THE SCIENTIFIC PRODUCTION IN TOMATO PROCESSING

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INTRODUCTION

Since 2006, the Centro Tecnológico Nacional Agroalimentario “Extremadura”-CTAEX has been analysing research and technology development, with the objective being to deliver information in a user-friendly format, via its web page www.observatoriotomate.com.

This article studies the volume of scientific literature generated in the tomato processing sector since 1980, the date on which special editions of Acta Horticulturae began to be published, which include the publications of all the International Symposia on the Processing Tomato organised by the International Society for Horticultural Science.

MATERIALS & METHODS

To carry out this work, the Web of Science (WOS) abstract database platform has been used, being one of the world's most extensive resources for citation, indexing, and citation analysis of a wide variety of scientific works in all possible scientific fields.

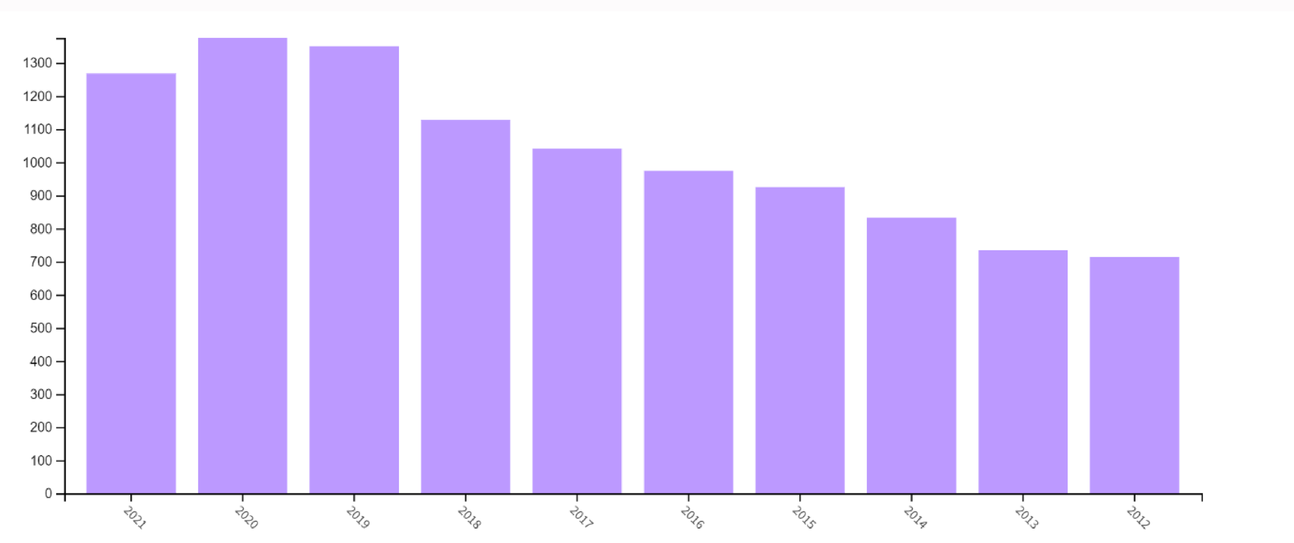
To carry out this bibliographic review, the search term "processing tomato" was introduced in the Web of Science platform, filtering the publication date by the time period of the interval from 01 January 1980 to 31 December 2021.

The selection of the start date of the search in 1980 is justified because it is the time at which the first Abstract dedicated to the processing tomato in the Acta Horticulturae, which is a peer reviewed series, mainly the proceedings of ISHS Symposia and the International Horticultural Congress (ISSN 0567-7572 print and ISSN 2406-6168 electronic).

RESULTS & DISCUSSION

Publication Years

From 1980 to December 2021, 20,710 documents were published, reaching more than 1,000 a year in the last five years. It is also reflected that the production of scientific literature in the times of COVID-19 has not ceased, highlighting that the year 2020, the start of the pandemic, was the year with the most prolific production of scientific literature.



Document Types

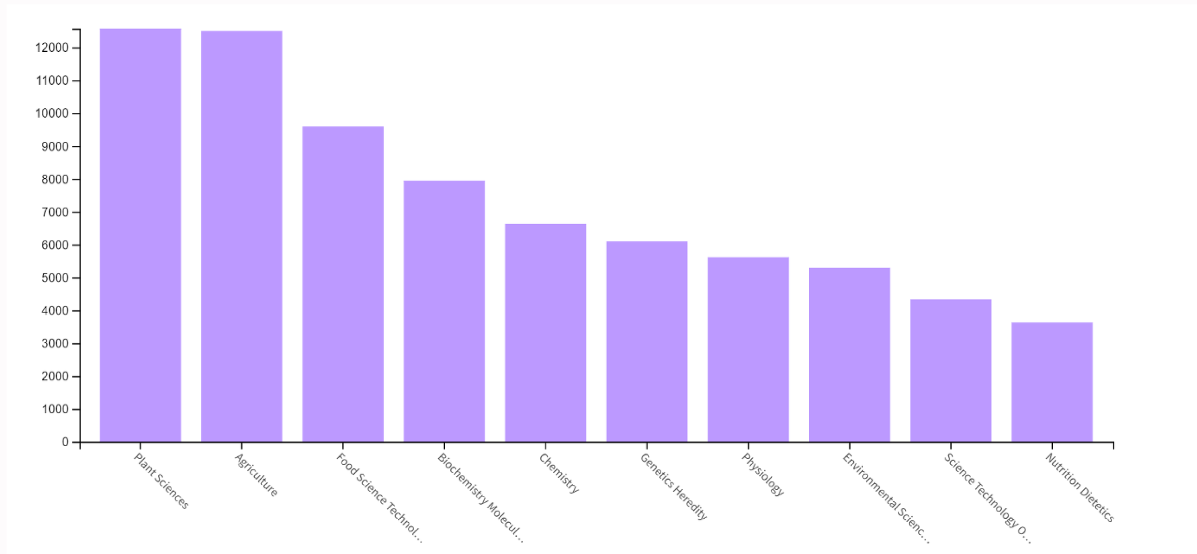
Articles are the type of document most published, with 17,320 records, which represents 83.63% of the publications, followed by Other with 4,011 (19.37%), Meeting with 2,491 (12.03%), Patent with 2,421 (11.69%), and Review Articles 1,484 (7.17%).

Database

The database in which the most documents appear is the Web of Science Core Collection, where 17,651 articles were published from 1980 to 2021, accounting for 85.23% of the publications, followed by Current Contents Connect, with 11,448 publications, accounting for 55.27% of the total. In third place, we find the MEDLINE® Database, with 7,669 publications, accounting for 37.03%.

Research Areas

The documents are published in different research areas, the area with the highest number of publications is Plant Sciences with 12,570 documents, followed closely by Agriculture, an area that encompasses 12,504 documents. Other areas featuring publications are Food Science Technology (with 9,594), Biochemistry Molecular Biology (7,946) or Chemistry (6,637 publications).

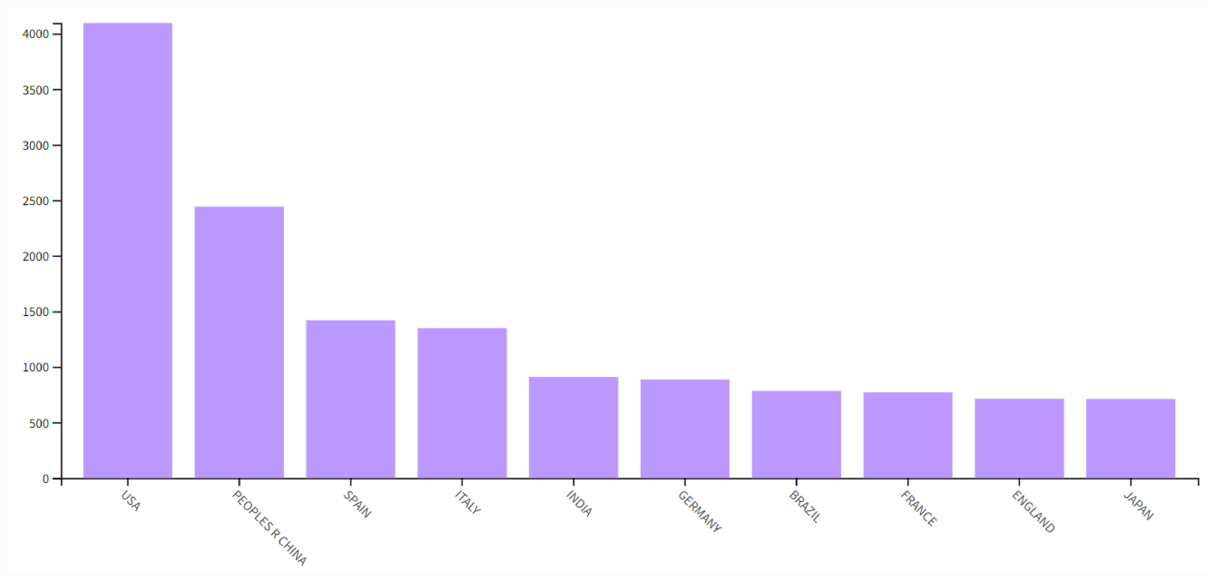


MeSH Heading

The Medical Subject Headings (MeSH) thesaurus is a controlled and hierarchically-organized vocabulary produced by the National Library of Medicine. In this field, the term that appears the most in the bibliographic review is Lycopersicon Esculentum with 2,775 results, followed by Gene Expression Regulation Plant with 1,298 publications and Fruit in third place with 1,273 records.

Countries / Regions

The country which publishes the most is the USA, which reaches 4,904 publications, followed by Peoples R. China with 2,442 publications and Spain in third place, with 1,418. These countries are followed in order of publications by: Italy, India, Germany, Brazil, France, England and Japan.



Editors

The ranking of editors is headed by Colvine S. with 153 publications, followed by Camara M. with 119 and Bieche B. with 72 publications.

