17th ISHS Symposium on Processing Tomato

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Abstract Book

Budapest, 9–12 June 2024


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17th ISHS Symposium on Processing Tomato

ISHS International Society for Horticultural Science

Welcome to Budapest

We are pleased to welcome in Budapest for the 17th ISHS Symposium on the Processing Tomato.

The Symposium is a unique forum that focuses on addressing key scientific questions and issues related to the entire tomato processing sector, from field (production for industrial purposes, applied ecophysiology, agronomy, biotic and abiotic stress resistance, genetics applied to industrial food system) to fork (organoleptic and nutritional food quality, smart quality control processes, healthy food, high quality cultivars).

Holding the symposium in parallel with the 15th World Processing Tomato Congress, helps bringing together academics, researchers and students with growers, processors and business professionals working in the processing tomato industry. This unique setup within the ISHS symposia has been a major success story ever since the first world processing tomato congress in Avignon (France) in 1989 and the creation of WPTC in 1998 at Pamplona (Spain).

Our call for papers attracted 69 abstract submissions from 15 different countries. This confirms the keen interest and enthusiasm the scientific community has for research in the fields of processing tomatoes. The ISHS symposium programme has been arranged into 8 oral sessions centered on the following major topics: "Irrigation management", "Automation and precision farming, and resilient crop management", "Alternaria Workshop", "Pest, plant diseases and resistance breeding", "Analysis and products", "Functionalized tomato products (FunTomP project)", a joint session with the congress on "The future of Food" and a Poster session for one-to-one discussions with the research authors.

Full papers for the majority of the oral and poster presentations will be collated in a special issue of *Acta Horticulturae* which will be available directly from ISHS in a few months.

We would like to thank the presenters, session chairs and members of the Scientific and Organising Committees and all sponsors for making this event possible and in particular The Morning Star Company for providing 6 « Adopt a scientist » grants enabling young researchers to get the necessary funding to attend the event and present their work.

Our aim is to stimulate discussion and foster new collaborative ventures to ensure a bright future for the tomato processing industry. We hope that you will find the event both interesting and enjoyable.

The Symposium Conveners

Lajos Helyes, Zoltán Pék and Luca Sandei

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Symposium programme

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Monday, 10 June

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08:00	**Registration**		
09:00	**Congress & Symposium joint opening ceremony (in Congress hall)**		
	Session 1: Congress & Symposium joint session (in congress hall)- The future of food Moderator: Jason Fritsch		
	Emerging trends in agriculture Ryan Avery *(Bayer Vegetable Seeds)*		
	Reimagining our food systems: Accelerating transformation to better sustain our planet and its people Magdalena Psuja *(TetraPak)*		
10:30	**Coffee break**		
11:00	**Session 2: Irrigation Management** Moderators: Matthew Stewart & Lajos Helyes		
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	Use of irridesk automatic irrigation system to management deficit irrigation strategies in processing tomato Carlos Campillo Torres *(CICYTEX)*	22	41
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14:00	**Session 3: Automation and precision farming, and resilient crop management** **Moderators:** Zoltán Pék & Carlos Campillo		
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	The long-term sustainability of the California processing tomato production; some disturbing observations and potential solutions Andrew Watson *(Food Systems International Corporation)*	2	22
16:30	**Coffee break**		
17:00	**Session 4: Alternaria workshop** **Moderators:** Luca Sandei & Sofia Stilwell		
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10:00	**Coffee break**		
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Abstracts

K | Oral

Toxicity of *Alternaria* mycotoxins: an overview of current knowledge

Dr. Thierry Gauthier
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Alternaria spp. mycotoxins are mainly found in fruit and vegetables and their by-products such as tomatoes and tomato processing products. Among the mycotoxins produced by *Alternaria* species, alternariol (AOH), methyl ether alternariol (AME) and tenuazonic acid (TeA) are the toxins with the highest prevalence rate. Additionally, tentoxin (TEN) is more specifically present in tomato juice and altenuene (ALT) in tomato paste. To date, toxicity studies have focused on AOH, AME and TeA. Several data show a similar impact of AOH and AME on the viability of human cells. In addition, micromolar concentrations of AOH and AME have been shown to produce genotoxic effects. The genotoxicity of AOH and AME is linked to their ability to interfere with topoisomerases. Unlike AME, AOH also has the property of stabilizing the DNA-topoisomerase I and II complex, with greater efficiency for the II isoenzyme, giving it the qualification of topoisomerase poison. AOH has immunosuppressive properties. Indeed, AOH is able to induce a reduction in the pro-inflammatory response in human macrophages as well as in human intestinal cells stimulated by LPS. AOH, which has a similar structure to estrogenic compounds, shows agonist properties for the ER receptors and in human endometrial cells, but still 10,000 times less than 17 estradiol. TeA displays lower cytotoxic potency than AOH and AME. TeA inhibits protein synthesis by preventing the release of newly synthesized proteins from the ribosome. The few data available for ALT and TEN indicate a low cytotoxicity and lack of genotoxicity of these two mycotoxins. Besides this major mycotoxins, altertoxin II and stemphyltoxin III are rarely found in tomato, but they induce a higher genotoxicity than AOH and AME. They do not interfere with topoisomerases, unlike AOH and AME but they trigger DNA base oxidation due to their epoxide structure.

Keywords: *Alternaria, Mycotoxins, Toxicity, Alternariol, Alternariol monomethyl ether, Tenuazonic acid, Altertoxins*

1 | Poster

Image-based production prediction analysis

Mr. José María Vadillo[1], Mr. Vito Cerasola[2], Dr. Carlos Campillo[3], Dr. Henar Prieto[1]

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The increase in new technologies, satellite images and drone flights is an opportunity and tools for the control and management of intensive horticultural crops. This paper studies the relationship between NDVI and the biomass production generated by the crop throughout the production cycle. It also analyses the relationship between the biomass generated throughout the crop and crop yield. In the 2022 season, a trial of processing tomato variety H1015 was carried out with 4 increasing doses of nitrogen with 4 replications each, implanted in the field in randomised blocks. Drone images were taken every 2 weeks to monitor the crop and subsequently analyse these images and obtain the NDVI index with R-studio. In addition, manual measurements were taken of the biomass generated by the crop in each plot and manual harvesting at the end of the cycle. These measurements have been analysed and related to each other in order to predict the crop yield with image analysis and the evolution of the NDVI index of the crop.

Keywords: *NDVI, nitrate, horticulture*

2 | Oral & Poster

The long-term sustainability of the California processing tomato production; some disturbing observations and potential solutions

Dr. Andrew Watson[1], Salko Aleckovic[2]

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California average processing tomato yields/ha, after increasing rapidly from 2000 to 2011, during which period sub-surfaced drip systems were being installed by most tomato growers, have not increased from 2012 to 2023, despite continued introduction of improved varieties, application of technical advances, and an increase in the ambient carbon dioxide concentration. This leveling-off of yield/ha coincides with complete adoption of sub-surface drip irrigation by California tomato growers. The objective of our research was to determine which factors are creating a ceiling on tomato yield/ha in California and hence to investigate potential solutions. Low oxygen concentration in the root zones of sub-surface drip irrigated crops is known to reduce root growth and efficiency and is considered a major factor. The % of flower abortions/truss on tomato plants grown in sub-surface drip irrigated fields in California was found to be 2 to 3 times higher than on the same varieties grown under center pivot irrigation in Brazil and Central Washington. There is a cost-effective way to increase the oxygen concentration in sub-surface drip irrigation water and we report on our research in this area. A second major factor is an increase in soil borne fungal diseases caused by a reduction in the tomato rotation period, driven by the economics of sub-surface drip irrigation. Crown rot/vine decline disease is an increasing threat to tomato yield. We have consistently isolated both Setophoma terrestris and Fusarium falciforme from diseased plants, suggesting a co-infection syndrome. This disease infects only old roots and crowns, and we are investigating using higher populations of short-season varieties to minimize loss of yield. A more serious threat is the development of new races of vascular pathogens in fields with a reduced tomato rotation period.

Keywords: *sub-surface drip irrigation, sustainability, oxygen, crown rot/vine decline*

3 | Oral

Fusarium oxysporum associated with yield decline in Australian processing tomatoes

Ms. Hanyue Feng[1], Prof. Dr. Paul W. J. Taylor[2], Assoc. Prof. Sigfredo Fuentes[3], Dr. Alexis Pang[4], Dr. Niloofar Vaghefi[5]
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The Australian Processing Tomato Industry in Victoria and New South Wales has experienced a yield decline over the last decade. Previous studies found that declining yield was in part due to diseases caused by soil-borne pathogens, especially *Fusarium oxysporum*. Infected plants were characterised by stunting, internal stem discolouration, poor root growth and ultimately yield loss. The forma specialis and physiological race structure of 25 F. oxysporum isolates collected from symptomatic processing tomato and cotton plants was determined by PCR and sequence analysis of the polygalacturonase cell wall degrading enzymes. Eight isolates were assessed in glasshouse bioassays for pathogenicity on a universal cultivar with resistance to Fol race 1 and 2 as determined in the USA. Plant growth was assessed by measuring fortnightly above ground height, physiological parameters, and dry weight. All the isolates were *F. oxysporum f.* sp. *lycopersici* (Fol) with the majority being race 3, followed by races 1 and 2; and a few did not group with known races of Fol. All isolates were able to cause disease and significant reduction of root biomass on H3402. Further studies are ongoing to further unravel the genetic variability of *Australian F. oxysporum* isolates and their correlation with cultivars carrying different sources of resistance.

Keywords: *processing tomatoes, yield decline, soil borne pathogen, Fusarium oxysporum species complex (FOSC), pathogenicity bioassay*

4 | Oral & Poster

Processing tomatoes under deficit Irrigation in Southern Italy: Yield and water use efficiency

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In water-limited environments, the irrigation of processing tomato should aim at limiting crop water shortage, increasing water use efficiency and optimizing fruit yield. The present study evaluates deficit irrigation strategies in a 2-year (2021 and 2022) field experiment in southern Italy.

In the control treatment, the irrigation schedule planned by the farmer was applied; in the deficit irrigation treatments, seasonal irrigation depths were reduced through driplines with drippers at different flow rates. Irrigation frequency (every 1-2 days) and duration (about 6 hours) were the same in all treatments. The long shape tomato, Taylor hybrid, was used. In the first year the trial was set up in a field that had never been cultivated with tomato; in the second year in a field where tomato was cultivated every 3 years.

At harvest, the different components of crop biomass and some qualitative characteristics of the fruits were measured. Climatic variables, irrigation depths and soil water content were also recorded.

In the irrigation schedule of the farmer (FARM treatment), seasonal irrigation depths were 539 mm in 2021 and 751 mm in 2022. In 2021, a seasonal irrigation depth of 431 mm was applied to the deficit irrigation treatment, i.e. the FARM irrigation depth was reduced by 20% (RED-20 treatment). In 2022 two deficit irrigation treatments were applied, reducing the FARM seasonal irrigation depth by 30% (RED-30%, 540mm) and by 40% (RED-40%, 452 mm). The higher rainfall in 2022 with respect to 2021 (157 mm vs 66 mm) and the different level of soil fertility in the two experimental plots, influenced production levels (higher in the first than in the second year) and the WUEs of total dry biomass and fresh fruit (with higher indices in the first year).

Comparing the deficit irrigation schedules with the FARM one, in 2021 fruit yield was significantly higher in FARM, but the WUEs were not. In 2022 there was no difference in fruit yield among treatments, while the WUEs differed (highest in RED-40%, intermediate in RED-30% and lowest in FARM).

Keywords: *Solanum lycopersicum L.; deficit irrigation; fruit yield; drip irrigation.*

5 | Oral

Application of rapid methods for sensory analysis in tomato products innovation: The case of Salmorejo

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In recent years, there is an increasing research interest on the different methodologies used to measure and interpret the descriptive responses provided by consumer to the organoleptic characteristics of food. Rapid methods for sensory analysis have proven to be just as effective in terms of information gathering with the difference that they can be used with untrained panels of judges or semi trained (consumers) and the advantages that this entails. Within rapid methods, The Flash Profile method has proven to be effective in the sensory categorization of different commercial brands of a specific food, providing advantages in terms of cost, speed, and flexibility.

The purpose of this contribution is to show an alternative application to traditional descriptive sensory methodologies to innovative tomato products. In this study, Flash profile methodology was applied to try to establish Spanish consumers' descriptors testing six different brands of salmorejo (as tomato product) and to explore similarities and differences among them with a potential impact in salmorejo innovation. The data obtained by the Flash Profile methodology was analyzed by applying the statistical analysis Generalized Procrustean Analysis (GPA). To determine the degree of consensus among the consumers who participated in the tasting, we used the consensus index Rc, with a result of 0.719, that is, 71.9% consensus. The results obtained by Flash Profile method enabled to observe the similarities and differences between the different brands, thus making it possible to interpret the organoleptic preferences of consumers in order to be able to use them in future new food products design. This can lead to innovation acceptance and food quality improvement and can also be use as marketing tools to put their tomato food products in value.

Keywords: rapid methods, Spanish tomato products, Consumers, Flash profile, Salmorejo

6 | Oral

Evaluation of Trichoderma atroviride to Combat Soil-Borne Pathogens in Processing Tomatoes

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Row crops such as processing tomatoes have incorporated expensive technology over the years to increase yield. Some of these technologies are difficult or impossible to move from one farm to the next, as is the case for pressurized irrigation systems or protective structures. Crop growers tend to use the farms that have these infrastructure investments intensively to amortize the initial costs and take advantage of the economic benefits provided. Consequently, it becomes difficult to rotate crops, or fallow the soil, in an effective way to reduce the accumulation of pests and pathogens. It is common to see an important increase in plant loss from soil-borne pathogens in farms that have two or more consecutive tomato crops. It has been widely documented that beneficial microorganisms including Trichoderma can act as an antagonist to many soil-borne pathogens and thus protect the crop from damage. Considering the evermore strict regulations and environmental goals of key markets lead by the European Union, it is important to find ecological alternatives to common methods of control that rely heavily on synthesized chemicals. Trials were conducted in the INTA experimental station in La Consulta, Mendoza, Argentina through the years 2021-2024 in a plot that has had tomato crops every year since 2019 under hail netting that is compatible with typical processing tomato machinery. In the trials a control treatment with no pathogen protection was compared to common chemical control, mancozeb with metalaxyl, and an ecological alternative Trichoderma atroviride. The variety used was HM 7883 which has been observed as susceptible to Phytophthora sp. attacks in soils where tomato has been grown repeatedly. In all the years the treatment with Trichoderma was equally or less affected by Phytophthora sp. than the chemical treatment and the control treatment.

