that interspecific hybrids also accumulate substantial levels of phenolic compounds, although their concentrations are notably lower than those observed in the wild tomato genotype. In contrast, commercial varieties such as Maglia Rosa ( $249.11 \mu\text{g g}^{-1}$ ), Zaofen-2 ( $240.98 \mu\text{g g}^{-1}$ ), IS-F55 ( $229.8 \mu\text{g g}^{-1}$ ), and Black Tomato ( $212.03 \mu\text{g g}^{-1}$ ) showed relatively lower phenolic contents. This pattern highlights a general drift where cultivated varieties tend to have lower phenolic content compared to both wild tomatoes and interspecific hybrids.

The observed differences in phenolic content among the genotypes can be attributed to genetic differences and environmental factors. Wild tomatoes, adapted to diverse and often stressful environments, likely evolved to produce higher levels of phenolic compounds as part of their natural defense mechanisms against pests, pathogens, and UV radiation. Interspecific hybrids, which inherit traits from both wild and cultivated parents, may retain some of these defensive capabilities, although at reduced levels compared to their wild counterparts. Cultivated varieties, on the other hand, have been selected over generations for traits such as yield, fruit size, and flavor, which may have come at the expense of secondary metabolite production like phenolics.

From a health perspective, phenolic compounds are widely recognized for their antioxidants, anti-inflammatory, and antimicrobial properties, making them beneficial for human health. While not all types of phenolic compounds are equally effective, the overall presence of high phenolic content in a food source is generally associated with enhanced nutritional value and potential health benefits (Rubatzky and Yamaguchi, 2012). The higher phenolic content found in wild tomatoes and interspecific hybrids, as demonstrated in this study, suggests that these genotypes may offer greater potential for providing health-promoting properties compared to commercial varieties. These results agreed with the research indicating that phenolic-rich plant materials can contribute to reducing the risk of chronic diseases such as cardiovascular disorders, cancer, and neurodegenerative conditions (Domínguez et al., 2020; Jaglan et al., 2022; Shahidi et al., 2019).



**Figure 2.** Phenolic content in fruit of three open-pollinated tomato varieties (Zaofen-2, Maglia Rosa, and Black Tomato) and six interspecific hybrids (IS-N122, IS-IS-N152, IS-N166, IS-O35, IS-O37, and IS-F55) derived from crossing a wild tomato (WT-LA2329) and cultivated tomato (Zaofen-2)

### 3.3. Correlation between total phenolic content in fruit and total phenolic content in leaves

The correlation analysis (Table 1) revealed a moderately strong positive correlation ( $r = 0.80$ ,  $P < 0.0001$ ) between the phenolic content of leaves and fruits. While this suggests a potential predictive relationship, caution is warranted in directly using leaf phenolic content to estimate fruit phenolic content with high confidence. The observed correlation implies shared regulatory mechanisms or common influencing factors, such as genetic pathways or biochemical processes governing phenolic synthesis in both tissues (Carvalho Lemos et al., 2019; Ilahy et al., 2019; Kolton et al., 2022). However, additional validation—including larger datasets or mechanistic studies—would be necessary to establish a robust predictive model. Thus, while the correlation supports a biological linkage, its utility for precise prediction requires further investigation.

**Table 1. Correlation between Total Phenolic Content in Fruit and Total Phenolic Content in Leaves**

Variable	Total phenolic content $\mu\text{g g}^{-1}$ fruit	Total phenolic content $\mu\text{g g}^{-1}$ in leaf
Total phenolic content $\mu\text{g g}^{-1}$ in fruit	1	
<i>p</i> -value	0.0001	
Total phenolic content $\mu\text{g g}^{-1}$ in leaf	0.80	1

Based on these initial findings, it seems that there is a significant disparity in the phenolic content of fruit between the wild and cultivated species, which are the two parents of the interspecific population. Therefore, it is not surprising that the phenolic content in the fruit of interspecific hybrids was somewhat higher than that found in the commercial parent. This study offers a snapshot of a self-pollinated population, specifically an F3 generation resulting from three consecutive self-pollinations of a relatively advanced backcross generation, either BC3 or BC4. Considering the preliminary results presented here, conducting a more comprehensive investigation into the variation of phenolic content in the population, particularly in earlier backcross generations, could reveal individuals with significantly higher concentrations of phenolics in their fruit, concentrations more similar to those observed in the wild parent.

#### 4. Conclusions

The recent research findings indicate that interspecific hybrid tomatoes contain a greater amount of total phenolic compounds compared to open pollinated varieties of tomatoes (*S. lycopersicum*). Furthermore, the wild tomato relative, WT-LA2329, exhibited significantly higher levels of total phenolic content than both varieties and hybrids. Moreover, there was a positive correlation between the total phenolic content in the fruits and leaves of the tomatoes, implying that the phenolic content in the leaf tissue could serve as an early indicator for selecting fruits with high phenolic content in future breeding programs. To validate these findings, further investigations are required. It is also necessary to explore the interspecific population to identify plants that may yield fruits with even higher phenolic concentrations than those observed in the BC4F3 hybrids. These preliminary results offer promising prospects for the development of tomatoes with enhanced phenolic content. Such improvements could potentially contribute to enhancing human diets and augmenting the plants resistance against diseases.