Publication/Source Titles

Regarding Source Titles, Acta Horticulturae stands out with 931 publications, followed by Plant Physiology with 304 records and the Journal of Agricultural and Food Chemistry with 301 attributed records.

Major concepts

In the area of major concepts, the first concept that appears in the ranking is Biochemistry and Molecular Biophysics with 6,539 records, followed by Agriculture with 4,483 records and Horticulture in third place with 3,924 publications in this field.

CONCLUSIONS

This technological vigilance system is an extremely useful tool for the processing tomato sector, as results from scientific investigation will help to align the strategies of tomato growers, industrial manufacturers and the scientific community.

The existence of these databases and the analysis of specific publications highlights the importance of the processing tomato, gathering knowledge about this product to achieve a more sustainable tomato with an optimum quality level while guaranteeing Food Safety at the same time.

16th ISHS SYMPOSIUM ON THE PROCESSING TOMATO

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Elaboration of eco-hybrided material for rural infrastructures from byproducts of the tomato processing industry

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INTRODUCTION

The production of waste generated in the tomato processing industries is calculated; 0.025 kilograms of skin and seeds obtained for every kilogram of tomato produced.

In other sectors such as construction, rural or forestry, roads are part of the industrial, agricultural and livestock fabric of our primary sector. These are roads that move the economy.

The main objective and innovation of the project is to combine research in the context of agri-food towards the search for polymers that can replace traditional polymers from non-renewable sources for the construction of rural roads.

This innovation was born from the hybridization of two determining sectors in the regional and national economy.

MATERIALS & METHODS

The starting substance to produce the polymer for the construction of rural roads is cutin, a component of the cuticle of the tomato skins extracted by digestion in alkaline solution. Research started with the optimization and standardization of the experimental method to extract cutin from tomato peels and seeds and chemical characterization of recycled aggregates from the construction and demolition waste (C&DW) to be used: laboratory dosage study; determination of the optimal percentages of binder (cutin); determination of compression strength of the aggregates-cutin specimens; and finally, the consortium is currently developing laboratory and pilot trials related to the formulations for a cutin-based biopolymers stabilization technique, applicable to rural roads.

RESULTS & DISCUSSION

In laboratory tests it is verified that, for curing periods of seven days, cutin manages to significantly improve the fundamental characteristics of the compacted recycled aggregates (resistance to simple compression and bearing capacity, C.B.R. index) and also, physical characteristics such as water absorption by capillarity and accelerated erosion, simulating the performance of a in situ stabilized soil with cement.

Id. SAMPLE	DENSITY (g/cm3)	MOISTURE (%)	CSR 7 days (MPa)	C.B.R Index (7 days)		WATER ABSORPTION BY CAPILLARITY ($g/m^2*s^{0.5}$)		SWINBURNE ACCELERATED EROSION (mm.)
				98%	100%	10 min.	60 min.	
1A7d	2,01	9,80	2,00	225	303	30	26	13
Standard	1.96	9.70	0.90	59	85 (*)	42	21	24

Table 1. Results obtain in laboratory test.
(*) CBR soaked in water for 4 days.

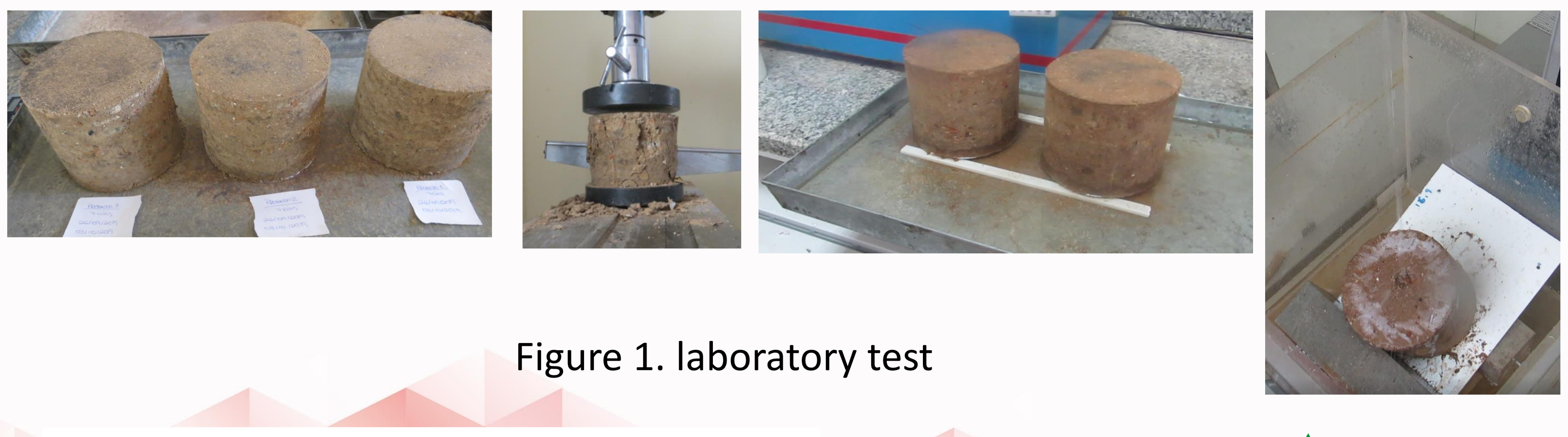

Figure 1. laboratory test

Pilot trials have been executed last February month [Caceres, Spain], to carry out this project has been needed 30 T of recycled aggregates from C&DW and 1500 l of the polymer cutin, mixed and compacted in situ.

Currently, pilot trials are being tracked by monitoring properties related to the durability of the ***aggregates-cutin*** mixture, such as density and moisture as well as static plate load test and extraction of samples in situ to test in laboratory.

Figure 2. stages of pilot trials

CONCLUSIONS

This project will have a remarkable economic and environmental impact, considering that it is possible to use the biopolymer *cutin* for other sectors apart from food. Therefore, a new biopolymer technological formulation and an innovative eco-friendly-material for construction, have been research and proved.

ACKNOWLEDGMENTS

Gratefulness to the partners of this project: Tomates del Guadiana S.L.C. (Spain) and Construcciones Sevilla Nevado S.A. (Spain)

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•UNE 41410 "Bloques de tierra comprimida para muros y tabiques. Definiciones, especificaciones y métodos de ensayo"

BIOMETHANATION OF TOMATO BY-PRODUCTS AT INDUSTRIAL SCALE: FEASIBILITY STUDY.

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INTRODUCTION

Tomato is one of the most important horticultural crops in Extremadura, a region located in the southwest of Spain. The productive activity of the tomato industry generates 3% skins and seeds and 1% sludge from waste water treatment plant, by the weight of the input raw material. These by-products must be treated before its discharge to avoid environmental problems.

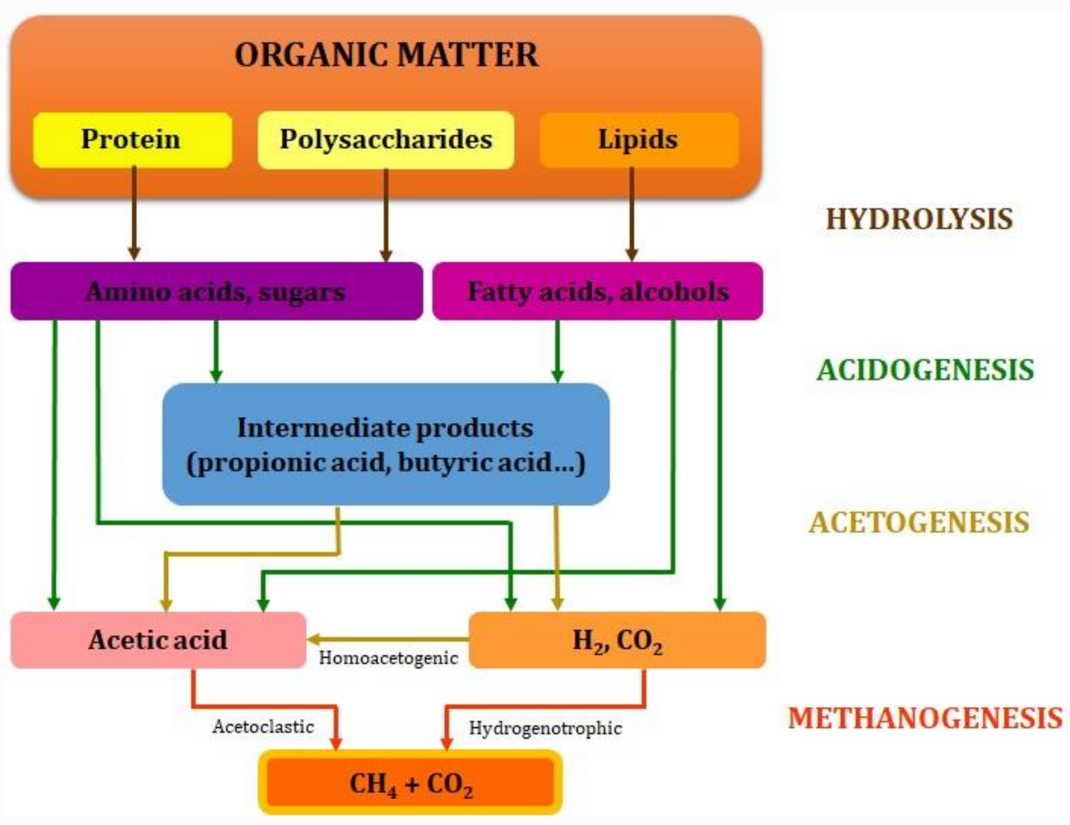

Figure 1. Stages of the biomethanation process. Adapted from (Solera et al., 2014).

Biomethanation allows to transform tomato waste into a renewable energy source called biogas. Figure 1 outlines the stages of this biological process.

This technology has proven to be effective for the treatment and energy recovery of tomato industry waste. However, few studies have analysed the economic viability of industrial-scale biomethanation projects.