Keywords: *Biocontrol; damping off; Phytophthora; solanum lycopersicum; soil sustainability*

7 | Oral

Mid-infrared spectroscopy, a routine tool for improving the quality of processed tomato products

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The aim of this study is to use the mid-infrared spectroscopy (MIRS, spectrometer Bruker ALPHA II) in real conditions meaning routine analyses in a technical institute to control quality of raw tomatoes on arrival at the plant and monitor the quality changes during processing.

A diversity of processing tomatoes were selected in the South-East and South-West of France in 2022 (36 varieties) and 2023 (38 varieties), representing respectively 93 and 152 samples. For each sample, a part of the fruit was characterized as raw material (15 fruits) for soluble solids content (°Brix), titratable acidity (mmol H+/100g) and dry matter (%), while the other part was processed under two conditions: hot break (HB) and cold break (CB), and then characterized for viscosity (Bostwick value). All samples were also systematically analyzed using MIRS (4000-600 cm-1).

About the raw material part, the prediction models by partial least squares regression (PLSR) were good for soluble solids content (R^2=0.92, RMSEP=3.45%) in external validation, for titratable acidity (R^2=0.90, RMSEP=4.6%) and for dry matter (R^2=0.80, RMSEP=4.6%). These results are very closed to those obtained under laboratory conditions (Bureau et al., 2020). Concerning viscosity, the best prediction was obtained (R^2=0.89, RMSEP=11.6%) by the model built with all HB and CB purees.

These results are very encouraging and point the possibility of deploying the MIRS tool to the profession in a routine use for controlling raw product quality, monitoring product processing and controlling output quality.

Keywords: *Processing tomato, processing, quality, MIRS, modeling*

8 | Oral

Survival and fungal colonization of the tomato pathogen *Athelia rolfsii* (syn. *Sclerotium rolfsii*) in response to organic soil health practices

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Organic soil fertility practices, such as compost amendment and cover cropping, are linked to numerous soil health benefits, including greater microbial biomass and activity. Less is known about how organic management influences persistence of plant pathogenic fungi in soil. Southern blight is one of the most destructive diseases in processing tomato worldwide. The causal agent, Athelia rolfsii (syn. Sclerotium rolfsii), can persist in soil for several years by producing durable masses of fungal tissue, called sclerotia. To test the hypothesis that organic soil management practices can suppress A. rolfsii populations, we investigated the impact of long-term organic versus conventional soil fertility regimes on survival of A. rolfsii sclerotia. We also identified biological indicators of pathogen suppressive soil based on fungal colonizers of sclerotia. In greenhouse pot studies, we buried sclerotia in soil that was collected from processing tomato-corn rotation plots with either conventional (synthetic fertilizer) or organic (compost and cover cropping) fertility regimes for over 20 years. After one month, sclerotia were less decomposed in organic soil; however, adding chitin to soil counteracted this negative effect. Fungal genera most commonly isolated from nonviable sclerotia in culture-based assays were Sarocladium, Aspergillus, Cladosporium, and Chaetomium. In a field experiment, sclerotia were buried for four months in organic and conventional plots. Amplicon sequencing-based metagenomic analysis revealed unique fungal colonizer community profiles in sclerotia that were buried in different soils, thus demonstrating a biological basis for the impact of soil fertility practices on pathogen survival. Differential abundance analysis indicated that fungal genera Sarocladium, Trichoderma, Cladosporium, and Botryotrichum most extensively colonized sclerotia, with higher relative abundance of Trichoderma and lower abundance of Botryotrichum in sclerotia buried in conventional versus organic plots. Organic practices altered microbial colonization of pathogen survival structures, which has significant implications for soilborne pathogen management.

Keywords: *disease, pathogen, crop protection, organic, compost, cover cropping, southern blight, sclerotia, microbiome*

9 | Poster

Alternaria species associated with symptomatic leaves and fruits of processing tomatoes in Australia

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Alternaria is an economically important genus of filamentous fungi, able to infect a wide range of crops including tomatoes worldwide. Tomato plants can be affected by *Alternaria* species anytime during their growth cycle, which causes stem canker or necrotic and chlorotic lesions on leaves and fruits. Severe epidemics can result in economic losses in the field and during fruit storage. In addition to causing yield losses due to early blight or postharvest disease, Alternaria species pose a serious toxicological risk due to their ability to produce a wide range of harmful mycotoxins that can accumulate in vegetable-based products. Fourteen *Alternaria* isolates obtained from fruits and leaves of processing tomato crops in Australia were characterised using multi-locus phylogenetic analyses. Sequencing of the glyceraldehyde 3-phosphate dehydrogenase, internal transcribed spacers and the intervening 5.8 region of the nuclear ribosomal DNA, RNA polymerase II subunit, and translation elongation factor 1-alpha identified *A. alternata*, *A. arborescens* and a potentially novel species of *Alternaria* within section *Alternaria*. While we did not conduct pathogenicity assays, studies outside Australia have reported *A. alternata* and *A. arborescens* to be highly aggressive on processing tomato fruits and also capable of producing several mycotoxins. Prevalence of different Alternaria species in processing tomato fields in Australia and their impact on yield requires further investigation.

10 | Poster

Pythium species isolated from irrigation water in a processing tomato field in Australia

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The Australian processing tomato industry is affected by crown and root diseases caused by soilborne pathogens including *Pythium* species, which are oomycetes that cause pre- and post-emergence damping off, root rot, and poor root development in tomatoes. Field surveys of Australian processing tomato crops from 2016 to 2018 identified 11 pathogenic *Pythium* spp. isolated from symptomatic tomato plants and soil samples. The Australian processing tomato fields are irrigated using sub-surface drip lines, which may contribute to pathogen dispersal and provide an ecosystem conducive to proliferation of soilborne pathogens in areas adjacent to the drip lines. However, presence of *Pythium* spp. within irrigation systems of processing tomato fields in Australia has not been investigated. Twenty-two isolates of *Pythium* spp. were isolated from six water samples collected from the irrigation system of a processing tomato crop in New South Wales. Isolates were characterised using multi-gene phylogenetic analysis of internal transcribed spacers of the nuclear ribosomal DNA and the intervening 5.8S region (ITS), Cytochrome c oxidase subunit I (Cox-1), and Cytochrome c oxidase subunit II (Cox-2) mitochondrial gene sequences. Twenty-one *Pythium* spp. were identified to belong to the *Pythium* B2a cluster, including species belonging to P. dissotocum species complex, along with tentative identification of a single species of Elongisporangium undulatum. *Pythium* dissotocum complex accommodates known pathogens of vegetables in hydroponic systems, incurring significant losses to vegetable industries worldwide. Species belonging to P. dissotocum complex have already been identified as the most abundant and widespread *Pythium* species in Australian processing tomato fields, but their impact on tomato yield is not known. Potential novel *Pythium* species were identified, the taxonomic characterisation of which is ongoing.

11 | Oral

Predicting carotenoid concentrations in growing and ripening tomato fruits under varied irrigation and light conditions: results from coupled confocal microscopy and image analysis

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Carotenoids, as secondary metabolites present in fruits, are essential for the nutritional value of tomato fruits. Additionally, Lycopene, among these carotenoids, influences the quality of tomato puree, impacting factors such as color and viscosity. The synthesis and storage of carotenoids occur during fruit ripening in chromoplasts, specialized subcellular organelles derived from chloroplasts. These chloroplasts are responsible for both the accumulation and degradation of chlorophyll during photosynthetic activity. Chloroplasts undergo division during fruit growth, changing their abundance before ripening and potentially affecting the storage capacity for carotenoids. The application of water deficit during tomato growth is crucial for designing water-saving cropping systems, leading to improved fruit quality upon harvest. Observations through confocal microscopy, coupled with physiological and biochemical analyses of tomato samples, reveal variations in the evolution of compartmental weights, such as the outer pericarp, inner pericarp, and gel. Differences in chloroplast distribution, as well as concentrations of chlorophyll and carotenoids, are evident among these compartments. Consequently, water deficit may have distinct effects on carotenoid content in different fruit compartments. Moreover, studies emphasize the significant influence of light intensity on carotenoid metabolism during ripening, as well as responses to ethylene production and ripening signals. Describing the intricate biophysical processes governing chloroplast abundance and carotenoid biosynthesis, and their response to water deficit and environmental conditions during fruit growth and ripening is complex. To address this challenge, we developed a biophysical model. Although still in its conceptual form, this model has already highlighted crucial variables that should be better measured in field experiments, particularly those related to volumes occupied by chloroplasts in different fruit compartments. In this work, we present a combination of image analysis techniques based on machine learning algorithms applied to analyze confocal microscopy images of tomato tissues in the pericarp, quantifying chloroplast presence and differentiating between the inner and outer pericarp. Our exploration aims to establish relationships between biochemical data on chlorophyll and carotenoid content and physiological observations obtained through image analysis, characterizing various genotypes under contrasting watering conditions. This work sets up a modeling framework that would lead to predicting carotenoid content in tomatoes at harvest under changing environmental conditions.

Keywords: *tomato, carotenoids, health, lycopene, microscopy, machine learning, image analysis*

12 | Oral

Oxyfluorfen: an Excellent Tool for Tomato Volunteer Plants Reduction in Processing Tomatoes

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More than 7,000 ha of processing tomatoes are cultivated in the irrigated valleys of the west of Argentina. Volunteer tomatoes become an issue as weed when tomatoes are grown year after year. Crop rotations with rye or barley in winter are not enough to promote seed germination of all tomato F2 seeds, emerging later on in the main crop. Diphenylether oxyfluorfen use for controlling many kinds of weeds in tomatoes at different days after and before transplanting was studied and it was found promising at 240-480 g/l a.i.ha-1 , however, registration and recommendation to control F2 or volunteer tomatoes is not cited for this purpose. The hypothesis of this study is to apply doses of oxyfluorfen before transplanting of processing tomatoes to evaluate tomato seedling phytotoxicity and plant survival on transplanted tomato seedlings, analyzing weed emergence reduction of F2 tomatoes and other weeds. Trials were conducted in INTA La Consulta Experiment Station, Mendoza, Argentina, South Latitude 33°42´ Longitude West 69°04´ altitude 947 m asl on a typical torrifluvent loamy soil during seasons 2021-22 and 2022-23. The study started immediately before planting (half an hour before) with oxyfluorfen, Galigan® EC 240 g/l sprayed in the plots as preplanting herbicide in 400 l.ha-1 volume of water at 0; 144; 216 and 288 g.ai.ha-1 doses. No differences among treatments on tomato seedlings plant growth at 30 DAT were found as well as in fruit production and fruit quality. Strong plant number reduction on F2 tomato volunteer plants among all herbicide doses against no oxyfluorfen treatment was found, however, no differences among oxyfluorfen doses were detected. No phytotoxic plant symptoms were found among all treatments including control. No statistical differences in fruit production either commercial and total, fruit size, brix, green fruits, overripen, sunburns and blossom end rot index was found. This means oxyfluorfen 144 g.ai.ha-1, Galigan® 600 ml.ha-1 was enough to get the best, cheap and environmentally friendly weed control for tomato volunteer plants as part of weed management on a tomato crop.

Keywords: *crop management, bed preparation, pre-plant herbicide, weed control*

13 | Oral & Poster

Tertiary Treated Wastewater used for Irrigation of Processing Tomatoes

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The shortage of fresh water due to increasing uses and climate change has led to considering wastewater for crop irrigation. In Capitanata plain (Southern Italy), tertiary treatment of municipal wastewater allows for 6 Million m3/year to be used for agricultural purposes. An open-field experiment was conducted (2021) on a private farm to compare the yield and quality of processing tomatoes irrigated with tertiary-treated wastewater and "conventional" water.

The trial had two irrigation treatments: conventional water and tertiary-treated wastewater from a nearby public wastewater treatment plant (WWTP).

Irrigation water, soil, and crop samples were taken to assess the chemical-physical parameters, possible contaminants and microbiological indicators. Tomato hybrid "Taylor" was transplanted on 11 June 2021 and was harvested on 5 October 2021.

Daily soil water balance and irrigation scheduling were calculated by a "cloud-based" Decision Support System (Bluleaf TM). Plant height, percentage of land cover, LAI, plant biomass, and fruit yield were collected biweekly.

Seasonal water irrigation volume was about 7,210 m3 ha-1 (in 44 watering events). LAI behaviour was similar in the two treatments during the first phase of the growing cycle, while it resulted higher in TWW during the fruit maturity stage. Total plant biomass at harvest was found to be greater in TWW than in CONV (125.9 vs. 92.5 t ha-1), as well as the commercial fruit yield (105.3 vs. 75.4 t ha-1). These positive effects on plant development and marketable fruit yield observed for the TWW treatment were likely due to the increased amounts of N, P and K supplied to the soil with the irrigation water.

The mean levels of E. coli and Salmonella spp. in TWW were above the Italian guidelines for treated wastewater reuse, and the irrigation treatments did not affect the microbial quality of the marketable yield.