#### Acknowledgment

The author extend his gratitude to Professor George F. Antonious from the Division of Environmental Studies at Kentucky State University's College of Agriculture, Communities, and the Environment for his valuable support. He also thankful for the technical aid provided by Belinda Labadie during the execution of this research.

#### Ethical Statement

There is no need to obtain permission from the ethics committee for this study.

#### Conflicts of Interest

We declare that there is no conflict of interest between us as the article authors.

#### Authorship Contribution Statement

Concept: Dawood, M. H.; Design: Dawood, M. H.; Data Collection or Processing: Dawood, M. H.; Statistical Analyses: Dawood, M. H.; Literature Search: Dawood, M. H.; Writing, Review and Editing: Dawood, M. H.

## References

- Aktaş, H. and Aydın, G. (2022). Determination of the response of wild and cultivated tomato genotypes to some disease and pests by molecular markers. *Horticultural Studies*, 39(1): 15-21.
- Bahorun, T., Luximon-Ramma, A., Crozier, A. and Aruoma, O. I. (2004). Total phenol, flavonoid, proanthocyanidin and vitamin C levels and antioxidant activities of Mauritian vegetables. *Journal of the Science of Food and Agriculture*, 84(12): 1553-1561.
- Balasundram, N., Sundram, K. and Samman, S. (2006). Phenolic compounds in plants and agri-industrial by-products: Antioxidant activity, occurrence, and potential uses. *Food Chemistry*, 99(1): 191-203.
- Buta, J. G. and Spaulding, D. W. (1997). Endogenous levels of phenolics in tomato fruit during growth and maturation. *Journal of Plant Growth Regulation*, 16(1): 43-46.
- Carvalho Lemos, V., Reimer, J. J. and Wormit, A. (2019). Color for life: Biosynthesis and distribution of phenolic compounds in pepper (*Capsicum annum*). *Agriculture*, 9(4): 81: 29.
- Chaudhary, J., Khatri, P., Singla, P., Kumawat, S., Kumari, A., Vinaykumar, R., Vikram, A., Jindal, S. K., Kardile, H., Kumar, R., Sonah, H and Deshmukh R. (2019). Advances in omics approaches for abiotic stress tolerance in tomato. *Biology*, 8(4): 90.
- Çinkılıç, H., Çinkılıç, L., Varış, S. and Kubaş, A. (2014). Greenhouse vegetable growing and its problems in Thrace Region. *Journal of Tekirdag Agricultural Faculty*, 11(2): 1-10.
- Dadáková, K., Heinrichová, T., Lochman, J. and Kašparovský, T. (2020). Production of defense phenolics in tomato leaves of different age. *Molecules*, 25(21): 4952.
- Dawood, M. and Snyder, J. C. (2021). Can spectrophotometry be used to quantify zingiberene sesquiterpenoids in tomato leaflet extracts? *Agriculture*, 11(11): 1037.
- de Sena Fernandes, M. E., Fernandes, F. L., Silva, N. O., da Silva, D. J. H., Pinto, F. G. and Ramos, R. S. (2014). Selection of tomato hybrids with zingiberene concentration for breeding programs to pest resistance. *Journal of Agricultural Science*, 6(6): 148.
- Domínguez, R., Gullón, P., Pateiro, M., Munekata, P. E. S., Zhang, W. and Lorenzo, J. M. (2020). Tomato as potential source of natural additives for meat industry. A review. *Antioxidants*, 9(1): 73.
- FAOSTAT (2023). Food and agriculture data. Food and Agriculture Organization of the United Nations. <http://faostat.fao.org>
- Felföldi, Z., Ranga, F., Socaci, S. A., Farcas, A., Plazas, M., Sestras, A. F., Vodnar, D. C., Prohens, J. and Sestras, R. E. (2021). Physico-chemical, nutritional, and sensory evaluation of two new commercial tomato hybrids and their parental lines. *Plants*, 10(11): 2480.
- Gahukar, R. T. (2018). Management of pests and diseases of important tropical/subtropical medicinal and aromatic plants: A review. *Journal of Applied Research on Medicinal and Aromatic Plants*, 9: 1-18.
- Garcia-Salas, P., Morales-Soto, A., Segura-Carretero, A. and Fernández-Gutiérrez, A. (2010). Phenolic-compound-extraction systems for fruit and vegetable samples. *Molecules*, 15(12): 8813-8826.
- Ilahy, R., Tlili, I., Siddiqui, M. W., Hdider, C. and Lenucci, M. S. (2019). Inside and beyond color: Comparative overview of functional quality of tomato and watermelon fruits. *Frontiers in Plant Science*, 10, 769.
- Jaglan, P., Buttar, H. S., Al-bawareed, O. A. and Chibisov, S. (2022). Potential health benefits of selected fruits: Apples, blueberries, grapes, guavas, mangos, pomegranates, and tomatoes. In: *Functional Foods and Nutraceuticals in Metabolic and Non-Communicable Diseases*, Ed(s): Singh, R. B., Watanabe, S. and Isaza, A., Elsevier.
- Keskin, L., Paksoy, M., and Türkmen, Ö. (2020). Some morphological characteristics of gene pool from the hybridization of local tomato genotypes and some commercial types. *Alinteri Journal of Agriculture Science*, 35(1): 113-119.
- Kořton, A., Długosz-Grochowska, O., Wojciechowska, R. and Czaja, M. (2022). Biosynthesis regulation of folates and phenols in plants. *Scientia Horticulturae*, 291, 110561.
- Lattanzio, V., Lattanzio, V. M. T. and Cardinali, A. (2006). Role of phenolics in the resistance mechanisms of plants against fungal pathogens and insects. *Phytochemistry: Advances in Research*, 66(2): 23-67.
- Liu, J., Fernie, A. R. and Yan, J. (2019). The past, present, and future of maize improvement: Domestication, genomics, and functional genomic routes toward crop enhancement. *Plant Communications*, 1(1): 100010.
- Martínez-Valverde, I., Periago, M. J., Provan, G., and Chesson, A. (2002). Phenolic compounds, lycopene and antioxidant activity in commercial varieties of tomato (*Lycopersicon esculentum*). *Journal of the Science of Food and Agriculture*, 82(3): 323-330.
- Mrabet, R. (2023). Sustainable Agriculture for Food and Nutritional Security. In: *Sustainable Agriculture and the Environment*, Ed(s): Farooq, M., Gogoli N., Pisante, M., Elsevier.
- Naczka, M. and Shahidi, F. (2006). Phenolics in cereals, fruits and vegetables: Occurrence, extraction and analysis. *Journal of Pharmaceutical and Biomedical Analysis*, 41(5): 1523-1542.
- Pérez-Jiménez, J., Neveu, V., Vos, F. and Scalbert, A. (2010). Identification of the 100 richest dietary sources of polyphenols: an application of the Phenol-Explorer database. *European Journal of Clinical Nutrition*, 64(S3): S112-S120.