MATERIALS & METHODS

The tomato processing industry is acutely seasonal. Tomato is harvested for 2 or 3 months so, both energy consumption and the generation of by-products, are concentrated along this time. Taking into account this condition, two scenarios can be raised to analyse the profitability of implementing biomethanation in a tomato processing factory located in Extremadura:

- Scenario 1: Tomato by-products are treated during the production months and the thermal energy generated is self-consumed in the industry.
- Scenario 2: Tomato by-products are treated throughout the year, after being dried and stored. The thermal energy produced during the months of production is self-consumed by the industry, electricity is produced and injected into the grid along the rest of the year.

Energy yield of tomato waste (84.17 Nm^3 biogas/t solid waste, 63% of methane in biogas) was obtained from biomethanation tests previously carried out at laboratory scale (Llerena-Ruiz et al., 2019).

RESULTS & DISCUSSION

The biogas plants required for both scenarios have been designed and budgeted, and the cost and incomes associated with the operation have been calculated. The results obtained are shown in Table 1.

Scenario 1 presents fewer risks than scenario 2, since income is exclusively associated with savings in thermal energy, that is self-consumed in the industry and does not depend on the regulation of the electricity´s price in the market. It is also the most profitable, since it has lower installation costs, higher income and lower expenses.

The biogas plant in scenario 2 is only relatively profitable if the maximum sale price for electricity (€120/MWh) is obtained.

Table 3. Economic viability of biomethanation.

	Scenario 1	Scenario 2
Substrate treated / solid waste treated (t/year)	33,460 / 6,692	
Biogas plant operation time (months)	2.5	12
Energy requirement in the biogas plant		
Thermal energy to dry solid waste (kWh/year)	----	332,174
Thermal energy to heat the reactor (kWh/year)	530,314	
Electricity (kWh/year)	138,221	
Installation costs		
Biogas plant (€)	1,475,402	1,566,453
Investment		
Non-refundable subsidy (41%) (€)	604,915	642,246
Own contribution (20%) (€)	295,080	313,291
Bank loan (39%) (€)	575,407	610,916
Income		
Thermal energy savings (€/year)	138,221	6,663
Electricity injected into the grid (€/year)	----	118,179
Cost		
Maintainance of biogas generator set (€/year)	----	13,131
Operation and maintainance of biogas plant (€/year)	20,254	30,922
Electricity (€/year)	16,587	3,456
Loan interest (€)	75,516	80,176
Economic parameters		
Payback period (years)	**10**	**13**
Net present value NPV (€)	**1,081,607**	**542,303**
Intern rate of return IRR (%)	**8**	**4**

CONCLUSIONS

1. Biomethanation is a biological treatment that closes the production cycle of the tomato processing industry and contributes to develop a green and circular economy.
2. It is profitable to treat the by-products of the tomato industry anaerobically, if they are treated during the production period, generating thermal energy from biogas that will be self-consumed by the industry.

ACKNOWLEDGMENTS

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TOMPRINT OPERATIONAL GROUP: CLOUD COMPUTING TOOL FOR CALCULATING THE CARBON FOOTPRINT OF PROCESSING TOMATO

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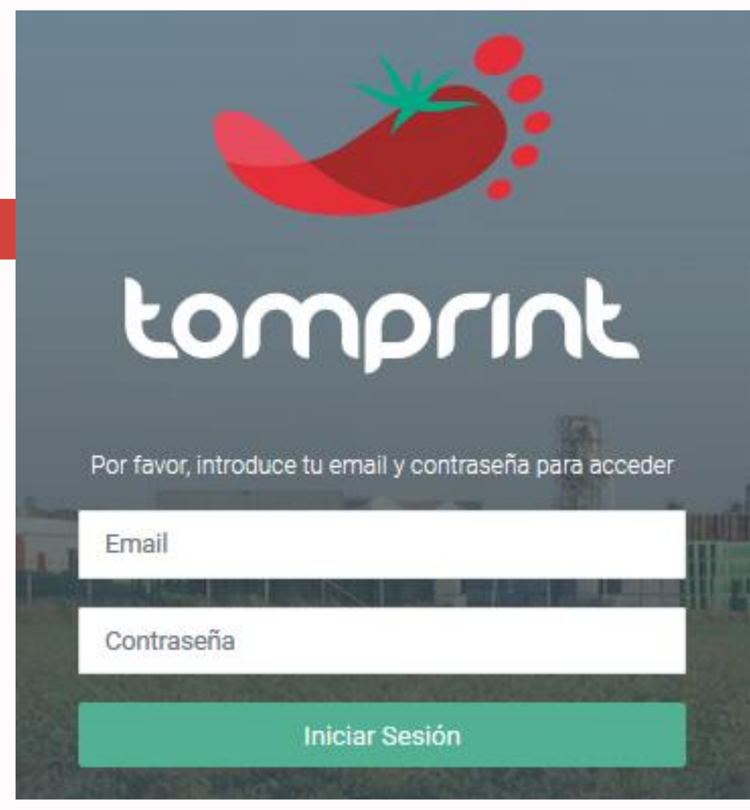


INTRODUCTION

The goal of the TomPrint Operational Group is the mitigation of the environmental effect produced by the processing tomato industry in Extremadura (Gutiérrez et al., 2018). One methodology for establishing the impact of production processes on environmental assets is the use of sustainability indicators. Among the most widely-used is the (CF) carbon footprint (López and Cattaneo, 2013). TomPrint includes five industries, which represent more than 50% of the Spanish processing tomato in 2021 (Grupo Conesa, Tomates del Guadiana, Pronat, Alsat and Tomalia) (Mesa del Tomate, 2021).

The aim of this work is the creation of a web tool based on cloud computing to calculate the CF of processing tomato.

MATERIALS & METHODS

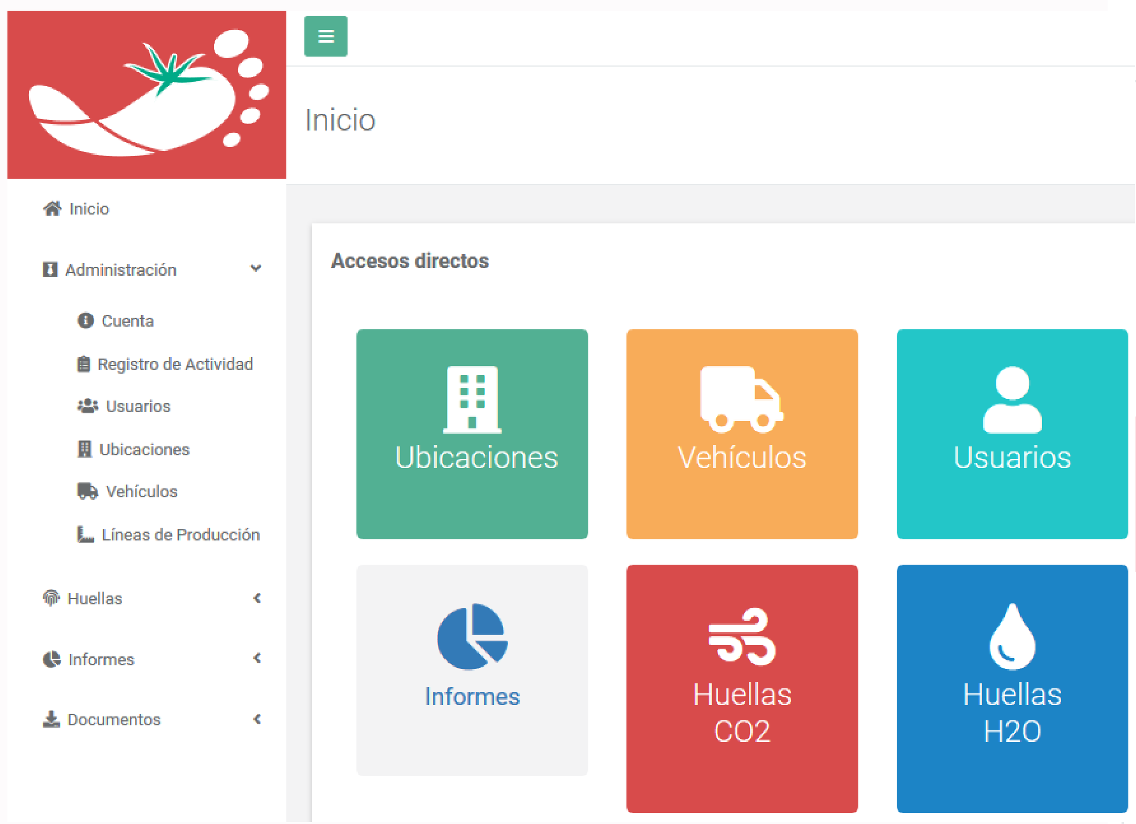
In the CF calculation, the TomPrint tool is based on the UNE-ISO 14064-1 methodology. The technical solution was developed by Solucionex and IAAS365, creating a tool with cloud-based architecture (Cloud Computing), taking advantage of the flexibility, scalability, performance and security of this model, allowing a progressive adoption of the solution by the sector. All the data needed to calculate this indicator were collected and filtered by CTAEX, from the five industries.