Keywords: *Solanum lycopersicum L., water treatment, water quality, fruit yield, drip irrigation*

14 | Poster

Life Waste4Green: New zero residue formulations based on botanical extracts

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This work has validated the use of two new natural pesticides developed in the framework of the Life Waste4Green project on processing tomatoes. These products are based on botanical extracts from agro-industrial waste and are effective against pests and diseases. In addition to CTAEX, ICA-CSIC, Idai Nature, ISCIII, Ava-Asaja and Frutuga have also participated in this project. The aim of the study was to test the efficacy of the new products in the control of pests and diseases in processing tomato crops, replacing conventional chemical pesticides.

The trial consisted of 3 different treatments, based on the total substitution of chemical pesticides with Waste4Green products, partial substitution with both products and a control treatment, in which only chemical pesticides were used. The trials were carried out at the Centro Tecnológico Nacional Agroalimentario Extremadura (CTAEX), Badajoz (Spain) during the 2022 and 2023 seasons.

In general, it was demonstrated that the substitution of chemical pesticides with the new products allows similar yields to those obtained with conventional products, without affecting the main quality parameters of processing tomatoes, making it possible to obtain fruit free of pesticide residues. The results suggested that the products developed in the project, which include botanical extracts of eucalyptus and alpeorujo, can be successfully applied to processing tomato crops, at a dose of 5 L/ha.

This study forms part of the LIFE17 ENV/ES/000192 Project.

Keywords: *organic farming, processing tomato, zero residues*

15 | Poster

Evaluation of the potential of different microbial treatments in processing tomatoes under abiotic water stress

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Although resistance to both biotic and abiotic factors has been included as a selection criterion in plant breeding programs for years, environmentally friendly microbial products may offer a viable alternative as they are able to contribute to crop resistance to the undesirable effects of climate change. In the present study, we have analyzed the performance of Solanum lycopersicum L., an important crop of great agronomic interest and widespread worldwide, under water stress by supplying different microbial products to the crop. The project was carried out using bacteria from the Biomar collection with the development of work at CTAEX.

In this sense, the aim was to assess the effect of 8 different bacterial strains on plant size, development parameters and productivity in processing tomato under different water regimes. For this purpose, a field trial was conducted, evaluating whether the plants showed the beneficial properties transmitted.

In this research the following parameters were evaluated: the health status of the plant, plant cover on the soil (%), chlorophyll (SPAD), nutritional status through foliar analysis, crop yield and brix degrees under 3 different water conditions: Control irrigation (100%) with 5,500 m3/ha (Crop evapotranspiration, (ETC needs)), 75% (25% reduction compared to the control) and 50% (50% reduction compared to the control). Within the yield parameters, tomatoes were evaluated according to their size (< 40mm, 40-60mm, > 60mm), maturity stage (overripe, ripe, and green) and health status (diseased, sunburn and apical necrosis).

After analysing the results, we have been able to verify the effect of different bacterial treatments on parameters such as net yield/ha, giving higher values in all the water regimes established with respect to the control treatment, which translates into a greater benefit for the producer, with higher yields on the one hand and lower water consumption on the other.

This study forms part of the RED CERVERA IDI-20200826 Project.

Keywords: abiotic stress, processing tomato, microbiome, bacteria

16 | Oral

Experimental and modelling approaches to explore the genetic-induced and water deficit-induced variations in the architectural traits (anatomy and conductivity) of the vasculature in tomato fruit pedicel and pericarp

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In plant production, fleshy fruits like tomatoes, comprising 90-95% water, face challenges due to water deficit, with a significant impact on yield and quality. The water uptake process through both xylem and phloem in the bearing shoot is crucial for tomato development. As fleshy fruits like tomatoes ripen, there is a dynamic shift in water flow patterns. During development, the phloem becomes the primary conduit for water, while the xylem's contribution diminishes. The vascular tissue within individual bundles continues to expand throughout development. The direction and magnitude of xylem flow are governed by the water transport pathway's hydraulic resistance and driving force. These changes in water fluxes during fruit development necessitate a thorough exploration of the vascular system's role. In tomatoes, the condition of water deficit increases the hydraulic resistance in the special abscission zone (AZ), and reduces the diameter of xylem vessels in tomato pedicel. However, model simulations reveal that under water-deficit, the primary limiting factor for water supply is the water status, rather than reduced stem conductivity. Hydraulic resistance may not originate from the pedicel and calyx regions but might be inherent to the fruit's vascular bundle hydraulic resistance, which is linked to its structural characteristics. The intricate relationship between water deficit, fruit vascular tissue, and fruit development is pivotal for comprehending the challenge of fruit production in water-shortage conditions. We use a combination of data derived by Magnetic Resonance Imaging (MRI), image segmentation techniques, and fruit model simulations to investigate the effects of water deficit on tomato fruit growth, with particular focus on the vascular system of the fruit and fruit stalk, quantifying the surface area of the xylem during fruit development, and allowing investigation of the intricate relationship between vascular architecture and fruit growth under well-irrigated and water-deficit irrigation conditions. In our results, we found differences in the surface area of the xylem within fruit under water deficit, highlighting the influence of water availability on vascular morphology and its subsequent impact on fruit growth.

These findings will contribute to our understanding of the physiological mechanisms underlying the response of fleshy fruits to water deficit and provide valuable insights for agricultural practices. Additionally, the observations of the vascular bundle structures will be used to improve the parameters estimation of the fruit model, for predicting and mitigating the impact of water deficit on fruit production.

Keywords: *tomatoes; water deficit;vascular architectural traits; MRI; virtual fruit model*

17 | Oral

Exploring dynamic management of Nitrogen (N) strategies to enhance N use efficiency and quality in processing tomato

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Multispectral radiometers are widespread in precision Nitrogen (N) management as they allow the rapid assessment of the crop nutritional status, and the Green Vegetation Index (GVI) is one of the indices best related to the N status and yield of tomato. The present work explored the adoption of three dynamic strategies for guiding N fertigation in processing tomato by monitoring the GVI along the growing season using a handheld multispectral radiometer. The experiment followed a complete randomized design with four replicates, and incorporated a control strategy that restored the full N requirements calculated through the N balance sheet (180 kg ha-1) and split along the growing season. The dynamic strategies were as follow: a) Spy plot (N SPY), supply of N when the GVI was below the 90% of the GVI monitored in the control strategy, b) Spy evolved (N EVO), supply of N when the GVI was below the 90% of the GVI curve monitored in the past year in a tomato crop maintained under non-limiting N conditions, c) Threshold curve (N THR), supply of N when the GVI was below the 90% of the critical GVI curve determined experimentally using a linear-plateau approach correlating the GVI with crop yield. The amount of N supplied in dynamic strategies was calculated using the daily N uptake derived from literature. All the dynamic strategies resulted in a significant reduction of N supply (-38% for N SPY and -58% for N EVO and N THR) in comparison to the control. No differences were recorded in total and marketable yield, thus resulting in a better N use efficiency. Even the quality was enhanced by dynamic N strategies increasing the fruit weight and the Brix, thus making dynamic N management a sustainable strategy to improve the fertilization efficiency and the quality in processing tomato.

Keywords: nitrogen fertilization, precision nitrogen management, multispectral radiometer, nitrogen use efficiency

18 | Oral

Effects of microwave pasteurization on a functional tomato sauce enriched with pea protein and olive powder

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With an interest in the Mediterranean diet, a functional tomato sauce enriched with pea protein and powdered olive was designed. Microwave pasteurization was considered due to its emphasis on sustainability. The novel tomato sauce was pasteurized using microwaves to establish its effects on the product's physicochemical properties and compared to conventional pasteurization.

For that, tomato purees and peels were prepared by peeling, hot breaking (85ºC, 3 min), and sieving. Peels were dried (55ºC, 24 hours), and pulverized. For the formulation of sauce, tomato peel powder, pea protein, olive powder, and salt were homogenized under 500 bars. For the conventional pasteurization, the prepared sample was put in a water bath for 20 minutes at 95°C. For microwave pasteurization, the sample was put in a microwave pasteurizer for 10 minutes to reach the core temperature of 95°C based on the product's pH. Protein (by Lowry method), lycopene, total phenolic content (TPC), DPPH antioxidant scavenging activity, and rheology experiments were conducted.

The results showed that microwave pasteurized sauce had a higher lycopene content (203 mg/kg) than conventional one (179mg/kg), possibly due to the shorter heat treatment time. The rheological behavior was explained by the Herschel-Buckley model. Microwave pasteurized sauce had a higher yield stress (65 Pa) than conventionally pasteurized one (44 Pa). The consistency indexes were statistically indifferent (around 0.4 Pa.sn) and the flow indexes were 0.78 and 0.68 for microwave and conventionally pasteurized sauce, respectively. The soluble protein (0.8mg BSA/mL), TPC (0.30 mg GAE/mL), and DPPH antioxidant scavenging activity (65%) results did not show statistically significant differences ($p < 0.05$).

In conclusion, pasteurization of the functional tomato sauce with microwave was shown to produce a sauce with better lycopene content and rheological behavior. The phenolic content and antioxidant properties of the product were not inferior to conventional pasteurization.

This study has received funding from the European Union's Horizon 2020- PRIMA Section I Program under grant agreement # 2032 (FunTomP).

Keywords: *microwave pasteurization; tomato sauce; functional product*

19 | Poster

Use of precision irrigation for water efficient management in a processing tomato commercial farm

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New technologies have been incorporated into agriculture to enhance precision automatic irrigation, which enables farmers to make more efficient irrigation decisions, increase yields, and preserve water resources. The study aimed to evaluate an automated drip irrigation system in a processing tomato commercial farm to improve the best water-efficient use. The study was conducted in a Talavera la Real (Extremadura, Spain) plot of processing tomato variety 'UG-16112' during the 2023 season. A map of apparent electrical conductivity (ECa) was created to characterize the plot's spatial variability and determine the sensor installation points for the automatic irrigation system's decision-making process. The plot was divided into two zones: one managed by the farmer and the other automated with the Irri_DesK web platform to save maximum water. The results indicate that the system in addition to managing irrigation automatically saved 26% of water compared to the farmer without any significant differences in production and increased the brix. These systems will allow irrigation to be managed by adjusting the doses to the specific characteristics of each area of the plot and the crop development and climatic conditions of each season.

Keywords: *apparent electrical conductivity; water use efficiency; precision irrigation; sensors, Irridesk*

20 | Oral

Effect of high-pressure homogenization on the quality attributes of a protein enriched tomato leather

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Tomato, an important element of the Mediterranean diet, is an important source of healthy nutrition. Tomatoes contain high amounts of vitamin C, lycopene, potassium and antioxidants. In Mediterranean diet, tomatoes are included in various forms, such as sauces, stews, and even consumed fresh.

Tomato leather is one of tomato forms, which is a dehydrated and condensed version of tomato juice, and it has a potential to become popular Mediterranean snack due to prolonged shelf life, easy to pack and easy to consume. To nutritionally enrich the leather product, plant proteins could be used as an alternative source. The production process of leather includes multiple processes, including high pressure homogenization, which is critical in deciding the quality of the finished product.

In this study, tomato leather was formulated with olive powder (0.5%) (OP) and different amount of RuBisCo protein (0.25%, 0.5% and 1%). After solubilization of OP and protein, homogenization was performed at 500 and 1000 MPa for 1 pass. Here, protein containing leather samples, which were not homogenized, were used as a control sample. Then, the leather solutions were left to dry at 60 °C at 10% relative humidity for 6 hours.

Moreover, physicochemical characterization of leather samples was conducted to investigate the effects of the homogenization on tomato leather. The mechanical properties of the leathers were assessed using a texture analyzer. Moreover, lycopene content, soluble protein content and water activity was also measured as physicochemical properties. Sensory analysis was also carried out for acceptability of the products.

This study has received funding from the European Union's Horizon 2020- PRIMA Section I Program under grant agreement # 2032 (FunTomP).

Keywords: *Leather, Tomato Product, High Pressure Homogenization, Sensory*

22 | Oral & Poster

Use of irridesk automatic irrigation system to management deficit irrgation strategies in processing tomato

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Droughts threaten to become more and more frequent, causing an increase in competition for water, so it is essential to create awareness of the need to use water efficiently. The use of controlled deficit irrigation strategies will be increasingly necessary for the sustainability of the crop. However, in many cases, it is difficult for the farmer to establish these water doses, the intensity, the moment and how these affect the quality and productivity of the crop, and they must also be adjusted to the changing conditions of climate, soil variability, efficiency in the use of water and other parameters to be taken into account. This work aims to evaluate an automatic irrigation system for the management of controlled deficit irrigation strategies in processing tomato. The study was carried out in 2023, within the Digispac and ET4Drought project on a plot located in the experimental farm "La Orden" in Badajoz. Three irrigation managements were compared. One treatment according to crop needs was obtained from a weighing lysimeter (Control) and two deficit irrigation treatments were managed automatically with the Irri_Desk web platform. One of them establishes deficit irrigation only in the ripening phase and the other induces stress in the initial and ripening phase of the crop. Irri_Desk used a lower volume of water than the control treatment (around 40% on average), adapting in each area to the information provided by the installed sensors. In any case, it can be seen that the deficit treatments have maintained an average production above the average for the area in recent years (80,000-85,000 kg/ha). It clearly shows that the deficit irrigation strategy applied in the initial phase of the crop had a direct effect on crop production. The yield obtained increased with the volume of water applied, however, the soluble solids content increased considerably in the two less irrigated treatments. It should be noted that there were no differences in ºBrix between the deficit treatments, but there was a considerable loss of yield in the treatment with deficit irrigation in the initial phase of cultivation.

Keywords: *Droughts, water efficiency use, brix, Etc, water reduce strategies, precision irrigation*

23 | Poster

Research on phase-change materials for the design of a solar thermal energy storage system for the tomato industry

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In the current context, the agri-food sector and specifically the tomato industry is strongly pressured by the prices of the energy needed for its processes, in addition to the costs associated with CO2 emissions. However, the intermittency of some renewable sources as the solar thermal technology makes the alternative of producing its own energy to supply the whole process not feasible.