- Pesaresi, P., Mizzotti, C., Colombo, M. and Masiero, S. (2014). Genetic regulation and structural changes during tomato fruit development and ripening. *Frontiers in Plant Science*, 5, 124.
- Rigano, M. M., Raiola, A., Docimo, T., Ruggieri, V., Calafiore, R., Vitaglione, P., Ferracane, R., Frusciante, L. and Barone, A. (2016). Metabolic and molecular changes of the phenylpropanoid pathway in tomato (*Solanum lycopersicum*) lines carrying different *Solanum pennellii* wild chromosomal regions. *Frontiers in Plant Science*, 7, 1484.
- Rosa-Martínez, E., Bovy, A., Plazas, M., Tikunov, Y., Prohens, J. and Pereira-Dias, L. (2023). Genetics and breeding of phenolic content in tomato, eggplant and pepper fruits. *Frontiers in Plant Science*, 14, 989.
- Rubatzky, V. E. and Yamaguchi, M. (2012). *World Vegetables: Principles, Production, and Nutritive Values*. Springer Science & Business Media, New York, NY, U. S. A.
- Scarano, A., Olivieri, F., Gerardi, C., Liso, M., Chiesa, M., Chieppa, M., Frusciante, L., Barone, A., Santino, A. and Rigano, M. M. (2020). Selection of tomato landraces with high fruit yield and nutritional quality under elevated temperatures. *Journal of the Science of Food and Agriculture*, 100(6): 2791-2799.
- Shahidi, F., Varatharajan, V., Oh, W. Y. and Peng, H. (2019). Phenolic compounds in agri-food by-products, their bioavailability and health effects. *Journal of Food Bioactives*, 5(1): 57-119.
- Tieman, D., Zhu, G., Resende, M. F. R., Lin, T., Nguyen, C., Bies, D., Rambla, J. L., Beltran, K. S. O., Taylor, M., Zhang, B., Ikeda, H., Liu, Z., Fisher, J., Zemach, I., Monforte, A., Zamir, D., Granell, A., Kirst, M., Huang, S. and Klee, H. (2017). A chemical genetic roadmap to improved tomato flavor. *Science*, 355(6323): 391-394.
- Turhan, A. and Özmen, N. (2021). Effects of chemical and organic fertilizer treatments on yield and quality traits of industrial tomato. *Journal of Tekirdag Agricultural Faculty*, 18(2): 213-221.
- University of Kentucky Cooperative Extension Service. (2019). Vegetable Production Guide for Commercial Growers (Publication ID-36). <https://publications.ca.uky.edu/files/ID36.pdf>
- USDA (2022). Food Availability (Per Capita). U. S. Department of Agriculture. <https://www.ers.usda.gov/data-products/food-availability-per-capita-data-system/food-availability-documentation/> (Accessed Date: 23.09.2022)