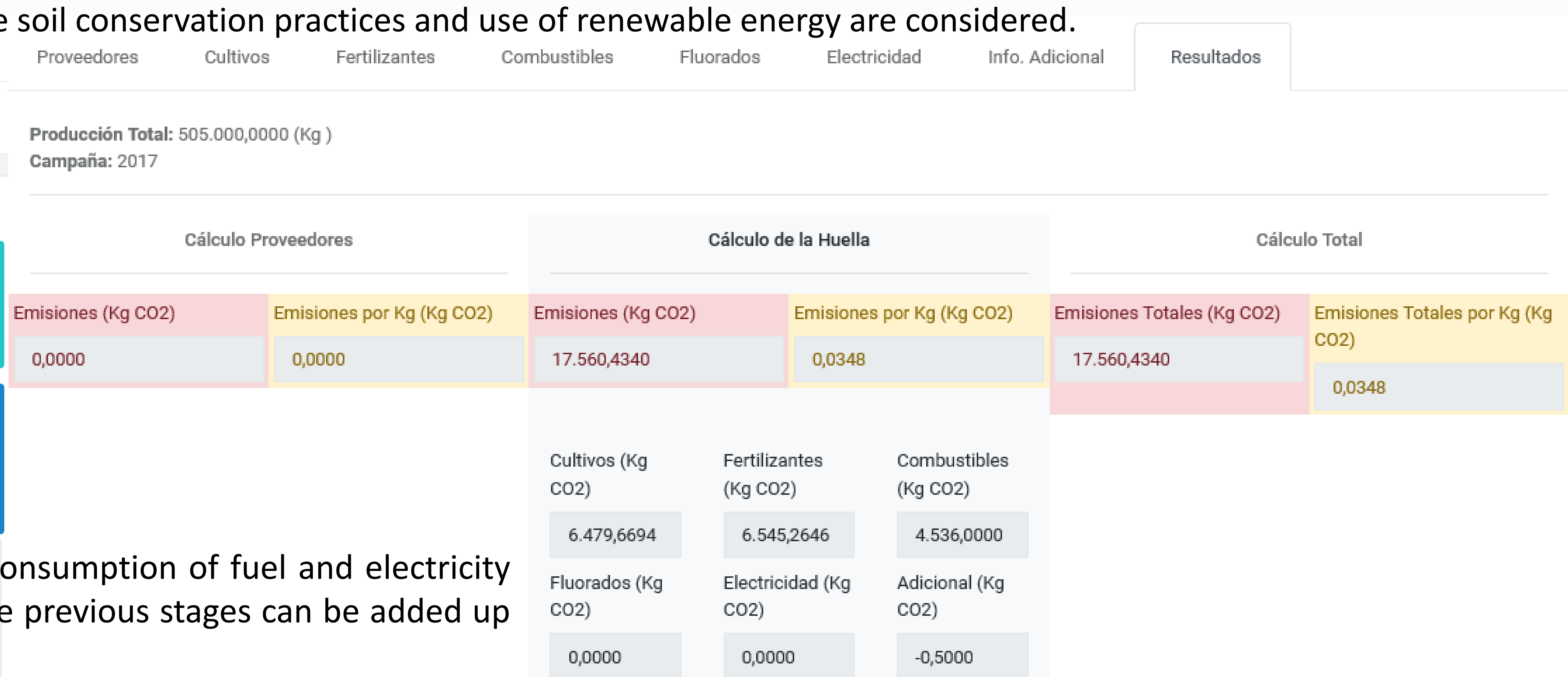
RESULTS & DISCUSSION

The TomPrint Web Tool enables an easy calculation of the CF of processing tomato, with three independent but interconnected modules: greenhouse, field and industry.

In this way, the total footprint of the processing tomato cycle can be calculated, because these stages can be connected. Inside each TomPrint registered organization, different user types can be created, depending on the level of responsibility in the company. In each organization, the locations where the activity takes place can be created (ubicaciones), the company vehicles can be registered (vehículos) and the different production lines can be created. When all the elements of the company have been registered and the necessary data has been collected, the calculation of CF can be started.

In the calculation of the FC of the farmers, the consumption of fertilizers, fuels and electricity is taken into account. Emissions from crop residues and their destination are also added, and possible soil conservation practices and use of renewable energy are considered.





In the industry CF, the emissions from the consumption of fuel and electricity are accumulated, and the emissions from the previous stages can be added up to obtain Scope 3.

CONCLUSIONS

Tomprint is an innovative, practical and easy to implement web tool, due to its cloud architecture, adapted to the requirements of the processing tomato sector, representing a technological advance for the processing tomato industry in Extremadura.

The carbon footprint calculation allows the creation of future plans to reduce emissions, having positive effects on the environment, and is also associated with a positive impact on the economy of companies.

Tomprint is designed to be versatile, so it can be used by any farmer or industry in the processing tomato sector, because it is based on widely accepted methodologies.

ACKNOWLEDGMENTS

For the development of this web tool, Tomprint Operational Group has receiving co-financing from the European Rural Development Fund (EAFRD) of 75%, with the rest being co-financed by the Extremadura council, 21.03%, and the remaining 3.97% by the Spanish State.

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SmarTom Operational Group: Integrated crops monitoring systems based on remote sense and hiperespectral images

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INTRODUCTION

Hyperspectral techniques arise from the union of spectroscopic techniques and Computer Artificial Vision. In this way, it is possible to know not only the concentration or presence of a chemical compound, but also its spatial distribution in the whole image or in an area defined by an image segmentation criterion. Although this technology has been successfully applied in many fields of knowledge, it is in the field of Food Science where it has been a great revolution in terms of improving quality inspection (Lorente et al., 2011). A hyperspectral image or hypercube can be defined as a battery of images of the same scene in which each of them corresponds to the reflectance at a single wavelength expressed in grayscale. In the field of tomatoes, spectroscopic and hyperspectral techniques have been successfully used to predict the state of ripening, acids, sugars, etc. (Beullens et al., 2006; Zhu et al., 2015). These studies have been done at laboratory scale. To our knowledge, this is the first time that a hyperspectral imaging technique is used for tomato analysis directly on the crop.

MATERIALS & METHODS

There were two pilot plots located in two locations that have been monitored with different systems; humidity probes using Watermark Granular Matrix Sensors and 5TE probes for measuring temperature, humidity and Electrical Conductivity (EC) of soils, connected to a MSENS1002-r00 datalogger, with recording and communication functions for precision agriculture for irrigation optimization; Hyperspectral images were acquired with a Specim IQ hyperspectral camera (Oulu, Finland). The generated hypercubes had a spatial resolution of 512x512 pixels. The spectral resolution was 204 bands distributed at equidistant intervals between 400 and 1000 nm. The camera also recorded the GPS coordinates of each capture and these were stored with the metadata of each hypercube. Within each session, an image was taken containing a reference target made of teflon and supplied by the manufacturer. This target allowed the camera to record the spectrum of each point in relative reflectance units. The rest of the capture conditions (acquisition distance, measurement geometry, exposure time...) were set to ensure repeatability among different capture sessions. These sessions covered the dates from May 20 to August 13 and were performed in two experimental plantations. The images from the ground and plants were taken. Those of plants, in turn, contained both fruits and leaves. Representative samples of soil, leaves, and fruits present in the images were stored for later laboratory analysis by reference methods. The entire algorithm for opening hypercubes, segmentation, spectral treatment, creation of the learning models, and export of results was programmed under MATLAB R2018a (The MathWorks, USA). The analyses of the foliar and soil samples were made in the CTAEX laboratories, with the measurement of the following parameters: Foliar NPK, pH (1/2.5), E.C. (µS/cm), % N,C/N, %C.O, %M.O, %M.O.T, % CLAY, % SILT, % SAND,

RESULTS & DISCUSSION

Firstly, the plantations were divided according to agronomic factors. These sectors were characterized according to their GPS coordinates and an algorithm was programmed for automatically assigning each of the images on an orthophoto of the plot. In sectors with humidity monitoring, it was possible to reduce 1,011m^3 per ha with respect to an irrigated block according to the theoretical needs based on daily evapotranspiration if there were significant differences in agricultural yield ($p<0.01$). Then, a segmentation criterion was established to differentiate the different elements present in the image. In simple scenes, such as those in the images acquired in the laboratory, one or two wavelengths are usually selected, and threshold limits are set. The methodology developed not only differentiated the elements of the image, but also successfully identified the state of ripeness of the tomatoes. The last of the tasks carried out with hyperspectral imaging was to predict the chemical composition from the images. From the results of the chemical analyses obtained by CTAEX, a complex spectral battery was created, in which the belonging to each element of the image and the concentration in the measured analytes were known for each sample.

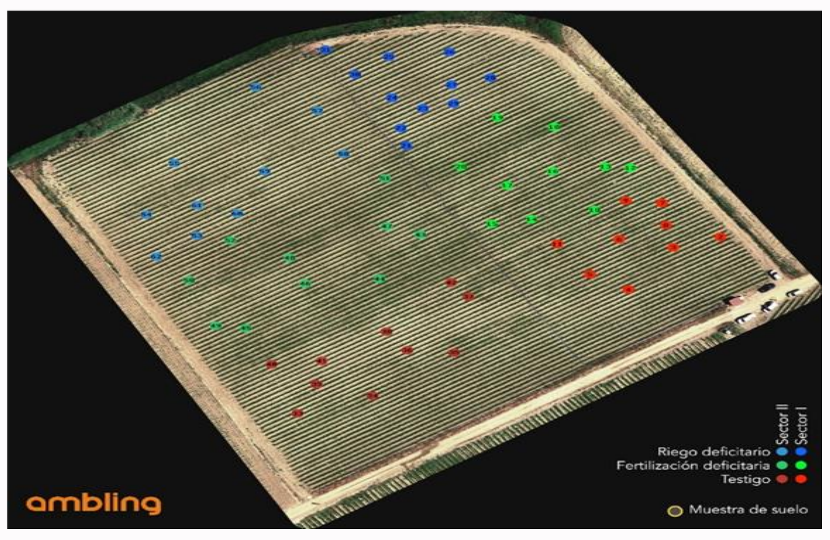

Figure 1. Orthophoto of one of the plots containing a whole capture session.

Figure 2. RGB image extracted from the hypercube and segmentation mask obtained.