The main product of the primary processing tomato industries is the tomato paste produced by the evaporation technique, which consists of removing the water from the tomato juice by heating it with steam. The energy consumption required for this process is very high. During the short campaign periods (July-September), energy supply needs account for 90% of the total annual consumption. The energy used to produce steam is mainly supplied by natural gas, which leads to high CO_2 emissions and increased economic costs.

One of the most viable and environmentally friendly alternatives to cover the energy needs and consumption patterns of the tomato industry is the integration of Thermal Energy Storage units (TES) in solar collector systems, allowing continuous 24-hour processes.

Therefore, there is a need to search for a solution or energy supply alternative that allows this industry to consume sustainable energy from a renewable source and free of CO2 emissions, and thus reducing its dependence on natural gas.

For this, a thermal storage system will be investigated to use solar energy as a renewable energy source. The Phase Change Materials (PCMs) that best suit the requirements of the tomato industry will be studied, according to its energy needs, consumption patterns and operating conditions. A system will be designed for the storage of solar thermal energy from solar collectors, which will be used later to produce steam according to the industry's demand.

This study is part of the STomSun Project funded by Regional Extremadura Government (Regional Call – Decreto 146/2022-Extremadura – Exp. CPP-23-0001-3)

Keywords: *thermal energy storage, PCMs, solar collector system, tomato evaporation*

25 | Poster

Effect of heat waves in processing tomato yields

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The current situation of climate change makes the heat wave phenomenon more frequent. In processing tomato this phenomenon can be seen in flowering due to high day and night temperatures during prolonged periods, which together with very low relative humidity, affect a deficient proliferation of pollen and a deficient opening of the flowers, causing failures in flowering and subsequent fruit set. To carry out this study, different commercial farms of processing tomatoes that had been grown for several years were evaluated. On these plots, the temperature and phenological stage were evaluated using sentinel 2 satellite images and the final production in each of the plots.

The results obtained highlight that it can be identified that if there is an increase in temperature above 40ºC during the period of crop growth and fruit set, identifying this zone between fifteen days before and after the maximum development of the crop, the higher the NDVI value, the greater the loss of production. These results help to establish protocols that help farmers to have different strategies to protect their crops against these heat waves.

Keywords: climate change, high temperature, flowering, fruit set, NDVI

26 | Poster

Effect of different plant density and deficit irrigation in grafted processing tomato

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Processing tomato is the most important horticultural crop in Extremadura with about 23,000 hectares and 1.8 million tons. Production costs have forced the establishment of a minimum production threshold of 85,000 kg/ha to be a profitable production, in addition to the drought conditions have been reduced by 25-30% the volumes of water for the crop. Thus, in view of this situation, the need arises to look for alternatives, such as grafting, so that the crop remains interesting for the producer in unfavorable conditions. Trials were conducted in La Orden, CICYTEX Experimental Station in Guadajira, Spain during the seasons 2023 in two plots with different locations and different conditions. The drip irrigation was used and daily water replenishment was done by a single surface tape according to evapotranspiration. In each plot twin trial was development (effect of irrigation and density) the statistical design was a split-plot with three replicants in both trials. Density trial was conducted with three planting densities (9,000 plants/ha, 14,000 plants/ha, 28,000 plants/ha) and on irrigation trial two treatment irrigation where daily water requirement (ETc) and deficit irrigation (70%ETc) were compared. In each treatment, a control with H1015 variety without rootstocks and 10 different rootstocks were compared. Field performance and adaptation, different quality parameters and final production were evaluated in each plot. The results obtained show that the density and type of irrigation have a significant influence on the quality and production of each plot. Lower densities allowed better yields with significant savings in plant cost and improved product quality. Some rootstocks performed better in deficit irrigation situations than others and could be recommended for years or situations of water drought. These results give the farmer the possibility to maintain stable yields in the face of different limiting situations, such as soil or water supply.

Keywords: *Solanum lycopersicum, grafting, crop management, Brix, rootstocks*

27 | Oral

Enhancing lycopene analysis in microwave-vacuum dried tomato snack bars by NIR spectra and hyperspectral imaging

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The demand for healthy snacks requires examining lycopene levels in tomato products. Lycopene is an essential antioxidant that significantly adds to the nutritional value of these snacks. A study evaluated three methods for lycopene analysis in tomato snack bars: NIR spectra, hyperspectral imaging, and chemical analysis. This research will improve lycopene analysis in tomato-based snacks.

Tomatoes were treated at 85°C for 3 minutes, then combined with pectin, protein, tomato powder, salt, and spices to make bars. The bars were chilled daily and dried in a microwave-vacuum dryer at 60% power for 10 minutes. We used non-destructive spectroscopy to measure lycopene levels in tomato snack bars by examining their NIR spectra. This method is fast and allows for real-time monitoring during production, which assures the preservation of product quality. We also used hyperspectral imaging to capture detailed spectral information across the snack bars. This method offers spatial resolution, which enables a thorough analysis of lycopene distribution within the product. To compare our techniques, we established a standard reference through traditional chemical analysis. This involved rigorous lycopene extraction and quantification, which provided a benchmark for comparing the new methods.

Through a comparative analysis, we gained valuable insights into the effectiveness of each method. The use of NIR spectra allowed for rapid assessments, which showed a promising correlation with traditional chemical analysis. Hyperspectral imaging, on the other hand, provided detailed spatial data that uncovered variations in lycopene distribution. Although the traditional chemical analysis was time-consuming and destructive, it did establish a reliable baseline for lycopene quantification.

Our research suggests that NIR spectra and hyperspectral imaging can replace traditional chemical analysis for tomato snack bars' lycopene levels. This can modernize quality control in snacks, fostering innovation and better nutrition.

This study has received funding from the European Union's Horizon 2020– PRIMA Section I Program under grant agreement # 2032 (FunTomP).

Keywords: *Lycopene Analysis, Tomato Snack Bars, NIR Spectra, Hyperspectral Imaging*

28 | Poster

How the QUANTM electric pump can reduce operational costs

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Manufacturers in hygienic facilities are constantly looking for ways to improve their processes and reduce production costs using equipment that maintains required levels of hygiene and standards. This session will review how the transverse flux drive technology in QUANTM pumps can improve operations and reduce energy consumption by up to 80%.

Operations managers are under constant pressure to meet deadlines while continuing to find ways to lower production costs. These issues can be overcome by using improved pump technologies while significantly lowering energy and maintenance costs.
Using pneumatic or electric VFD controlled peristaltic, diaphragm, or rotary lobe pumps for specific raw material transfer, process transfer, and filling applications provide unique opportunities for improvement. QUANTM electric pumps improve efficiencies and reduce operational costs while providing the immense flexibility of diaphragm pump technology with an electronic controlled drive.

Now, "being green" can be transformed onto the factory floor. Understanding how your Utility Company can assist with equipment costs combined with reduced daily energy consumption can help lower costs. When compared to their pneumatic counterparts, QUANTM pumps can reduce KWh consumption can by factor of 5x or more.

An understanding of these technologies allows for continued process improvements while lowering total overall operating costs.

Keywords: *sustainability, energy efficient, cost reduction, improve processes, electric pump, hygienic*

29 | Oral

Lycopene as innovative food ingredient according to EU novel food regulation

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The new trends in food product development revealed the necessity to implement an adequate regulatory framework at the European level in order to stimulate trade in the internal market as well as innovation. Regulation (EC) No. 258/97 initially regulated the concept of novel food, with the objective to ensure that these novel foods were subject to a single safety assessment through a Community procedure before being placed on the European Union market. Subsequently, in 2018, Regulation (EU) No. 2015/2283 came into force, with the aim of improving the conditions so that economic operators could introduce new and innovative foods to the EU market more easily, while still maintaining a high level of food safety. The mentioned Regulations limits its scope of application to those foods or food ingredients that, until May 15, 1997 (date of entry into force of the aforementioned Regulation), had not been used in an important measure for human consumption in the European Community.

These novel foods or food ingredients should not pose any risk to the consumer; mislead the consumer; and differ from other foods and food ingredients whose replacement they were intended in such a way that their normal consumption would not imply disadvantages for the consumer from the point of view of nutrition.

Up to date, four novel foods have been approved with relation to tomato and tomato products, their derivates or components: Tomato Lycopene Oleoresin; Tomato Lycopene; Lycopene from Blakeslea trispora and the synthetic Lycopene.

The present work aims to review the authorization process of these four novel lycopene types, its safety concerns and conditions of use in the European market as part of the new food ingredients innovation process.

Keywords: *Lycopene, Novel Foods, safety concerns, tomato oleoresin, Tomato*

30 | Poster

Study for the development of probiotics fermented milk products with fresh pulp or concentrated pulp with prior enzymatic hydrolysis

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The influence of the gut microbiota on the health of individuals is well known. A healthy microbiota enhances metabolic activity, promotes resistance to infection, inflammation, autoimmune and tumour diseases, improves the transmission of endocrine signals and, via the brain-gut axis, also improves neurological function. In the present study, tomato pulp and concentrated tomato pulp with prior enzymatic hydrolysis of tomato (co-product obtained in the processing of tomato concentrate) have been introduced into the production of a probiotic lactic fermented milk product.

The aim of the study was to develop a sensory acceptable probiotic fermented milk product incorporating fresh tomato pulp or concentrated tomato pulp with prior enzymatic hydrolysis of tomato without affecting the probiotic populations. The procedure for making the fermented milk product to be investigated was based on the utility model U201831412, developed prior to this research by CSIC-CIAL and PRONAT. Thus, the study was carried out by means of descriptive sensory analysis (QDA), microbiological determinations (Mesophilic Aerobes, Mesophilic Anaerobes, Enterobacteria, Lactic Bacteria, Moulds and yeasts, S. thermophilus, L. Bulgaricus and L. rhamnosus GG) and physicochemical determinations (Syneresis, Acidity, pH, Colour).

Finally, after evaluation of the results as a whole, it was determined that the best concentration for the fermented milk product made from fresh pulp was 10% and for the fermented milk product made from concentrated pulp with prior enzymatic hydrolysis was 5%. In addition, the shelf life of both products was determined. The results of the shelf-life test for both samples indicate that the best-before date is 28 days, which is similar to that of existing yoghurts on the market.

Thus, 2 new products have been obtained on the market with similar nutritional and sensory characteristics to the existing ones but with new flavour nuances.

This study forms part of the CDTI IDI-20200826 Project (ACRONYM "SyBARIOTA")

Keywords: *tomato, probiotic lactic fermented, fresh pulp, concentrated pulp after enzymatic hydrolysis*

31 | Oral

The effect of pea protein and RuBisCO on the physicochemical properties of spray-dried tomato powder

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Participation supported by an Adopt a Scientist Grant funded by Morning Star

Tomato is one of the most desired vegetables due to its potential health benefits attributed to the rich content of bioactive compounds especially lycopene, flavonoids, phenolics and vitamins. To enhance the convenience and versatility of tomato-derived products, the study focused on investigating the effect of different plant proteins, pea protein and RuBisCO, on the physicochemical properties of spray-dried tomato powders enriched with olive powder. For the production of functionalized tomato powders, diced tomatoes were firstly homogenized using a high shear mixer and exposed to hot-break treatment for 3 minutes at 85°C followed by quick cooling to room temperature within an ice bath. Tomato juice was filtered by sifting through a strainer to remove the suspended pulp and seeds, and was mixed with 1% (w/w) plant protein, pea protein and RuBiSCo, and 3% (w/w) maltodextrin. All samples were subjected to high-pressure homogenization at 100 MPa for 2 passes prior to spray drying. Spray drying was conducted at an inlet air temperature of 150 °C and feed flow rate of 8-10 ml/min to keep air outlet temperature at 85 °C. Samples were mixed with 5% (w/w) olive powder to achieve the final formulation of tomato powders. Spray-dried tomato powders were characterized in terms of antioxidant capacity and total phenolic content as well as moisture content, hygroscopicity and solubility. It was determined that pea protein containing tomato powders had lower antioxidant capacity and total phenolic content than those containing RuBisCO ($p < 0.05$). Although there was not any significant difference between moisture content, water activity and hygroscopity values of tomato powders, pea protein added outstanding solubility properties to tomato powders over RuBisCO ($p < 0.05$).

This study has received funding from the European Union's Horizon 2020– PRIMA Section I Program under grant agreement # 2032 (FunTomP).

Keywords: *tomato powder; pea protein; RuBisCO; spray drying; functional product*

32 | Oral

Improving the quality of tomato products by using microwave-vacuum drying in a snack bar manufacturing system

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The study focuses on using microwave-vacuum drying to produce a tomato-based snack bar, aiming to create a convenient, nutritionally rich snack by preserving the quality of the dried tomato product. Traditional drying methods often lead to undesirable changes in the texture, color, and nutritional content of dried fruits and vegetables while taking a considerable amount of time and energy. Microwave-vacuum drying is a promising alternative that offers rapid and uniform drying while minimizing the negative impact on product quality.

Fresh tomatoes were selected, processed (85ºC, 3 minutes), and incorporated into a snack bar matrix by mixing with pectin, protein, tomato powder, salt, and spices. Ingredients were mixed and snack bars were molded and kept in the fridge for 1 day. Microwave-vacuum dryer was used for drying at 60% power, 0.5 atm vacuum pressure for 10 minutes. Control samples were obtained from a conventional oven at 120°C for 90 minutes. Physicochemical analysis included color, texture, water activity, moisture, lycopene content, FTIR, and NMR relaxometry. A sensorial analysis was also conducted.

The microwave-vacuum drying system effectively preserves essential attributes of dried tomatoes. Snack bars exhibit enhanced color, improved texture, and higher nutritional components. The lycopene content and total phenolics increased considerably. FTIR and NMR relaxometry results showed three water populations. The microwave-vacuum system enhances morphological and sensorial properties. Optimized parameters ensure rapid drying without compromising quality.

This study emphasizes the effectiveness of microwave-vacuum drying as a better method for producing snack bars made from tomatoes. It offers a practical and healthy alternative to the standard drying techniques. The optimal conditions identified in this research create a pathway for developing superior-quality dried tomato products, fulfilling the increasing demand for innovative and nutritious snack options.

This study has received funding from the European Union's Horizon 2020- PRIMA Section I Program under grant agreement # 2032 (FunTomP).

Keywords: *Microwave-vacuum drying, snack bar, tomato product, quality preservation, innovative processing*

33 | Poster

LIFE ALGAR BBE MicroALGae with ARomatic plants as biostimulants with biocide effect

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This work is part of the LIFE ALGAR-BBE project and is based on the field validation under real conditions in industrial tomato of safe and sustainable formulations of natural origin, with biostimulant capacity and biocidal action, developed in the project itself from microalgae, aromatic plant extracts, olive residues (olive pits) and residual Spirulina biomass after extraction of the pigment phycociana. The main objective of LIFE ALGAR-BBE (LIFE18 ENV/ES/000518 Project) is to mitigate the adverse effects on the environment and human health of chemical pesticides currently used on crops.

ENDESA, CTAEX and NEOALGAE carried out different actions before its application in the field, from the production of microalgae, obtaining extracts of aromatic species and the study of the biocidal capacity of extracts in vitro, which allowed the selection of the most effective species, the formulation, preparation of the biostimulant, evaluation of the biocidal capacity of the formulations in vitro and determination of their phytotoxicity. Then, dosage trials, application methods and studies with reduction of fertiliser units were carried out in the field, leading to the selection of a formulation and three application methods, finally making it possible to eliminate the application of chemical pesticides from farm schedules.

The trials were duplicated in Spain and Portugal, establishing in each area a trial with four theses in one hectare: formulated via foliar at 3 liters per hectare, formulated via drip at 5 liters per hectare, combination of the formulated via foliar and drip at the mentioned doses and the control without formulated and the usual chemical pesticide treatments in the area according to the pests and diseases detected.

The analysis of results showed an increase in productivity in applications with biofertilizers via foliar and via foliar plus drip between 7,600 and 38,000 kilograms per hectare, being always higher in foliar applications only.

Keywords: microalgae, processing tomato, aromatic plant extracts, chemical pesticides

34 | Oral

Production of a cellulosic fiber from tomato wastes

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Participation supported by an Adopt a Scientist Grant funded by Morning Star

Cellulose is one of the most abundant natural polymers in the biosphere. It is found in the cell walls of plants where it provides rigidity to the cell. Cellulosic fibers are of interest for the food industry due to their water and oil holding property and emulsifying activity. Cellulose based products can be used as a thickener and stabilizers for a wide range of food applications. For this study, cellulosic fibers are produced from tomato remains of the industry aiming to utilize the waste to produce a value-added product.

Dry tomato waste obtained after tomato sauce production was obtained from a local company. Production of the cellulose was carried out in a 4-step process. Firstly, hot water extraction (10 minutes at a boil) was performed to remove sugars, phenolics and water soluble pectins. Then acidic extraction (1M HCl, 85ºC, 30 minutes) was performed to remove acid soluble pectins. After that, a basic extraction (1M NaOH, 85ºC, 30 minutes) was performed to remove hemicelluloses). Finally, bleaching (1% NaO2Cl, 80ºC, 2 hours) was performed to remove lignin and pigments. The fibers are then air dried and milled using a ball mill. Techno functional properties of the fibers such as water and oil holding capacity, swelling, emulsifying activity was investigated. Particle size after the ball milling was measured by laser scattering method. FTIR spectra was obtained. The final product's cellulose content was measured by standard gravimetric method.

Tomato waste fiber was shown to possess significant water holding (~9 g water/g), oil holding (2 g oil/g) and swelling (5-6 mL/g) properties. FTIR spectra showed that the produced fiber was 85% similar to micro fibrillated cellulose from the program's library. Gravimetric analysis showed that the product was more than 90% holocellulose (cellulose and hemicellulose) and 80% cellulose.

A 4-step isolation process was used to produce cellulose fibers from the waste of tomato industry. The results showed that the product has similar properties to orange peel fiber and superior to many commercial fibers from soybean, pea or wheat.

This study has received funding from the European Union's Horizon 2020- PRIMA Section I Program under grant agreement # 2032 (FunTomP).

Keywords: *cellulose, fiber, tomato, waste,*

35 | Oral & Poster

Comparative analysis of satellite and on-site sensor-based irrigation recommendations on processing tomato yield

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An efficient use of available water is essential for the sustainable management of horticultural crops, which can be achieved through information provided by various methodologies involving both satellite sensors and on-site sensorization of the cultivation area. The objective of this study is to evaluate the cultivation management of processing tomatoes under different irrigation advisory recommendations on a commercial plot. For this purpose, three irrigation calculation modalities and their effects on productive performance and fruit quality were compared in three trials using information from satellite sensors (GF) against the irrigation volume calculated by the farmer (AGRI) and the recommended irrigation volume from sensors deployed in the field (IRRIX). Each trial was managed based on an irrigation recommendation system, with irrigation recommendations provided by both the GF and IRRIX systems. The irrigation volume for the GF treatment was calculated and adjusted daily based on the processing and periodic analysis of multispectral satellite images corresponding to the Sentinel 2 mission and daily meteorological data provided by IBM. Meanwhile, on-site sensors provided data for the calculation of automatic irrigation prescriptions through the IrriDESK decision support system. The AGRI irrigation calculation was based on the farmer's experience. The results showed a reduction in the calculated doses by the digitized systems, with IrriDESK being the most restrictive. On the other hand, production was higher in the AGRI treatment; however, quality was reduced in terms of BRIX and pH at the harvest time. Consequently, despite higher production, the economic yield per hectare was lower. Based on these results, the application of sensor-based methodologies reduces the amount of irrigation provided but also decreases production that does not correspond to the reduction in irrigation. This suggests the influence of soil variability in the different trials.

Keywords: *Sustainable Agriculture, Irrigation Advisory Systems, Satellite Sensor Irrigation, Irrigation Efficiency, Water Management*

37 | Oral

Host resistance in commercial tomato cultivars to manage *Phytophthora infestans* status

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Late blight, incited by *Phytophthora infestans*, is a devastating disease of tomato. Systemic and contact fungicides are relied upon for conventional production, but effective options are limited for organic growers. In 2018 and 2019, 12 and 23 tomato cultivars, respectively, were tested under growth chamber, greenhouse, and field conditions for late blight resistance. Plants were inoculated with 1x105 (greenhouse and growth chamber) or 1x104 (field) sporangia/ml suspensions of an isolate of P. infestans clonal lineage US-23. In the growth-chamber study, the lowest disease severity at the final assessment at 14 days after inoculation (< 20%) was observed in 'Matt's Wild Cherry' and 'Tomato Stellar', with significantly less disease than all other cultivars. The relative area under the disease progress curve (rAUDPC) data indicated these cultivars were significantly less susceptible than all other cultivars except for 'Mountain Magic' which was similar to 'Matt's Wild Cherry'. In greenhouse experiment 1 (2019), 'Mountain Magic', 'Tomato Stellar', and 'Mountain Merit' had the least amount of foliar disease severity (0 – 8.0%) for each observation date. In greenhouse experiment 2 (2019), 'Iron Lady', and 'Defiant' had the lowest disease severity but were similar to 'Lemon Drop', according to the rAUDPC data. For the field experiment (2019), eleven of the cultivars included in the study had foliar disease severity < 5% on the final observation date. According to the rAUDPC data, 'Iron Lady', and 'Defiant' had the lowest disease severity but were similar to 'Lemon Drop'. 'Lemon Drop', 'Cherry Bomb', and 'Fantastico' were similar to each other; 'Plum Regal' was similar to 'Cherry Bomb' and 'Fantastico'. Disease control in tomatoes grown for both organic and conventional markets could be advanced by using tomato cultivars with resistance to *P. infestans*.

Keywords: Phytophthora infestans, oomycete, tomato, genetic resistance

38 | Oral

Evaluation of fungicides and a fumigant for management of Fusarium diseases in the Central Valley of California

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Numerous soilborne diseases affect processing tomato in the Central Valley of California, among the most serious of which are the Fusarium diseases; Fusarium wilt (Fusarium oxysporum f. sp. lycopersici race 3), Fusarium crown and root rot (F. oxysporum f. sp. radicis-lycopersici) and Fusarium stem rot and decline (pathogens in FSSC clade 3). While host resistance or tolerance is the most effective approach for managing these diseases, there is not currently a sufficient diversity of cultivars with resistance and/or tolerance for the latter two diseases. While acknowledging that chemical control should not be a primary tactic against these diseases, there was interest in whether these tools had utility as part of an integrated disease management approach. Multiple field trials were conducted in commercial fields in 2021 and 2023. Pre-plant treatments included a fumigant applied via injection into a sub-surface drip irrigation system. Treatments applied at transplanting included different fungicides or a biostimulant applied via a soil drench within 24 hr of transplanting. Early season applications of fungicides were made via the drip system. Materials evaluated included the fumigant metam potassium (metam-K), fungicides pydiflumetofen and flutriafol and a biostimulant containing N-fixing microbes Azotobacter and Clostridium. Not all trials included all materials. During the season, we measured disease incidence and severity with an emphasis on vine decline as the primary disease metric. We measured NDVI, machine-harvested yield, cull rate and fruit quality (soluble solids, pH and color). Efficacy varied from trial to trial and the magnitude of the effect was not related to the level of disease pressure, although the relative disease tolerance of the cultivars could be a contributing factor. Averaging the performance over three trials and two years, pre-plant fumigation with metam-K resulted in a marketable yield increase of 25.5 t/ha, but with a range from 8 to 58 t/ha.

Keywords: *crop protection*

39 | Poster

Study on soil herbicides for weed control in tomatoes (*Solanum lycopersicum L.*)

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Tomatoes (*Solanum lycopersicum L.*) are one of the most widespread vegetable crops around the globe and in Bulgaria as well. Very often, effective weed control is a crucial element for sustainable crop production. In the period 2022 - 2023, a field experiment with tomatoes, variety "Prista" F1 was carried out in the experimental field of the Agricultural University - Plovdiv, Bulgaria. The trial included the following variants: 1. Untreated control (without manual weeding and herbicides); 2. Economic control (manually weeded); 3. Benfluralin (1.500 kg ai ha-1); 4. Metribuzin (0.276 kg ai ha-1); 5. Clomazone (0.144 kg ai ha-1). The herbicides were applied before transplanting the tomatoes (BBCH 00). After spraying, the benfluralin variant was incorporated into the soil. The efficacy of the studied herbicides was evaluated by the 10-score scale of EWRS. The highest control of *Portulaca oleracea* L., *Amaranthus retroflexus* L., *Setaria viridis* (L.) P.Beauv., and *Solanum nigrum* L. after the application of Benfluralin and Metribuzin was found. None of the herbicides studied controlled *Convolvulus arvensis* L. and *Sorghum halepense* (L.) Pers. developed from rhizomes. The highest yield of tomatoes was obtained at Economic control, followed by Benfluralin (1.500 kg ai ha-1) and Metribuzin (0.276 kg ai ha-1).

Keywords: *tomatoes; herbicides; weeds; efficacy; yield*

40 | Oral

Recent approaches in the HPLC determinations of bioactive compounds from tomatoes

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Tomatoes and their products receive an increasing interest in the fields of food technology and human nutrition due to the high content of biologically active components, which contribute efficiently to the reduced risk of serious biological disorder such as degeneration, cancers, and heart diseases via their high antioxidant activity. The most important bioactive compounds in tomatoes are: carotenoids, tocopherols, polyphenols and vitamin C. In the traditional determination, the four groups were usually analysed separately with time-consuming and cost-effective procedures. Recently, the development of the HPLC methods for the analysis of bioactive compounds from fruits and vegetables is a part of research projects aiming at elaboration of new HPLC methods that assists in achieving simple, precise, and of short-time qualitative and quantitative analyses. The development included separation of carotenoids on core C30 with modified gradient elution and hyphenation with MS/MS detection. With the new protocol the main carotenoids and their different geometrical isomers could be efficiently separated. Two unusual carotenoids could be identified as dimethoxylycopene and di-OH-cyclolycopene adduct. In case of fat-soluble tocopherols, the un-saponified extract was separated into its free and acylated individuals with identification of tocopherol hydroquinones for the first time. Most recently, simultaneous determination of vitamin C and polyphenols from anthocyanins-containing tomatoes was achieved by application of phosphor-conditioned C18 phase (PCP) with gradient elution of acetonitrile in 1% orthophosphoric acid. The newly developed method provided excellent separation of organic acids, flavonols and anthocyanins from different tomatoes in one HPLC run.

Keywords: *Bioactive components in tomato, HPLC, carotenoids*

41 | Oral

Spray drying of sugar-reduced tomato juice to produce clean-label tomato powder for diabetics

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Tomatoes and tomato products are known to be interesting in terms of their phytomicronutrient content. These are known to play a role in reducing the risk of cardiovascular disease (Cheng et al. 2019), diabetes (Banihani 2018) and cancer (Liu et al. 2010). Given these health effects of tomatoes, it would be interesting to make the most of these phytomicronutriments available for consumers suffering from these diseases. Powder would be a good alternative as it could potentially be the most concentrated form of tomato-derived products in phytomicronutrients (over 1000 times more than in tomato) (Mapelli-Brahm et al 2018). In our study, the spray drying process was used to produce tomato powders. The main problem of spay drying for sugar rich products is their stickiness, which lead to the use of additives to modify the product properties. In order to obtain a clean label product without additives, a centrifugation process was applied to tomato juices with the aim of reducing their sugar content. This process eliminates the need for maltodextrins, while at the same time improving drying yields. It was found that centrifugation at 13,000g for 15 min reduced the sugar content by more than 75%. The pellet obtained was then dried, giving a drying yield of over 60% at spray drying between 140 and 150°C. The application of this combination of processes without the addition of additives is an interesting approach, as it produces a powder rich in phytomicronutrients, notably lycopene. It is also a low-sugar product, that can be interesting for diabetic consumers or those wishing to consume a healthy product. All these data will allow to produce in the food industry a functional food with low calories, without additives and an interesting content of molecules of interest like lycopenes.