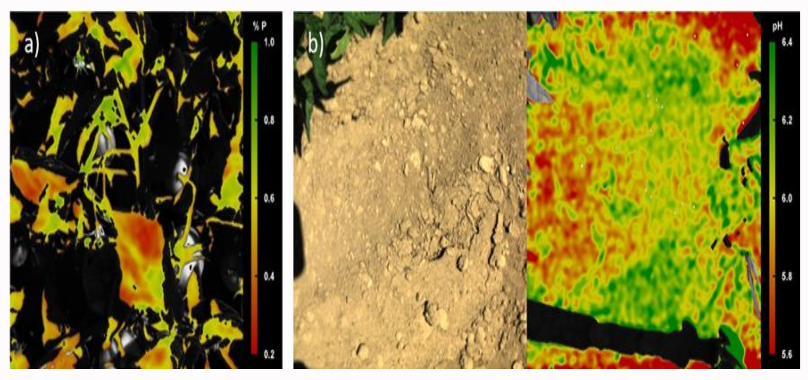

Figure 3. a) Phosphorus concentration in the leaf region. b) Soil pH.

CONCLUSIONS

The elements of the image have been differentiated. The state of maturity of the tomatoes has been successfully identified. A complex spectral battery has been created in which the belonging to each element of the image and the concentration in the measured analytes of each sample were known.

ACKNOWLEDGMENTS

This supra-autonomous Operational Group has a total amount of aid of 599,962.24 €, 80% co-financed by the European Agricultural Fund for Rural Development-FEADER

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16th ISHS SYMPOSIUM ON THE PROCESSING TOMATO

ISHS International Society for Horticultural Science

Operational Group VALORARES: Influence of agroindustry waste compost and compost tea on processing tomato crop

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INTRODUCTION

The VALORARES Operating Group focuses its efforts on the "Valorisation and use of by-products generated in the Extremadura agri-food sector through composting". The project arises from a serious problem in the day-to-day business of Extremadura companies, such as the generation of waste and its management, together with environmental issues such as climate change, water scarcity, loss of biodiversity, and the search for alternative energy sources. The initiative is based on improving efficiency in the management of by-products from the agri-food industries and livestock farms by developing innovative composting techniques that allow them to be recycled and recovered, producing stable, quality compost that can be incorporated back into the production chain through application in the nursery as part of the substrate, in the field as an organic amendment or in disease control from compost tea production.

MATERIALS & METHODS

Once the soil characterised, nutritional requirements of the crop were calculated using REDAFEX, a fertiliser advice tool developed by the Regional Government of Extremadura in collaboration with CTAEX. Afterwards, corresponding fertilising programs were designed.

So, six out of the seven theses studied varied in the basal dressing composition, requiring 48 fertilizer units (UF) of nitrogen, 90 UF of phosphorus and 220 UF of potassium.

The theses consisted, compared to conventional fertilization, in substitution of 50, 75 and 100 % of nitrogenous needs with the contribution of compost, in reducing 25 % of the synthetic nitrogen requirement by providing up to 60 UF of nitrogen with the addition of compost and, finally, in maintaining the conventional fertilizer with the addition of compost up to 72 UF of nitrogen.

The seventh thesis consisted of the weekly contribution of compost tea by foliar application up to two weeks before harvest.

On 23 August, the moment harvest, sampling was carried out manually, with four 9 m^2 samples taken from each thesis to ensure the reliability of the results.

In the analysis of variance, the multiple comparison test according to Tukey has been used for a significance level α equal to 0.05.

RESULTS & DISCUSSION

The analysis of results has revealed no differences at the statistical level. However, the values achieved showed an increase of 9% in acceptable raw material which means an increase of 11 tons per hectare in suitable tomato, when complementing conventional fertilization with compost at 1300 kg/ha.

It also highlights the increase of net yield of 7 tonnes per hectare with the weekly application of compost tea.

The addition of compost and compost tea together with conventional fertilisation has led to an improvement in the organic carbon and organic matter content of the soils.

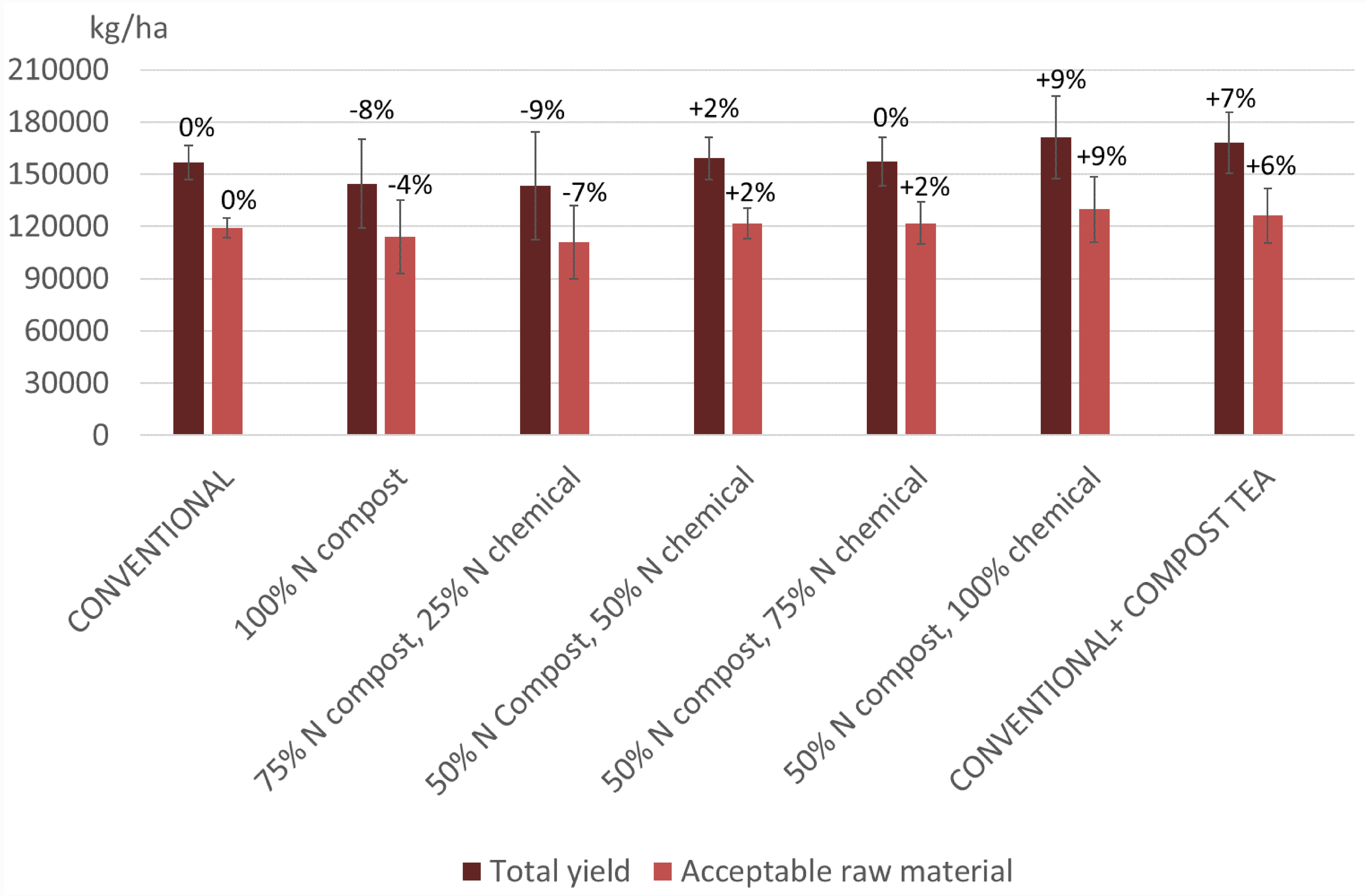

Figure 1. Influence of basal dressing fertilization and compost tea on industrial tomato yield

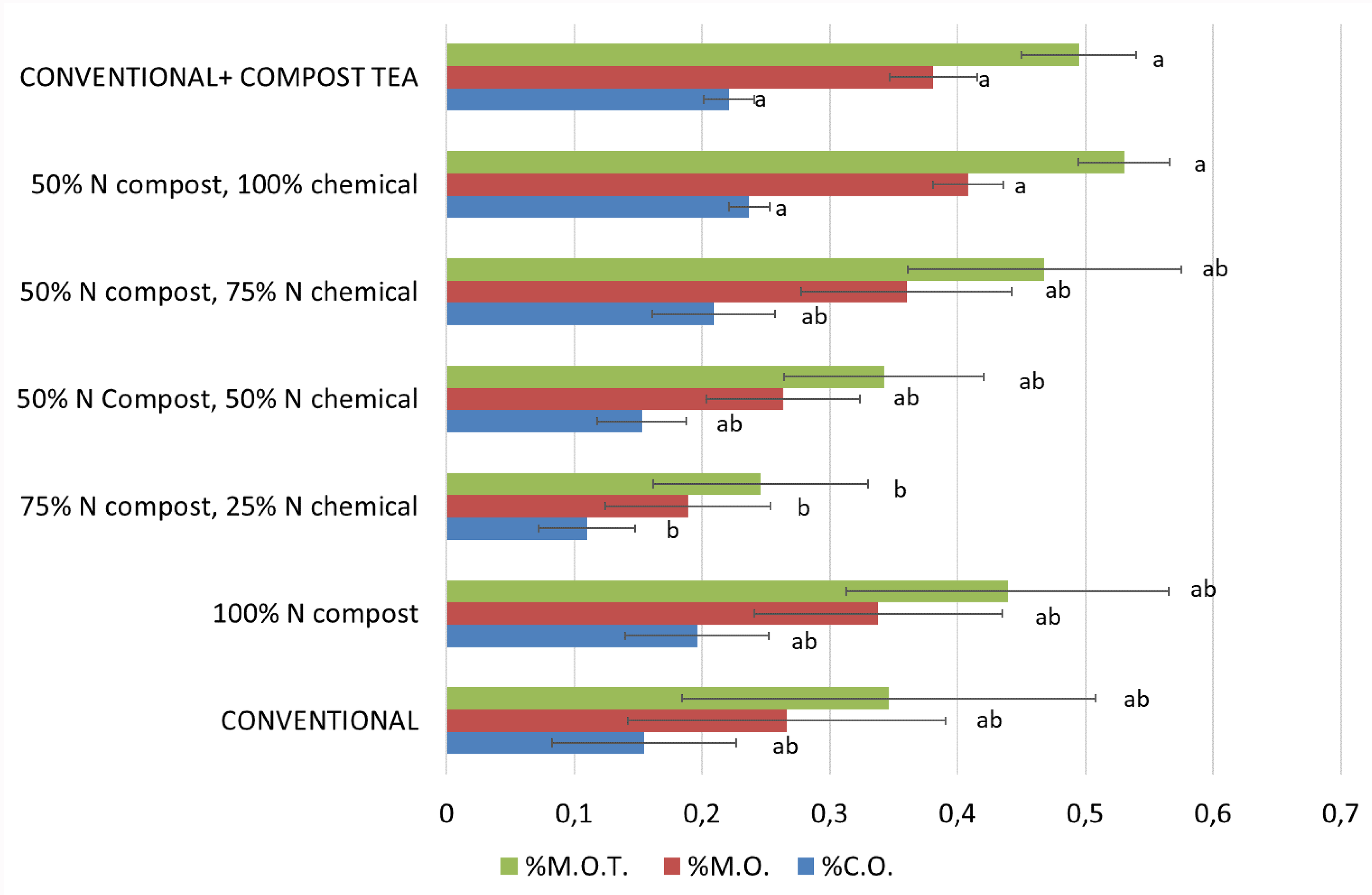

Figure 2. Organic matter and organic carbon as a function of the fertiliser plan. Significance: Shown by different letter

CONCLUSIONS

This study demonstrates the benefits of compost and compost tea as supplements to conventional fertilisation to improve plant vigour and productivity.

ACKNOWLEDGMENTS

Study included in the VALORARES Task Force entitled "Valorisation and use of by-products generated in the agro-food sector in Extremadura through composting". The Task Force is constituted on the basis of Article 19 of Decree 94/2016, of 5 July, of the Regional Government of Extremadura, receiving 75% co-financing from the European Fund for Rural Development (EAFRD), with the remaining 21.03% co-financed by the Regional Government of Extremadura and the remaining 3.97% by the Spanish State.

16th ISHS SYMPOSIUM ON THE PROCESSING TOMATO

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Trends on Active and optimum days for processing tomato in the European Unión

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INTRODUCTION

The processing tomato cultivation, like the rest of the outdoor cultivation is very dependent on climatic conditions, an aspect that is accentuated in climates such as the Mediterranean characterized by a large inter-annual as well as intra-annual variability.

The climatic conditions and trends in the main climatic variables with affect tomato crops, is an essential information, taking into account the current global warming.

The first objective was to characterize the differences between the cultivation areas, the second and main objective was the analysis of the effect of climate change on the duration of the active and optimum of crop period.

MATERIALS & METHODS

From eleven stations operated by European Climate Assessment & Data set (ECAD) Dataset used in the present study was generated with data from the daily maximun and minimum temperature, at the meteorological stations located in the study area, from 1989 to 2018.

Which is a daily, high-resolution data set of in-situ meteorological observations, daily maximum and minimum temperature were used to compute the **active days** (tm>10ºC) and the **optimum days** (25ºC<tm<30ºC) in different periods (annual, growing season and not growing season) in the most important areas of processing tomato in Europe.

ANOVA test was used to characterizations and the trend analysis for the time series was done using Mann-Kendall and Series Slope methods to estimate trend magnitude

ACKNOWLEDGMENTS

This research was funded by the Junta de Extremadura and the European Regional Development Fund (ERDF) through the projects: GR21022 (RMN028 "Investigación en Climatología Agroforestal").

RESULTS & DISCUSSION

Figure 1. Active and optimum days for processing tomato in the UE

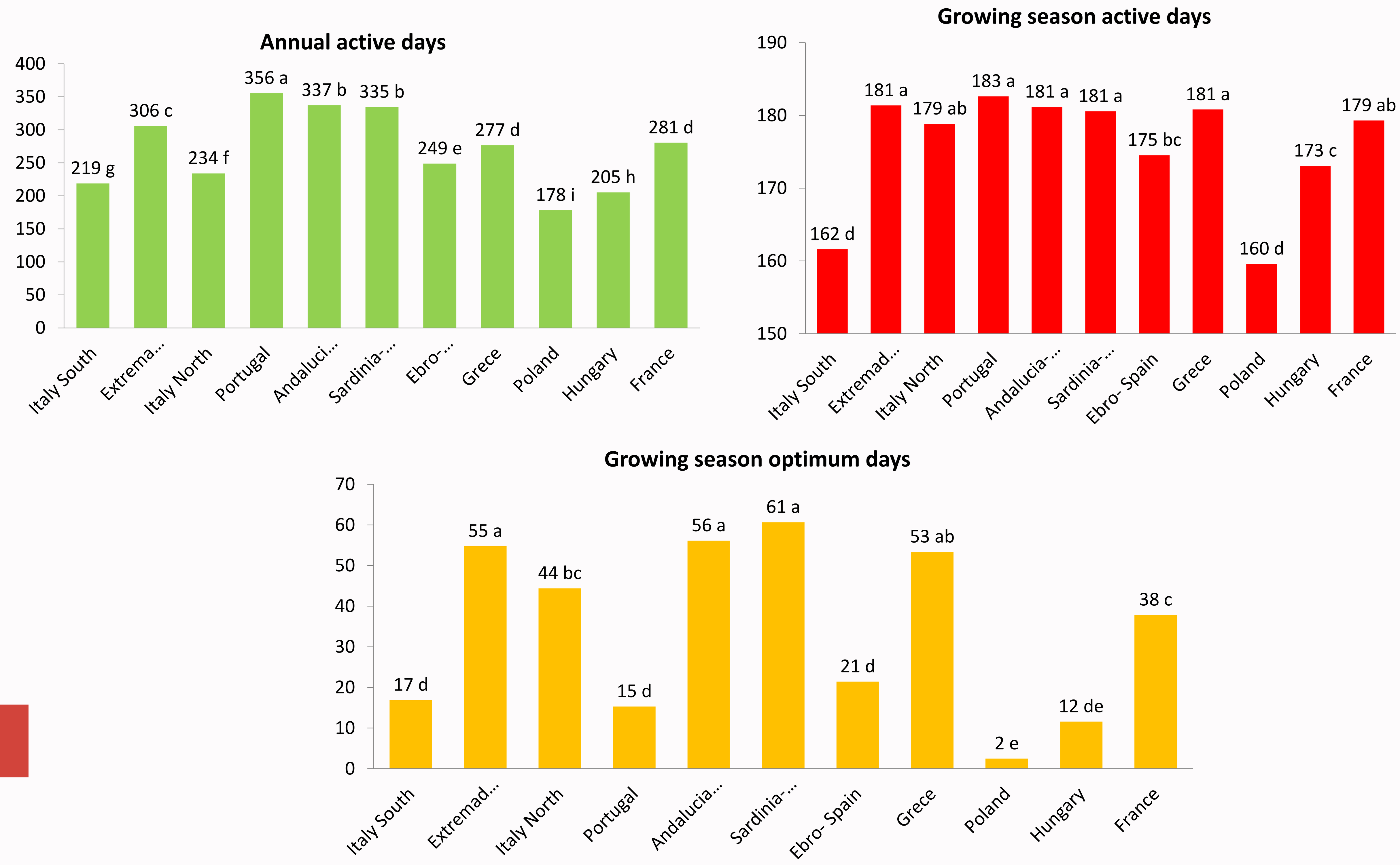

Table 1. Active and optimum days trends for processing tomato in the UE

	Active days							Optimum days		
	Annual		Growing season			Not Growing season		Growing season		
	Test Z	Q	Test Z	Q		Test Z	Q	Test Z	Q	
Italy South	1,36	0,778	0,61	0,20		1,52	1,00	1,14	0,813	
Extremadura-Spain	-0,21	-0,100				-0,11	0,00	2,25	**0,444**	*
Italy North	-0,12	-0,042	-0,61	-0,19		-0,12	-0,07	0,37	0,477	
Portugal	0,92	0,146				1,15	0,17	-0,02	0,000	
Andalucia- Spain	-0,39	-0,080	-0,10	0,00		-0,27	-0,05	1,81	0,421	
Sardinia-Italy	1,45	0,308	-1,84	0,00		1,65	0,36	4,09	**1,250**	**
Ebro- Spain	0,73	0,190	3,03	**0,33**	**	-0,55	-0,17	-0,25	0,000	
Grece	1,22	0,844	-1,50	-0,14		1,59	0,90	3,24	**2,000**	**
Poland	1,05	0,263	1,35	0,11		-0,20	-0,05	2,23	**0,083**	*
Hungary	1,61	0,412	1,40	0,14		1,06	0,17	2,94	**0,400**	**
France	-0,23	-0,074	1,61	0,00		0,00	0,00	1,07	0,286	

*Coefficients are significant at level P < 0.05; **Coefficients are significant at level P < 0.01

The obtained results have allowed us to identify significant creasing trends in growing season active days in Ebro, and growing season optimun days in Extremadura, Sardinia,Grace Poland and Hungary.

CONCLUSIONS

1.- There are significant differences in the number of annual active in the different processing tomato areas in the UE. During the growing season, these differences are minor. Regarding the optimal days, there were major significant differences between the main cultivation areas.

2.- All significant trends found indicate an increase in the number of optimal days during the growing season.

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DESCRIPTION OF THE CONCENTRATED TOMATO MICROFLORA BEFORE HEAT TREATMENT

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INTRODUCTION

The heat treatment is the most critical step in the preparation of the tomato concentrated, essential to ensure the stability of the product and the one that needs more energy within the process.

The objective of this study was to reduce the intensity of the heat treatment safely, for this we quantify and describe the microbial species present in the product just before pasteurization, both quantitatively and qualitatively, taking samples from several companies in the region.

Once we had the preliminary description of the microflora present in the concentrated, we proceeded to gradually reduce the heat treatment and check its effectiveness at a pilot scale. The heat treatment time was maintained, but the pasteurization temperature was gradually reduced from 70 ° C to 100 ° C. All samples were packaged using the same system that it is used on an industrial scale, and the stability over time of the samples obtained was subsequently determined.