Keywords: *tomato, powder, drying, phytomicronutriments, centrifugation*

42 | Oral
Ralstonia solanacearum control: Monitoring and containment measures to prevent its spread in Northern Italy tomato processing industry

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Ralstonia solanacearum is a quarantine bacterial pathogen that causes vascular wilt disease in more than 200 crop species, including tomato. The bacterium can survive in tomato plant debris and many weeds; disperse in infested soil, irrigation water, which constitute a possible reservoir source of inoculum. The bacterium usually infects tomato plants through the roots. Soil born organisms, such as the root-knot nematode, insect and cultivation practices can cause injuries to plant roots and penetration of the bacterium. R. solanacearum-caused wilt in tomato accounts for a 35%- 90% yield loss under high temperatures and high moisture conditions (also due to climate change).

The purpose of this study was to simulate, for three consecutive years (from 2021 to 2023), what happens industrially during the tomato processing, using tomatoes contaminated with the Ralstonia, in order to assess the possible risk of transmission at the washing and depuration plant stages, and the study and application of a successful sanitation protocol in order to obtain the complete bacterial inactivation.

Ripe harvested processing tomatoes: a) fully infested by R. solanacearum; b) infested and diluted with a specific quantity (5 times of sound tomatoes - used in order to mimic what usually occurs in a common receiving station of industrial tomato processing plant) coming from the same infected field, were washed with precise volumes of washing-water applying a protocol of operations at the SSICA pilot plant. All the wastewaters obtained from the pilot plant were treated with NaClO sodium hypochlorite, using an experimental design made with the application of different concentrations/time combination, in order to evaluate the residual presence of the pathogen in the water samples, in tomatoes and in the MOT fractions (materials other than tomato).

The results obtained after 3 years of experiments, have indicated no presence of R. solanacearum in all the samples after the application of the washing protocol treatment regardless the dosage or treatment time with NaClO, and the same for the tomatoes. On the contrary, MOT showed presence of the bacterium in the basal part of the plants in the samples collected especially closed to the loci of the infection but never in tomato fruits.

This work represents the last step in a three years' study commissioned from the Emilia Romagna Region that will complete the statistical significance of the trials and confirms the results of the previous years of experimentation, open the possibility to harvest and process tomatoes coming from Ralstonia infested fields after the application of a correct protocol of operations to guarantee ambient, farms and industries as well as the consumers' health.

Keywords: Processing tomato, Ralstonia solanacearum, bacterial wilt, spoilage pathogen, tomato crop residues, washing protocol treatment.

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First results of mechanical direct sowing of processing tomato on biodegradable mulch film

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Processing tomato (*Solanum Lycopersicum L.*) is among the most widely grown horticultural crops in the world. In recent decades, processing tomatoes have been benefiting from soil mulching, and for this reason the mulched area continues to increase worldwide. Notably, only 3.6 percent of currently used mulch films are biodegradable, while the rest are plastic materials, usually polyethylene, which raise critical disposal issues. The purpose of this work was to evaluate the mechanical direct sowing of processing tomatoes on biodegradable mulch film grown in an area highly suited to processing tomato production. The experimental work was conducted in Lesina in the province of Foggia, Italy. The site has a Mediterranean climate with mild winters and dry-and-warm summers. Cherry tomato, genotype Cesarino, was mechanically sown on biodegradable mulch film and compared with seedlings of the same genotype mechanically transplanted on biodegradable mulch film. Throughout the crop cycle (emergence, flowering, fruit set, fruit ripening and harvest), weather parameters were monitored and agronomic (phenological phase (BBCH),plant height, soil water content, collar diameter, and epigeal and hypogeal biomasses), physiological (leaf pigments such as chlorophyll and leaf temperature) and fruit qualitative (colour, pH and °Brix) traits were recorded. Considering spatial and temporal variability three field replications (20 m x 1.7 m) for each thesis were used. All collected data were subjected to analysis of variance (ANOVA), and means were separated by Duncan's $p < 0.05$. The experiment reported interesting results, in fact, the technique of the direct sowing on biodegradable mulch film reduced the volume of the irrigation water and the nitrogen use, while preserving fruit yields and quality. These results were putatively due to the higher root length and growth of plants resulting from direct sowing than transplanted seedlings.

Keywords: *tomato, sustainability, climate change, irrigation, nutrition*

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Alternaria toxins in processed tomato products: Diffusion ability and behavior during industrial processing

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Tomatoes can be subjected to spoilage by a wide range of filamentous fungi. Among their associated mycobiota, *Alternaria* is a real matter of concern to tomato processors, due to its ability to produce several toxic metabolites such as tenuazonic acid (TEA), alternariol (AOH) and its monometylic ether (AME). Such molecules are often found in finished products, the control measures applied in the tomato process being apparently ineffective in reducing them. Therefore, this work was aimed to assess if *Alternaria* toxins' occurrence could be explained considering a "hidden" contamination of the raw materials or a possible resistance of the toxins to the thermal treatments applied. The "hidden" contamination was checked by means of a diffusion test that was carried out on tomatoes by inoculating apical berries with fungal suspensions of different toxigenic *Alternaria* SSICA strains, incubated at 25°C up to ten days. The results showed that a limited diffusion of the toxins occurred only in the berries close to the inoculated one. The heat-resistance of the three above-mentioned toxins was assessed in tomato juice, puree and paste by means of heat treatments at 95°C up to 240 min. All toxins proved to be partially reduced, even if their decimal reduction times (DT) proved higher than 250 min in all tested tomato products. The fate of the three above-mentioned toxins was also assessed during tomato processing by using naturally contaminated industrial berries as raw material processed into tomato puree. The quantification of TEA, AOH and AME toxins was carried out by means of UHPLC-HRMS/MS.

Keywords: Tenuazonic acid; Alternariol; Alternariol monometyl-ether; tomato products; tomato processing, heat treatment.

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Quality characteristics of typical canned cherry tomatoes obtained with direct mechanical sowing of tomato plants on biodegradable mulch film

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Nowadays, in a constantly evolving industrial worldwide market, it is essential to aim for innovation in holistic way, while preserving both quality characteristics and high sustainability of the vegetables crops in order to highlight its high dietetically benefits. All the stakeholders of the whole food supply chain have to contribute to this approach with the common objective of providing innovative environmentally friendly solutions maintaining high quality standards of production. Among the main players, the agricultural producers aim to increase yield's and crop's quality in a sustainable way, and at the same time, food industry need to obtain processed products increasingly rich in quality and bio-actives substances that contributes to the consumer's choices and its healthy diet.

The aim of this work was to evaluate how the use of biodegradable materials in an experimental field can influence the final agronomic production yield and its influence on the main qualitative and nutritional parameters of processed cherry tomatoes.

A typical cherry tomato cultivated in south of Italy was mechanically sown on biodegradable mulch film compared with seedlings mechanically transplanted on the same film. Cherry tomatoes exp. thesis were harvested, agronomical evaluated and then directly processed with hot filling techniques (by means of SSICA semi-industrial pilot plant) into canned cherry tomatoes. Fresh cherry tomatoes and their processed products were characterized in their leading quality parameters (°Brix, Colour, pH, Sugars, Acidity, Polyphenols, Lycopene, etc.). and, at the same time, the technological industrial yield obtained were evaluated. Overall data shows that the innovative mulched treatments used in the field do not significantly affect the quality of the canned products obtained.

Keywords: *Canned cherry tomatoes, biodegradable mulch film, quality parameters, processing yield*

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Vegetation indices to monitor water and chlorophyll content of tomato leaves

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Plant monitoring is not only an issue in the case of plants grown indoors but also affects the crops cultivated in the field more and more. In conjunction with the development of precision agriculture, numerous vegetation indices came to light. The problem of which vegetation index (VI) to apply to a given task can be confusing. Thus, an experiment was carried out to reveal which VI is the best alternative to monitor the water and chlorophyll content of tomato leaves. Four levels of water supply treatment were applied to the H1015 processing tomato variety in the experimental field of the Institute of Horticultural Science at Gödöllő, Hungary in 2023. The relative water content (RWC) and chlorophyll content (CC) were measured three times during the growing season specifically in the phase of flowering, and fruit development and in the beginning of the ripening phase. The chlorophyll content of leaves was determined by HPLC measurements. Simultaneously with the laboratory measurements, the non-destructive hyperspectral reflectance spectrum (VIS/NIR) was collected from the different treatments in the field. Overall, 228 VIs were involved in the study and the correlation between RWC and CC with the VIs was evaluated. Depending on the nature of VI, both strong positive and strong negative correlations were discovered in the case of RWC and CC as well, with many VIs. The highest correlation with RWC was 0.95 in the case of SR678/750 (Simple ratio 678/750). The strongest correlation coefficient was negative (r= -0.87) registered between total CC and FR (Simple Ratio 690/735 Fluorescence ratio). When the correlations were investigated separately to chlorophyll-a and chlorophyll-b, the results were very similar to when the total chlorophyll was involved. The study revealed that some simple ratio indices can be used well in the monitoring of RWC and CC in tomato leaves in the field. However, more data must be collected from different growing seasons and locations to build a larger database and draw more reliable conclusions.

Keywords: *VI, water stress, monitoring*

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Adaptive responses of tomato plants to varying irrigation levels: Insights into root development efficiency

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Saving irrigation water is a worldwide challenge. In the same time, crop yields should be kept on a reasonable level, or even increasing the efficiency of the water used. For plants, beside manipulating its stomata, an effective tool is the expansion of the root zone during the process of adaptation to water scarcity or low soil moisture levels. The adaptive responses of tomato plants to different irrigation levels were investigated in our research, focusing on root development and photosynthetic traits. The study was conducted over two consecutive years during the 2020 and 2021 growing seasons in Gödöllő, Hungary. The examination covered how these plants adjusted to three watering conditions such as full irrigation (100% of crop evapotranspiration), reduced irrigation (50%), and no irrigation. Using the CI-600 in-situ root imager, root structures were non-destructively examined weekly for multiple weeks, at three different depths of the root zone. As a strategy to optimize water uptake, plants exhibited a tendency to develop deeper and more extensive root systems under water stress conditions, in agreement with previous research. The variations in root depth and architecture were influenced by both soil depth and the severity of water stress and discrepancies between growing seasons were also identified, which is likely attributable to changes in irrigation levels and environmental factors such as temperature. An important finding was that the adaptation could undergo relatively quick, even within one week, when plants developed roots toward root zone levels with more favourable moisture conditions. SPAD values were notably higher under non-irrigated conditions, particularly during the 2021 growing season, indicating reduced chlorophyll degradation. Our study provided data and insights to understanding how tomato roots utilize their root zone. These results might be considerable to plant breeders as well while developing drought-tolerant cultivars and to irrigation professionals to harness the root zone more effectively supporting the resilience of irrigated crops.

Keywords: *root adaptation, water stress, root length, SPAD*

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Prediction of tomato quality traits utilizing machine learning models

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Tomatoes are globally important resource in food processing, with significant implications for nutrition, agriculture, and health. Understanding tomato ripening is essential, as it affects vital qualities like °Brix, lycopene content, and fruit colour. Amidst global population growth and climate challenges, machine learning (ML) models have emerged as promising tools for the future in predicting tomato quality. This study utilized a dataset comprising physicochemical traits and environmental factors for 20 tomato cultivars grown across 20 locations over five growing seasons in Hungary. Two machine learning models, the XGBoost and Artificial Neural Networks (ANNs) were trained to predict three key tomato quality metrics such as °Brix, lycopene content, and the chromaticity ratio (a/b ratio). The results demonstrated that in predicting both °Brix and lycopene levels, XGBoost was more effective than the ANN model. In the case of °Brix, XGBoost recorded a high R^2 value of 0.98 and a minimal RMSE of 0.07, exceeding the performance of ANNs which attained an R^2 of 0.89 and a RMSE of 0.17. Similarly, in the prediction of lycopene content, XGBoost achieved an R^2 of 0.87 and an RMSE of 0.61, bettering the ANN's R^2 of 0.84 and RMSE of 0.86. Additionally, XGBoost excelled in predicting the a/b ratio with an R^2 of 0.93 and a minimal RMSE of 0.03, while the ANN model displayed limitations, resulting in a negative R^2 value of -0.35. The SHAP analysis showed that XGBoost and ANNs effectively predict °Brix and lycopene in tomatoes, each with distinct data interpretations. It highlighted the significant impact of tomato cultivar selection on these predictions. Additionally, climate factors like humidity and temperature, and environmental aspects such as soil type and growing location, were crucial. This emphasizes the need for meticulous model choice, fine-tuning, and validation in precision agriculture, especially for ANNs.

Keywords: *XGBoost, ANN, ml, brix, lycopene*

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Viscosity of tomato-based product can be influence by structural modification of constitutive particles as well as biochemical modification of pectins

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In order to influence the viscosity of tomato-based products, processors can choose to manufacture their products from varieties known to provide more or less viscous products, or to act on key parameters of the process known to modify texture, such as break temperature and product concentration. While these solutions are known to have an impact on texture, the underlying physicochemical mechanisms remain poorly understood and therefore poorly controlled.

Using an experimental design including two lines contrasting for the texture of their purées and both hot- and cold-break processes that also cause textural changes, the aim of our study was to identify the molecular and physical mechanisms underlying each origin of the changes. Initially, rheological analysis of the purées did not enable us to differentiate between textural changes due to the process and those due to the change in variety, but sensory analysis showed that consumers did differentiate between the two causes of textural change.

A detailed physico-chemical analysis of each puree showed that changes in texture due to variety appeared to be linked to different proportions of soluble/insoluble sugars. The soluble pectins also showed differences in structure and conformation. Fluorescence microscopy of the particles in the purées revealed for the first time interactions between lycopene-rich particles and cell-wall fragments, which are particles theoretically opposed for their hydrophobicity.