MATERIALS & METHODS

To determine the specie of the bacteria present in the concentrated before the treatment , we took 20 colonies of initial tomato concentrated, Hot break and another 20 of Cold Break, both major products in the industry were randomly isolated.

The enumeration of viable microorganisms was determined by growing a sample of the concentrated tomato in PCA Agar, using decimal dilutions.

The amplification and sequencing of the 16 S. ribosomal gene region sequence. The obtained sequence was compared with the database by the blast algorithm in GenBank NCBI (National Center for Biotechnology Information), using the methodology described in 1 and 2.

Calculation of heat treatments, T = temperature, t = thermal support time(4 min),

z = 10 ºC :

$$P_{65}=\int_0^t 10^{(T-65)/z}\,dt$$

Microbiological stability test or commercial sterility test was performed according to the standard (standard V08-408).

RESULTS & DISCUSSION

Table 1. Preliminary study of heat treatments

Temperature ºC	Total bacteria u.f.c./g	+/-
100	45	5
90	235	185
70	4000	150
INITIAL	6300	456

Illustration 1. CTAEX pilot hub

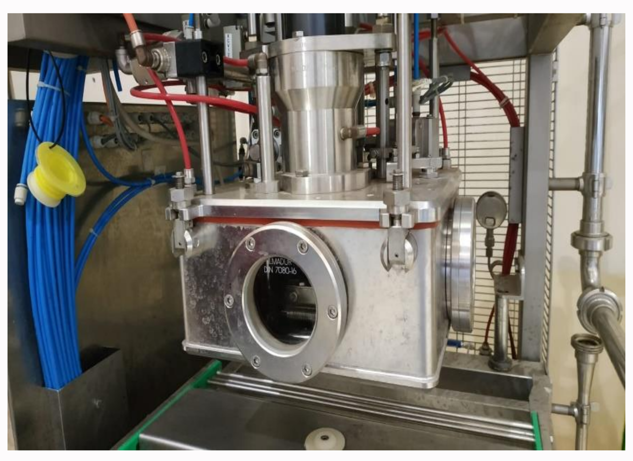
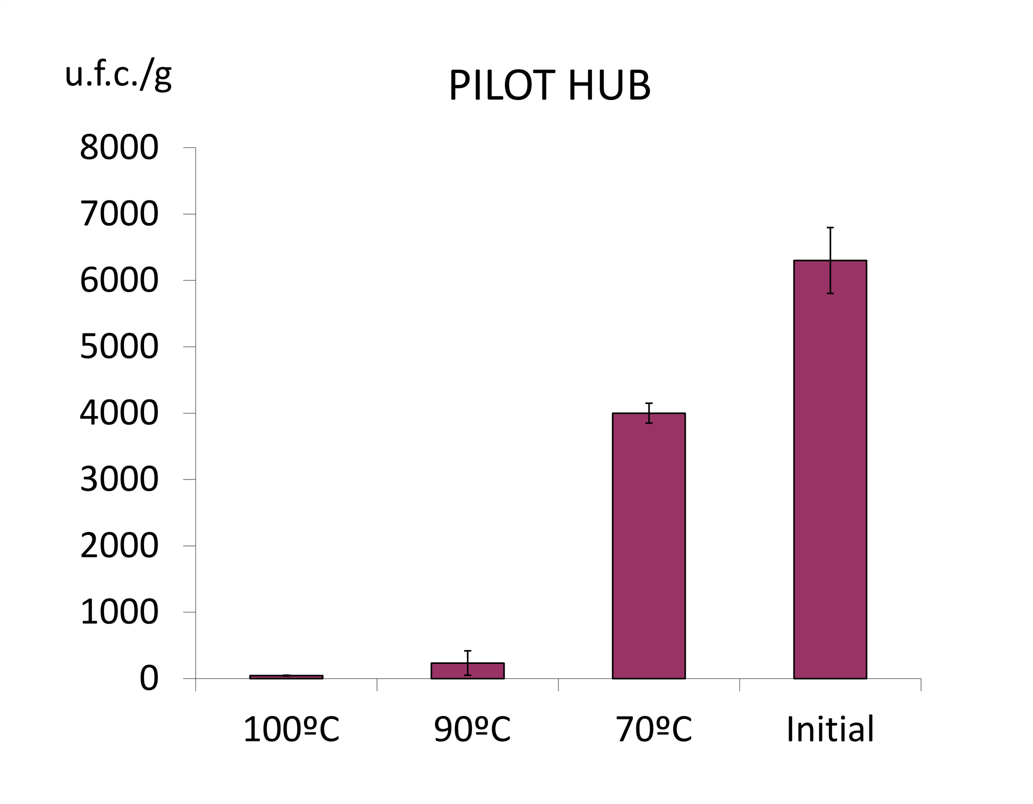


Illustration 2. Aseptic filler



Ilustration 3. Evolution of viable bacteria in each heat trath

Ilustration 4. Bacterial isolates

Table 2. Bacterial species in unpasteurized tomato

Identified bacteria	HOT BREAK	%	COLD BREAK	%
Bacillus subtillis	8	40 %	9	45 %
Bacillus amyloliquefaciens	5	25 %		
Bacillus pumilus	6	30 %	7	35 %
Bacillus lycheniformis	1	5 %	1	5 %
Bacillus clausii			1	5 %
Paenibacillus musseliensis			1	5 %
Brevibacillus brevis			1	5 %

Table 3. Stability of tomato concentrate after heat treatment

T ºC	70	90	100
P65	12.65	1,265	12,650
RESULTS	*UNSTABLE*	*STABLE*	*STABLE*

CONCLUSIONS

The taxonomic study of the concentrated tomatoe´s microflora showed that all the bacteria found in the concentrated tomato before the heat treatment, were of the genus *Bacillus*, mainly its sporulated form, most of the bacteria of this genus, in theory, do not have the ability to grow at the pH of the concentrated tomato.

As for the heat treatments, the aseptic bags were stable after pasteurized above 90 °C, finding significant improvements in the quality of the final product when softer heat treatments were applied. These conclusions have been reached using a pilot tomato concentrate plant so that in no case are they applicable to the industry until some tests are carried out at an industrial scale.

ACKNOWLEDGMENTS

The present study was partially supported by the Government of Extremadura through the COINVESTIGA program and the project "Sistema integral basado en tecnologías de biología molecular para el control de la seguridad alimentaria en industrias de tomate" **RAPIMET**.

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The potential of near infrared reflectance spectroscopy (NIRS) for the estimation of quality parameters in tomato paste

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INTRODUCTION

Monitoring quality traits is very important for the industry in different stages of the tomato production cycle including the agricultural production, harvesting and processing (1). Some of the quality parameters that are commonly used as control tools in tomato production and processing are viscosity, consistency, acidity, soluble solids, color, sugar, organic acids and lycopene content (1,2,3,4,5).

Non destructive optical methods based on near infrared spectroscopy have been used for estimation of physiological properties of many products (6,7). In this work, the development of a robust spectroscopic procedure for determining, simultaneously and non-destructively, relevant quality parameters of tomato paste is described.

MATERIALS & METHODS

1. Sampling

Samples of tomato paste products were picked at different production batches. These samples presented a broad range of variation for calibrating the properties of interest. Process of tomato paste is shown in figure 1.

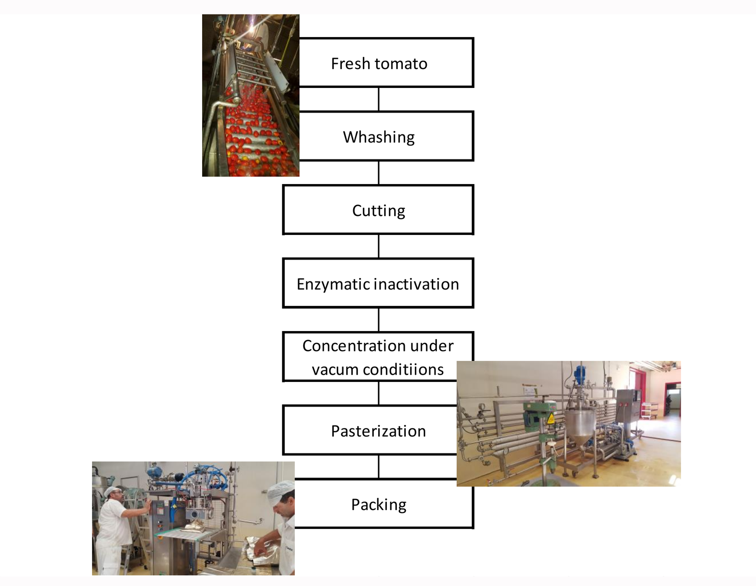


Figure 1. Flowchart tomato paste

3. NIR análisis

NIRS analysis was performed using a Monochromator-NIR reflectance and transflectance analyser (NIRS DS2500) (figure 2).

This instrument operate in the 450–2500 nm range with a 0.5 nm.

The spectral (optical) information is related by an algorithm with the information of the physicochemical composition (reference method), using software WinISI.

2. Reference Analysis

The levels of sugars, acids, soluble solids, titratable acidity, and pH in these juices were determined using standard reference methods.

Figure 2. NIRS DS 2500

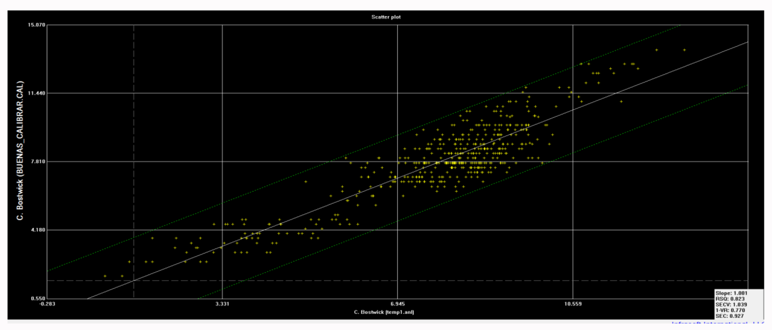
RESULTS & DISCUSSION

50 samples of tomato paste were analized. Physicochemical results obtained are shown in table 1.