This study enables us to provide new hypotheses as to the molecular mechanisms that cause texture changes and opens the way to better control of this parameter for industrial tomatoes.

Keywords: *Industry Tomato, processing, pectin, particle, viscosity*

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Alternaria toxins: Risk prevention and control for tomato food chain

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One of the major fungal pathogens of tomato fruits is Alternaria, developing during cultivation or post-harvest. Alternaria genus produce a wide range of mycotoxins, and some of these toxins are issues for consumer health. Recent scientific studies have led to the establishment of a European recommendation for the control of 3 Alternaria toxins (Alternariol, Alternariol monomethylether, Tenuazonic acid) in foods, including processed tomato products. To enrich existing data on the subject and to propose biocontrol solutions, TOMALT collaborative research project started. Some Alternaria species were isolated from contaminated tomatoes, then identified, and their toxinogenesis on different matrix in vitro and in vivo was evaluated with quantification of 6 Alternaria toxins by LC-MS/MS: the 3 toxins as mentioned by the UE recommendation, plus Tentoxin, Altertoxin I and Altenuene. It highlights the importance of the strain chemotype and the growth matrix on mycotoxin contamination profile. To fight against Alternaria contamination of tomatoes, biocontrol solutions were tested. A plant extract was evaluated against Alternaria alternata, in vitro and also in vivo on lots of tomatoes bulk stored in crates and showed promising antifungal effect. To better understand the fate of Alternaria toxins during tomato processing, naturally contaminated tomato fruits were processed into concentrates at pilot scale, and the impact of different processes on Alternaria toxins was investigated.

Keywords: *Alternaria, mycotoxins, tomato, biocontrol, thermostability*

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Regulated deficit irrigation to overcome climate change effects enhancing processing tomato fruit quality

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Crop growth models project a severe exposure to irrigation resource constraints for high-water demanding vegetables as processing tomato (Solanum lycopersicum L.). A yield decrease is expected by 2050, making it necessary to adapt crop management strategies to future conditions. This research aimed to assess a water saving approach through optimization of irrigation management able ensuring good yield and fruit quality. A field-trial was carried out in Northern Italy (Ferrara) in 2020 to compare a full-irrigation management (IRR, restoring 100 % ETc) with a regulated deficit strategy (RDI, based on 50 % ETc restitution when BBCH 702 phenological phase was reached). This stage occurred on 30th June 2020, when 518 growing degree days (GDD) were cumulated starting from the transplant (8th May 2020). RDI strategy led to a 11.39 % water saving, resulting in comparable total and marketable yield and in an enhanced soluble solids content in tomato fruits (+ 7.38 %) with respect to IRR management. Several free amino acids were promoted (alanine + 67.97 %, arginine + 70.66 %, asparagine + 27.88 %, glycine + 62.32 %, histidine + 19.23 %, isoleucine + 16.00 %, leucine + 27.21 %, ornithine + 14.81 %, serine + 33.41 %, tryptophan + 59.41 %, valine + 29.36 %) and amino acid derivatives (GABA + 35.78 %, MEA + 24.53 %) by the regulated irrigation. These findings suggest that RDI strategy caused stomatal closure and photorespiration. However, plants were able to adjust primary metabolism to cope with the release of excess ammonia and with the oxidative stress caused by the slowdown of the photosynthetic electron transport.

Keywords: abiotic stress, tomato, irrigation, fruit quality, sustainability

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Agricultural ICT platform "CropScope" achieved water saving and yield increasing

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DXAS Agricultural Technology LDA (DXAS), a joint venture between Kagome and NEC, have introduced an agricultural ICT platform, "CropScope," which combines AI farming advice and automatic irrigation control functions compatible with pulse drip irrigation, to tomato fields in northern Italy and Portugal. In northern Italy, CropScope was introduced for the first time as a field trial conducted from April to August in 2023, resulting in increased yield and requiring less irrigation compared to a field where the platform was not introduced. The platform was also commercially introduced recently to a large-scale tomato field in Portugal, and high yield was achieved.

The three companies aim to contribute to sustainable agriculture by promoting environmentally friendly and profitable farming by expanding the areas in which CropScope is introduced, while also confirming reproducibility and effectively responding to water shortages at farming sites, which are challenges faced around the world.

The three companies introduced CropScope services, which consist of AI farming advice and automated irrigation control functions compatible with pulse drip irrigation, to tomato fields in northern Italy and Portugal.

A field trial of CropScope in northern Italy was able to increase yield by about 23% with about 19% less irrigation compared to a field that did not introduce the platform. It was confirmed that this system will produce good results even in new cultivation environments where climates, soil, etc. differ from those in the regions where CropScope was previously introduced. In Portugal, by combining the skills of experienced agronomists, it was able to obtain a high yield of 148t/ha on large commercial fields of about 21ha (total of 2 fields).

Keywords: automation, precision farming, fertilization, irrigation

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Ripening process evaluation of tomatoes treated with different concentrations of 1-MCP ripening inhibitor

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Initially, gaseous 1-Methylcyclopropene was only used for cut flowers, but later on it was also found effective as an anti-ripening agent for fruits and vegetables. Several previous studies have confirmed the efficacy of 1-MCP on apples, pears, plums and tomatoes, but the treatment parameters for tomatoes are not yet fully developed. At present, the manufacturer's recommendation is to treat tomatoes for 24 hours at a gas concentration of approximately 600 ppb 1-MCP. The aim of our research was to investigate how the ripening process of tomatoes changes under different 1-MCP gas concentrations. In our experiment, in Hungary grown and freshly harvested fruits of Lycopersicon esculentum cv. Boderine tomatoes were tested. Tomatoes were harvested at 4 different stages of ripeness based on their colour: mature green, turning, pink and fully ripe red. Two different treatments were applied per group and there was also a control, untreated group for comparison. 1-MCP treatments were carried out on the day of harvest at 20 °C for 24 h at 625 ppb and 1000 ppb concentrations, followed by room storage at 20 °C. During storage surface colour, chlorophyll content and the texture were monitored by non-destructive methods for 2 weeks. Based on our results obtained, 1-Methylcyclopropene anti-ripening treatment was the most effective for the mature green tomatoes, with approximately 80% of the samples remaining green after 1 week of treatment, compared to 20% in the control group. Furthermore, it can be concluded that an 1-MCP concentration of 625 ppb was sufficient to treat tomatoes, with higher concentrations not providing a significant benefit in terms of the characteristics we tested.

Keywords: *1-methylcyclopropene, postharvest*

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Valorization of tomato pomace to use it as a substrate in the fermentation

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Tomato pomace is a by-product of tomato processing, composed of peel, pulp, and tomato seeds, which is rich in proteins, fats, minerals, and fatty acids. The global annual tomato production has reached 186 million tons, resulting in a significant amount of tomato pomace. It requires proper management to prevent resource waste and environmental pollution. Therefore, the valorization of tomato pomace is of great significance, and it should be hydrolyzed to use it in fermentation to produce several value-added products.

For that, tomato pomace was hydrolyzed with different methods to obtain reducing sugar. Acid hydrolysis, alkaline-assisted enzyme hydrolysis, and hydrothermal-assisted enzyme hydrolysis were applied to 10% (w/v) tomato pomace. Acid hydrolysis with H2SO4 (1%, 2% w/v), alkaline pretreatment with NaOH (1%, 2% w/v), and hydrothermal pretreatment were conducted at 121 °C for 15 and 30 min. After alkaline and hydrothermal pretreatment, enzymatic hydrolysis was conducted at pH 5.0, °50 C, and 200 rpm for 18 hours with the addition of pectinase and cellulase. The weight of the resulting biomass after hydrolyzation was measured. The reducing sugar content was analyzed using the DNS method. In addition, lycopene and pectin extraction steps were applied before hydrolysis to obtain several products from tomato pomace.

The results showed that alkaline pretreatment for 15 minutes before enzyme hydrolysis generated a higher reducing sugar concentration (12.19 g/L) with 58.19% biomass conversion. In comparison, hydrothermal pretreatment for 30 min before enzyme hydrolysis gave a similar reducing sugar concentration (12.18 g/L) with 56.05% biomass conversion. When the results were compared statistically, there was no significant difference between them.

In conclusion, a sustainable hydrolysis method, hydrothermal-assisted enzyme hydrolysis, gave promising results concerning reducing sugar content. By transforming tomato pomace into fermentable sugar to produce high value-added products, the tomato processing industry can achieve a more sustainable approach to waste management.

This study has received funding from the European Union's Horizon 2020- PRIMA Section I Program under grant agreement # 2032 (FunTomP).

Keywords: *Tomato pomace; hydrolyzation; reducing sugar; sustainability; waste management*

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Insights from utilizing Water Retainer® in the growth and yield of processing tomato seedlings

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Global climate change poses a significant challenge to outdoor plant cultivation. Weather extremes are becoming increasingly frequent, raising the risk associated with cultivation. The Danube-Tisza interfluve is particularly susceptible to drought. Two hundred years ago, the primary concerns in the area were floods and drainage; today, prolonged periods of drought are more common. Our cultivation technology must now prioritize water retention and conservation. It can be reducing the need for irrigation, by preserving soil moisture. Water Retainer® may be effective in enhancing the soil's water-holding capacity. In our experiment, we investigated the impact of Water Retainer® on the growth of processing tomato seedlings and crop yield. The experiment was conducted at the Kalocsa Research Station of the Vegetable Growing Research Center of the Institute of Horticultural Sciences of the Hungarian University of Agriculture and Life Sciences (MATE KERTI ZKK). The seeds (Uno Rosso F1) were sown in 66-cell seedling trays filled with Baltic peat. Immediately after sowing, we irrigated the trays with two different concentrations of Water Retainer®: 1.5 ml/m^2 for one treatment and 2 ml/m^2 for the other. Additionally, two control groups were established without Water Retainer®, one receiving optimal (100%) and the other 50% of the total irrigation amount during seedling cultivation. At the end of the seedling growth period, we measured seedling height, the number of true leaves, and stem diameter. Subsequently, the seedlings were transplanted into the field and received no further treatment. A drip irrigation system provided on-demand irrigation and fertilization. During the harvest, we recorded the weights of ripe, half-ripe, green, and unhealthy fruits. We also sampled the ripe fruits to measure their soluble solids content. During seedling cultivation, the seedlings treated with Water Retainer® were successfully grown using half the amount of irrigation compared to the untreated control crops. The measurements taken at the end of the seedling growth period demonstrated the effects of water stress on the treated groups relative to the 100% irrigated control group. Out of the six parameters examined at harvest, treatment effects were evident in two, with a 95% probability. The correlation between yield and soluble solids content was more subtle in our experiment.

Keywords: *processing tomato, seedlings, irrigation, water retention*

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Tomatoes as a pilot of pedagogical knowledge construction in Master programs

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Tomato is a popular horticultural product in the world. In Colombia, tomato is produced all around the country and its harvesting can reach more than 500.000 Tm year-1. As a result, tomato consumption is higher than any other vegetable product. Popular varieties in Colombian gastronomy are cv Chonto and Milano, the most harvested in the country. Colombia produces tomatoes in many conditions in green houses and free-exposed orchards that include small infrastructure with low use of technology. However, these growing conditions account for the astonishing FAO statistics of 30% food losses. Low technology implementation during postharvest increases high fresh food losses. A Vegetable Science graduate program (master's degree) could contribute to change this situation. The program might include the study of tomato varieties as a base to experiment with the principal physiological changes observed in fruit when using low-cost treatments that delay rot and other losses on green and mature harvested tomatoes. In addition, a pilot of the proposal could was launched including used refrigeration, KMnO4 sachets, CaCl2 sprinkles, and minimal processes that lead groups to identify principal physiological and physicochemical changes (respiration, ethylene production, texture, color, flavor, and microscopical changes that results will be in included in this paper. These processes would show students the principal phenomena. Fresh cut tomato rot faster than whole fruits due to higher respiration rates and explains the manipulation effect. The microscopy explains tissue modification closely related to decay. The purpose of the proposal is to generate models to raise awareness among the new graduate cohorts about the real possibilities of technology and to create an interphase between the academic environment and the agriculture industry, through the student's abilities. To tackle the disconnection between academic programs and people, we need different strategies to overcome and propose solutions. Educational innovation through horticulture vegetable models could make the difference between theory and practice and enhance the soft and hard abilities of students. The objective of this paper is to show results in the transition to more effective pedagogic experiences as we found in our tomato pilot with students.

Keywords: education, innovation, losses, disconnection

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Distance from hedges slightly influences the antioxidant status of open field tomato genotypes

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The impact of hedgerows on microclimate is well known and their advantages are utilized in agroforestry systems, however, little is known about their influence on the nutritional content of crops. Additionally, limited results are available about how these advantages are interrelated with the distance from hedges. An experiment was set up in 2022 at the certified organic field of Experimental and Research Field of the Hungarian University of Agriculture and Life Sciences, Soroksár. The area is divided by a planted hedge in Southwest- Northeast direction. On both sides of the hedge, five-five blocks in increasing distances were positioned; each distance was three meters farther. The test plants were two commercial varieties ('ACE55' and 'Roma') and a Hungarian landrace ('Szentlőrinckáta') of tomato (Solanum lycopersicum L.), both being determinate types. The antioxidant status (FRAP and TPC) of samples collected in August 2022 were determined spectrophotometrically.

The TPC values of the samples ranged between 0.21 and 0.37 mg GAE/l on the Northwestern, exposed side, and between 0.24 and 0.32 on the Southeastern, protected side. Distance from the hedge had a slight impact on the TPC values; samples collected from the closest and farthest plots showed the highest values. The FRAP values of the samples ranged between 0.32 and 0.61 mg AAE/l on the exposed side, while on the protected side it was between 0.37 and 0.78 mg AAE/l. Similarly, to TPC values, the distance slightly impacted the FRAP values, with the closest plots having the highest antioxidant power. Among genotypes, 'Szentlőrinckáta' showed generally the highest polyphenolic and FRAP values; this excellence was more pronounced on the protected side. Hedges modulate the microclimate of the adjacent crops by shading and reducing evaporation; the elevated antioxidant properties could refer to higher stress levels of the plants due to changed environment.