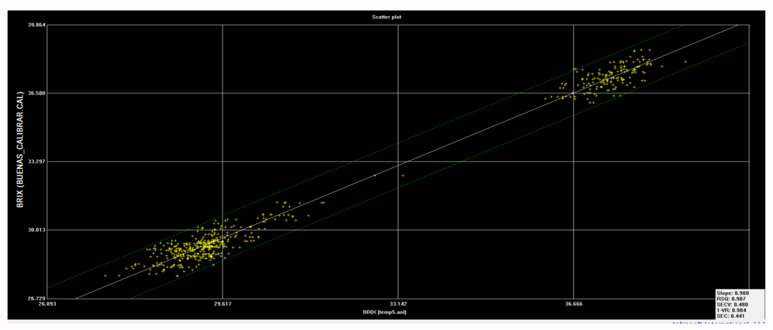
Table 1. Physicochemical results concentrated tomate

	RANGO
BOSTWICK (cm/30s)	1,8-21
pH	4,2-4,7
BRIX (°)	27,5-38,6
AZÚCARES REDUCTORES (g/100 g glucosa)	7,9-63
ACIDEZ TOTAL (g ácido citrico/100g)	1,2-3,3
SAL (%NaCl)	0,1-0,37
COLOR a/b	1,8-2,7
COLOR A	27-35
COLOR B	11,5-16
COLOR L	21,1-26,75

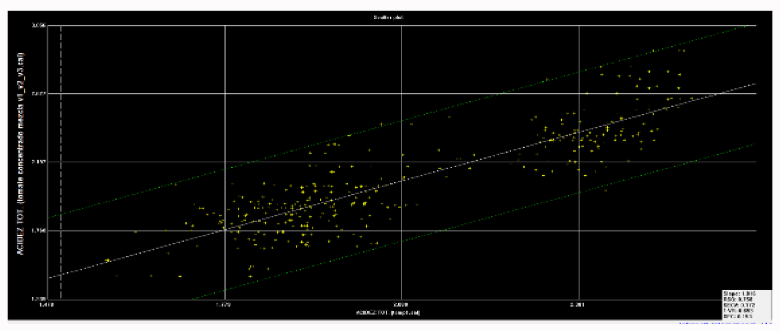
Results obtained in the calibration NIRS are shown in the graphic 1, 2 , 3 and 4 and table 2.



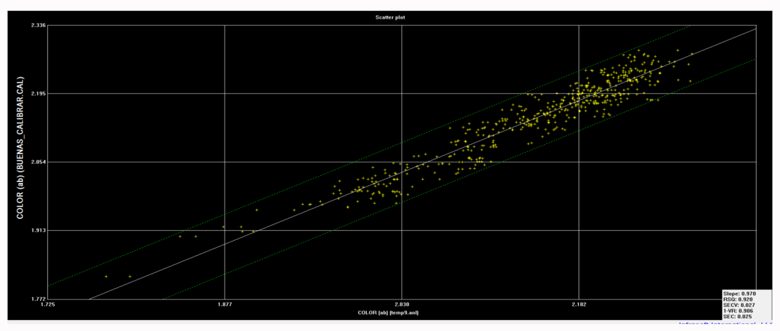
Grafic 1. Calibration curve Bostwick



Grafic 2. Calibration curve Brix



Grafic 2. Calibration curve tritatable acidity



Grafic 2. Calibration curve Color a/b

Table 2. Calibration determination coefficient tomato paste

	R^2	VIABLE
BOSTWICK (cm/30s)	0,8	SI
pH	0,34	NO
BRIX (°)	0,98	SI
AZÚCARES REDUCTORES (g/100 g glucosa)	0,46	NO
ACIDEZ TOTAL (g ácido citrico/100g)	0,75	SI
SAL (%NaCl)	0,03	NO
COLOR a/b	0,95	SI
COLOR A	0,94	SI
COLOR B	0,93	SI
COLOR L	0,91	SI

In general, the results obtained are good. Specially, excellent results have been obtained in Brix (R2= 0.98) and it was very good correlation in color a/b, color a, color b, color L (R2= 0.95, R2= 0.94, R2= 0.93 and R2= 0.91, respectively). Bostwick showed a good correlation (R2= 0.80). And tritatable acidity showed a correct correlation to predict. But this trend did not continue in salt content, pH and reducing sugar showed a bad correlation (R2= 0.03, R2= 0.34 and R2= 0.46, respectively).

CONCLUSIONS

As a result, this method should not be used as a method of reference but as control method in industry processes of tomato paste.

ACKNOWLEDGMENTS

This project has received funding from the Government of Extremadura through the COINVESTIGA program.

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Non-destructive determination of quality parameters in tomato based products by near-infrared spectroscopy

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INTRODUCTION

Tomato production in Spain in 2021 was 3,185 million kg (date of last update: 21-10-2021), which corresponds to 8.22% of the tomatoes produced in the world. (1).

Different analytical methods have been applied for quality control of different tomato products. Analytical quantification of control parameters is destructive as well as time and labour consuming.

Near-infrared (NIR) spectroscopy is a well-know, rapid and non-destructive technique for analyses of many different food products (2,3). In this study, it was used to develop a novel method for analysis tomato based products, ketchup and fried tomatoes sauce, in order to evaluate the correlation between data obtained by near infrared spectra and physical-chemical analyses and know the quality parameters immediately.

MATERIALS & METHODS

In the first place, tomato based products were picked at different production batches to obtain the greatest possible variability (figure 1).

Figure 1. Flowchart tomato based products

After that, tomato based products were analized chemically and to do this official methods were used. Among the analysis it were carried out, those that stood out, were brix, color a, color b, color a/b, brix, bostwick, pH, reducing sugar, tritatable acidity and salt content.

Samples were scanned using a Monochromator-NIR reflectance and transflectance analyser (NIRS DS2500) (figure 2). The complexity of the NIR signal makes it essential to use chemometric techniques that allow interpreting, understanding and modeling large data sets.

Figure 2. Spectroscopic measurements

The spectral (optical) information is related by an algorithm with the information of the physicochemical composition (reference method), using statistical models.

RESULTS & DISCUSSION

50 samples of ketchup and 50 samples of fried tomatoes sauce were analized. Physicochemical results obtained are shown in table 1 and 2.

Table 1. Physicochemical results ketchup

	RANGE
BOSTWICK (cm/30s)	2,5-5,5
pH	3,76-4,00
BRIX (°)	27,23-31,61
AZÚCARES REDUCTORES (g/100 g glucosa)	12,07-19,66
ACIDEZ TOTAL (g ácido cítrico/100g)	1,66-3,29
SAL (%NaCl)	1,18-1,54
COLOR a/b	0,91-1,92
COLOR A	11,02-24,55
COLOR B	11,22-12,86
COLOR L	18,34-20,24

Table 2. Physicochemical results fried tomatoes sauce

	RANGE
BOSTWICK (cm/30s)	8,5-11,5
pH	4,16-4,35
BRIX (°)	9,95-10,82
AZÚCARES REDUCTORES (g/100 g glucosa)	3,87-5,99
ACIDEZ TOTAL (g ácido cítrico/100g)	0,37-0,67
SAL (%NaCl)	0,23-1,18
COLOR a/b	1,52-1,88
COLOR A	26,35-29,67
COLOR B	14,77-18,14
COLOR L	17,13-29,02

The statistic used in the evaluation, selection and validation of the calibration equations was the calibration determination coefficient (R^2).

Results obtained in the calibration NIRS are shown in the table 3 and 4.

Table 3. Calibration determination coefficient ketchup

	R^2
BOSTWICK (cm/30s)	0,87
pH	0,72
BRIX (°)	0,98
AZÚCARES REDUCTORES (g/100 g glucosa)	0,75
ACIDEZ TOTAL (g ácido cítrico/100g)	0,74
SAL (%NaCl)	0,6
COLOR a/b	0,94
COLOR A	0,99
COLOR B	0,93
COLOR L	0,75

Table 4. Calibration determination coefficient fried tomatoes sauce

	R^2
BOSTWICK (cm/30s)	0,77
pH	0,31
BRIX (°)	0,94
AZÚCARES REDUCTORES (g/100 g glucosa)	0,72
ACIDEZ TOTAL (g ácido cítrico/100g)	0,46
SAL (%NaCl)	0,81
COLOR a/b	0,97
COLOR A	0,93
COLOR B	0,95
COLOR L	0,62

Regression coefficient between NIR spectroscopy and reference analyses of quality parameters in **ketchup** showed good results for same parameters. The highest correlation was detected for color a (R^2= 0.99), brix (R^2=0.98). Color a/b and color b showed a very good correlation (R^2= 0.94 and R^2=0.93, respectively), bostwick showed a good correlation (R^2= 0.87), pH, reducing sugars and tritatable acidity showed a correct correlation to predict. Finally, salt content showed a semicuantitative correlation (R^2= 0.6), so it is not good method to determinate salt content.

Regression coefficient between NIR spectroscopy and reference analyses of quality parameters in **fried tomato sauce** the results are not as good as ketchup. The highest correlation was detected for color a/b (R^2= 0.97), color b (R^2=0.95). Brix and color a showed a very good correlation (R^2= 0.94 and R^2=0.93, respectively), salt content showed a good correlation (R^2= 0.87), reducing sugar and Bostwick showed a correct correlation to predict. Color L showed a semicuantitative correlation (R^2=0.62). pH and tritatable acidity are not viable.

CONCLUSIONS

In conclusion, this method can be used to predict same parameters of ketchup and fried tomato sauce but it can not be used to definitive method, but as routine monitoring of the process.

ACKNOWLEDGMENTS

This project has received funding from the Government of Extremadura through the COINVESTIGA program.

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