Keywords: *hedgerow, microclimate, FRAP, TPC*

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Mitigation of high temperature stress by foliar application of chitosan in tomato seedlings

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Chitosan is a natural biopolymer that is non-toxic, biodegradable, and biocompatible. It is derived from chitins and has the ability to improve physiological responses and reduce the negative impact of abiotic stresses in plants. In order to study the impact of foliar application of chitosan on tomato seedling cv.Zucchero F1 under high temperature stress, a two factorial experiment was conducted in a controlled environmental condition. Treatments were included two temperature levels (25/20 °C optimal, 45/20 °C high) and two different chitosan concentrations (100 and 150 mg. L-1 and 0 as control) with four replications. Seedlings at the fourth true leaf stage were foliar sprayed with different concentrations of chitosan or distilled water depending on the treatments, every two days. After one week of chitosan application, half of the seedlings were subjected to high temperature stress at 45 °C for four hours each day. The findings indicated a significant reduction in SPAD values and total chlorophyll concentrations in seedlings leaves subjected to high temperature condition. However, the application of 100 mg. L-1 chitosan resulted in enhanced SPAD values whereas both dosages of chitosan led to an increase in total chlorophyll concentrations under stressful conditions. Shoot length decreased under high temperature and chitosan had no significant effect on shoot length in both stress and non-stress conditions as compared to non-chitosan treated seedlings. Leaf relative water content significantly decreased in seedlings grown under heat stress and chitosan 100 mg. L-1 stimulated the adverse effects of heat stress. Overall, 100 mg. L-1 of chitosan can alleviate the adverse effect of high temperature stress in tomato seedlings.

Keywords: *abiotic stress, chlorophyll, chitosan, heat stress*

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Effect of Water Retrainer® during seedling period on bioactive components of processing tomato

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One of the most important problems in agriculture is the unequal distribution of rainfall and drought as a result of climate change. At different growth stages of tomato, drought stress can affect the amount and ratio of bioactive components in the fruit. In our research, we investigated the effect of a new water retention agent containing natural ingredients and biodegradable in the soil (Water Retrainer®) during the seedling period under different irrigation intensities. For two years, we monitored the changing of the dry matter content and several bioactive components of Uno Rosso F1 tomatoes (vitamin C, tocopherol derivatives, lycopene, β-carotene, total polyphenol content, antioxidant capacity) with and without the use of the Water Retrainer® water retention agent. Although the conditions of field cultivation were the same of the plants, the seedling stress had a significant effect on the bioactive components of the crop. Our results proved that the antioxidant compounds, like lycopene, vitamin C, polyphenols in tomatoes reacted much more sensitively to growing conditions and water supply. The amount of β-carotene was significantly higher in the fruits of plants exposed to drought stress, while the amount of polyphenols, vitamin C and antioxidant capacity was higher in the fruits of plants that received a balanced water supply in the seedling phase. We performed a discriminant analysis on the data and found that it is possible to classify with 100% probability which treatment the samples received during seedling cultivation. The seedling treatments significantly influenced the composition of the bioactive components of the crop, but at the same time it can be said that the seasonal effect was proportionally more significant. The processes caused by drought stress at the seedling stage cannot be completely reversed, but the difference in terms of cultivation, yield and product quality does not cause a significant decline.

Keywords: *processing tomato, seedlings, irrigation, water retention, bioactive components, antioxidants*

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Phelipanche – a California re-emergence: Processing tomato industry efforts in the development of contain, control and long term management strategies

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In 2024, the California processing tomato industry is funding seven university research labs, across two U.S. Land Grant Institutions (UC Davis and University of Wisconsin) with research collaborators in both Chile and Israel on one pest problem, Branched broomrape (Phelipanche ramosa). This work is multi-disciplinary, including teams of scientists spanning weed physiology, traditional weed management, population genetics, molecular biology, plant breeding, remote sensing and mechanical engineering. A herculean collaborative effort by all included on one pest problem, but not enough. Eight years in to a re-emergence of this parasitic weed in California processing tomato fields, with multiple years of trials and some wins, we are working against the cruel and relentless biology of this major global tomato threat. What follows is a synopsis of ongoing work in this area and a look into future directions.

The records of the California Tomato Research Institute (CTRI) were reviewed and analyzed, including project reports, funding requests and published literature from CTRI sponsored research.

Keywords: *Phelipanche ramosa, Branched Broomrape, parasitic plants, weeds, UC Davis, California Tomato Research Institute, CTRI*

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Smart processing tomato cultivation: Precision irrigation system using DSS and LoRaWAN technology

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Processing tomato represents one of the main industrial cultivations for Italy, and in particular for Puglia region, the main European country for production of such processed food. Irrigation is a fundamental management technique to reach sustainable yield and optimize the quality of the crop.

Since water is a limited resource in the Mediterranean basin, the use of systems to optimize the water management has gained importance during the last decades, both for water and energetic cost increases.

Furthermore, the possibility of automating irrigation operations in the different lots of the field represents an important factor for saving human labor.

The experimental activity was carried out during the 2023 season, in the Torremaggiore countryside (FG), one of the areas with the highest concentration of processing tomato cultivation, and the farmer's ordinary management was compared with a "smart" one.

A smart management of processing tomato irrigation, through the use of DSS (Decision Supporting Systems), was adopted in order to monitor the soil water potential with sensors; the valves were managed via a LoRaWAN technology to automate the opening and closing of irrigation according to the soil conditions.

Physiological parameters were also monitored on the plants together with data collected with a drone (NDVI, GNDVI); at harvest yield and quality data were collected and recorded.

The results achieved in this first season highlighted how the "smart" management system either allowed a significant water saving (< 20%), or related labor saving using the automated valves, compared to the farmer's ordinary management. The use of smart and automated devices allowed the farmer to save money with positive impacts on both farm and environment sustainability.

Keywords: *Water; sensors; drone; yield.*

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Combined effect of ultraviolet (UV-C) and heat treatment on the lycopene content of a functional tomato juice

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The use of combined UV-C and heat treatment is a promising preservation technique for low-UV transmittance juices. The aim of this study is to investigate the effects of UV-C radiation treatments combined with heat on the content of lycopene in a novel functional tomato juice formulation. Fruits of a VHL tomato variety 'Heinz 1657' were peeled and processed into pulp and a functional tomato juice was developed using a D-optimal mixture design with 4 components; tomato peel powder (TPP) (which contains antioxidants including flavonoids, phenolic acids, and lycopene, helping to reduce the risk of chronic diseases), pea protein (PP) (which prevents hypertension and regulates intestinal flora activity), olive powder (OP) (which helps prevent cancer and cardiovascular disease), and the liquid fraction of tomato pulp (obtained by centrifugation) combined with tomato pulp (juice/pulp (JP)). An untrained sensory panel evaluated 20 recipes to rate their preference for the responses: color (Y1), brightness (Y2), opacity (Y3), viscosity (Y4), taste (Y5), off-flavor (Y6), sourness (Y7), saltiness (Y8), sweetness (Y9) and overall acceptance (Y10). For each response, the polynomial models that best fitted the experimental results were obtained and response surface was used to find the optimal formulation which comprised 1% TPP, 1% PP, 1% OP, and 96% juice/pulp (JP). This juice was then treated in a UV-C/Thermal continuous reactor equipped with four UV-C lamps. Juice samples were pumped through the reactor connected to a water bath at 70 and 80 °C ± 1.0 °C and irradiated with different doses, which varied according to the flow rate and number of UV-C lamps turned on. Lycopene content was determined before and after treatments by HPLC using isocratic elution. Results showed that samples treated with combined heat and UV-C processes had higher lycopene levels, suggesting that this combined preservation method holds the ability to improve or retain vital quality attributes in functional tomato juices. As a result, there is a great opportunity for the combination of UV-C technology and heat to be commercially explored for its benefits in the food industry.

This research is part of the Partnership for Research and Innovation in the Mediterranean Area, PRIMA Horizon 2020 (H2020) grant number 2032, Functionalized Tomato Products (FunTomP) project, supported by the European Union.

Keywords: *tomato, functional juice, UV-C, lycopene, beta-carotene, mixture design*

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Characterization of a new type of resistance breaking TSWV strain isolated from tomato in Hungary

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The worldwide use of the resistance gene Sw-5b in tomato breeding is an effective method against Orthotospovirus tomatomaculae (Tomato spotted wilt orthotospovirus, TSWV) epidemics. NSm protein (movement protein, MP) encoded by the M RNA of TSWV was formerly identified as the avirulence determinant against Sw-5b gene in tomato. In the last decades, Sw-5b resistance breaking (RB) TSWV isolates have been identified in several countries in the world. In the case of the previously described TSWV Sw-5b RB strains, the resistance breaking phenotype was the result of point mutations C118Y and/or T120N of the MP.

In the summer of 2022, we recognized a resistant tomato plant bearing the Sw-5b gene showing TSWV-like symptoms in a plastic tunnel in Kecskemét, Hungary. Test plant bioassays were carried out with the collected sample. Both resistant and susceptible tomato cultivars were inoculated and in both cases systemic symptom development was observed 6-8 days after inoculation. The NSm avirulence gene was amplified by RT-PCR method and after nucleotide sequence determination, the mutation responsible for the RB phenotype was identified. Phylogenetic analysis and amino acid sequence comparison of the NSm were assessed with 7 RB and 8 normal (NI) TSWV strains retrieved from the NCBI GeneBank and the location of the Hungarian RB isolate in the ML tree and the relationship to the other isolates was evaluated.

Comparison of the amino acid sequences of the Hungarian resistance breaking and the normal isolates revealed a single alteration D122G in NSm protein that has not been detected previously in any of the resistance breaking TSWV strains. Based on the phylogenetic analysis, we concluded that this isolate grouped together with the isolates of Clade 1.

Keywords: TSWV, NSm, movement protein (MP), resistance breaking, Solanum lycopersicum, Swb-5 resistance gene

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Tomato pomace: From a waste to novel food ingredients

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The tomato industry is associated with generation of a significant amount of side stream – tomato pomace. This side stream is rich in important biologically active and functional ingredients. However, these side streams are most often treated as waste, possessing an environmental risk and economic burden. Direct application of dried tomato pomace is limited due to low fibres solubility, which often leads to their incompatibility with the food matrix. The influence of the subcritical water extraction on the WHC, OHC, TPC, DPPH and FRAP of the tomato pomace residue and extract have been studied. Additionally, the polyphenol and carotenoid profiles have been obtained using HPLC-DAD-ESI-MS. Increases of the WHC and OHC of the tomato pomace residue compared to the untreated sample was observed. The TPC and antioxidant capacity values in the extract were 3 times and 5 times higher, respectively, compared to the untreated sample. The results showed that subcritical water extraction could be used to improve both the tomato pomace functionality and polyphenols extractability.

Keywords: *Tomato pomace; Subcritical water extraction, Techno-functional properties, Polyphenols, Antioxidant capacity*

68 | Oral

Potential for high-throughput phenotyping of industrial tomatoes for post-harvest quality assessment: Insights from linen and champagne use cases in France

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High-throughput phenotyping (HTP) of industrial tomatoes at post-harvest plays a pivotal role in evaluating harvest quality, encompassing both the sanitary status of the tomatoes and potentially the organoleptic aspects. This study leverages insights from PhenoStation analogous systems, namely for linen during the process of scutching the fiber and for post-harvest quality assessment of champagne grapes, to elucidate key methodologies and implications for tomato phenotyping. HTP techniques, including advanced imaging processed through deep learning methods combined with a "human in the loop" approach, enable rapid and comprehensive assessment of various phenotypic traits. This facilitates detection of disease contamination whether fungal or microbial, and potentially of flavor attributes. Integrating advanced imaging with other key technology such as polarized light or HTP unveils intricate metabolic dynamics and structural changes in post-harvest tomatoes. Insights garnered from linen and champagne industries highlight the efficacy of HTP in predicting quality attributes and guiding interventions for enhanced post-harvest management. This review underscores the significance of HTP in revolutionizing post-harvest tomato quality assessment, offering promising avenues for optimized remuneration of growers depending on quality as well as better segregation of product per quality to increase high end customer satisfactions and revenues.

Keywords: *high-throughput phenotyping, industrial tomatoes, post-harvest, quality assessment, linen, champagne, deep learning, human in the loop*

69 | Poster

Experimental evaluation of processing tomato grown in agrivoltaic systems under Mediterranean climates in California

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Agrivoltaic is a promising technology that allows for the simultaneous use of land for both food production and solar energy generation, but there is limited information on its impact on crop growth, yield, and water use. The study objectives were to evaluate the effect of agrivoltaic on 1) processing tomato growth, 2) on yield and quality, and water use through experimentation and modeling. The study was conducted near Davis, California; the experimental design was a randomized complete block with four replications. Growth was quantified through LAI, canopy cover, and photosynthesis. Water crop use was estimated using a seasonal water balance. Results showed a significant reduction in yield of 66.4% under agrivoltaic production in 2021 and 70.9% in 2022, and crop water/evapotranspiration was shown to have been reduced by 11.4% under agrivoltaic production in 2021 and 10.5% in 2022, and minimal difference in harvested fruit quality in both years while photosynthetic performance was found to be significantly different at the highest and lowest light levels.

Keywords: *Agrivoltaics, Processing Tomatoes, Evapotranspiration, Yield, Crop Quality*

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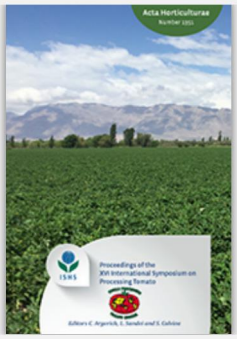

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