Final report

for the CORE Organic Cofund funded project

"Development of smart and low energy input processing chains, natural food additives and colourants, and supportive material for a code of practice to increase sustainability and consumer acceptance of organic food stuffs - SusOrgPlus"

Period covered: 01.05.2018 – 30.04.2021

[Note to coordinators: this report covers the whole duration of the project. Once approved by the funding bodies, the final report without the annexes should be made publicly available in Organic Eprints.]

Index

1. General information

1.1 Project information

Project information			
Project acronym	SusOrgPlus	**Project ID**	2078
Project title	Development of smart and low energy input processing chains, natural food additives and colourants, and supportive material for a code of practice to increase sustainability and consumer acceptance of organic food stuffs		
Project website	https://susorgplus.eu/		
Details of the project coordinator			
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Institution	University of Kassel	**Country**	Germany
Start of project	01.05.2018	**End date of project**	30.04.2021
Duration in months	36	**New end date in case of a project extension due to COVID-19**	No extension

1.2 Consortium

Partner no.	Country	Institution/ organisation name	Type of institution/ organisation[1)]	Functions[2)]	Involved in WPs	Contact person[3)]
1.	GER	Uni Kassel	University	Project coordinator/ WPL (8)	all	g.gersdorff@uni-kassel.de
2.	NOR	SINTEF	Research center	WPL (2)	2, 3, 5, 6, 7, 8	Michael Bantle michael.bantle@sintef.no
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4.	IT	UNITUS	University	WPL (4)	1, 2, 4, 5, 6, 7, 8	Riccardo Massantini massanti@unitus.it
5.	IT	UNITE	University	WPL (3,7)	3, 4, 5, 7, 8	Paola Pittia ppittia@unite.it
6.	SWE	SLU	University	WPL (6)	5, 6, 7, 8	Girma Gebresenbet Girma.Gebresenbet@slu.se
7.	GER	Innotech	Company	P	1, 2, 7, 8	Albert Esper info@innotech-ing.de

1) University, Public research centre, Private research centre, Company, Other
2) PC = Project coordinator, WPL = Work package leader, WPCL = Work package co-leader, P = Participant
3) inclusive e-mail address

2. Summary

2.1 Final project summary suitable for web publication for a wider audience

SusOrgPlus has developed novel, affordable smart processing systems with dynamic control (e.g. temperature, humidity,) for the production of high quality ingredients and highly nutritious dried (and further processed) products. The results obtained show a high potential for non-invasive product monitoring of moisture content, colour and valuable compounds during drying processes and to further improve the developed product related, individual drying strategies. Additionally, alternative control point driven strategies were investigated which were *intermittent, product* and *step wise* drying and were compared to air temperature controlled drying utilizing simple and cost-effective sensors and microcontrollers. The results show the high potential to increase product quality as well as process efficiency of drying processes.

The development and modelling of the CO_2 neutral heat pump batch dryer shows a high potential to phase out fossil fuels to enable future processing chains with low environmental impacts will increase the sustainability of organic produce.

Further, methods (drying/milling, extraction/microencapsulation) for plant based and rich in secondary plant compounds (antioxidants, lycopene etc.) powder and extract development were evaluated regarding product quality. They were further utilized to enrich organic foods (colorants, flavorings and nutritional fortification) and develop innovative foods like bakery products or pasta or dried fruits and vegetable. This will help the organic sector to increase the competitiveness and the potential to phase out contentious artificial substances, i.e. colourants and other ingredients, due to improved processing strategies and plant-based substitutes. Additionally, it will help to reduce direct waste of food and utilise and upgrade products that are rejected from the market or help to utilise by-products (e.g. tomato juice production) or underutilized species (e.g. nettle).

The developed products have been assessed by chemical and sensory analyses and products and drying systems have been evaluated on their environmental and economic impact (LCA/LCCA) to show clearly the advantages of new drying systems and new products.

Results obtained will feed in the Code of Practice (CoP) to be available to processors. The results have also been presented at national and international workshops, fairs, seminars/webinars and in scientific and stakeholder related articles. The involvement of students supported the training of high qualified employees sensitised for the needs of the sector to improve the sustainability of future food processing.

2.2 Process update of the whole project

1. **Development of a low cost smart processing systems including dynamic multi factor process control** for the production of dried foods and additives and colorants in powder form with increased nutritional value and improved overall quality for on-farm and off-farm applications. Against this background, computer- vision (CV) was developed for the automatic recognition of a product, as well as the corresponding drying strategy and monitoring throughout the drying process. Furthermore, prediction algorithms have been developed to monitor different product parameters during the process to be utilized to adjust the drying parameters continuously to obtain efficient drying processes in terms of product and process quality. The development of such systems is based on hyperspectral measurements, the data of which are used to filter out the most important information and convert it into simple, low-cost systems (e.g. CCD sensors). Additionally to the work proposed, off-line applications for smart drying were developed. Therefore, simple and cost-effective sensors and microcontrollers have been integrated into a model dryer to enable product temperature control and the non-invasive monitoring of product colour.
2. **Development of a demonstration unit on CO_2 neutral drying system, utilising waste heat recovery and a HP application**, which are economically viable even on a small scale and thus enable the phasing out of fossil fuels, as well as cost-efficient production and implementation of intelligent processing systems: Based on process simulations, a CO_2 heat pump dryer for batch drying with sensors and cameras to monitor process and product parameters to integrate the idea of smart drying into the heat pump dryer.

3. **Development, testing and evaluation of novel natural food additives/colourants** (also from previously rejected raw materials) and their application in different products including qualitative and sensory evaluation of their preservative functions, their nutritional and dietary (neutraceutical) value, their function as colorants and flavorings. The consortium decided to include tomatoes, hops and nettles, as well as the by-products from juice or extract production in the development in order to increase the proportion of value-giving ingredients (polyphenols, antioxidants, etc.) in baked goods. Furthermore, work was carried out with green tea extracts in the area of carrot drying.
4. **Conduction of an environmental impact analysis, including LCA and LCCA**, to assess the overall benefits of using underutilized or unutilized products (pre-sorted by aesthetic considerations, i.e. "ugly fruits"), increased process efficiency and fossil fuel reduction, as well as the impact of applying smart processing principles on product quality and beneficial properties of the new products (additives/colors).
5. **Stakeholder engagement, student involvement and dissemination**. Stakeholder involvement has a crucial impact on the creation of new knowledge, knowledge transfer and the development of the planned innovations, therefore a stakeholder-led approach was adopted for the overall technological development. Dissemination activities were specifically designed to reach a wide range of stakeholders, especially producers and processors. During the project, 1 workshop/seminar per partner country was successfully conducted in each of the participating countries. The consortium also organized an event on sustainable food processing in cooperation with ATB Potsdam for researchers and processors at the end of the project. The project results provide several approaches for improved processing with regard to increasing product quality and reducing environmental impact and thus process costs. The findings and project progress were disseminated in a stakeholder-oriented way via regular contributions to the CORE Organic newsletter and via one Practice Abstract. Furthermore, the project enabled the integration of 15 young scientists (bachelor, master and PhD students) and thus their further education in different areas of food processing. Besides the workshops and seminars/trainings for stakeholders, the project, as well as project results were presented at 19 national and international conferences with 32 contributions and 22 conference papers and published in 16 publications in international journals, or are under preparation/submitted (15) at this time.

3. Outcomes of the project

3.1. Main results, discussion, conclusions and fulfilment of objectives

3.1.1 WP1

WP1	*Development of smart processing chains*
WP leader: UNITUS and UNIKASSEL **Responsible partners:** Innotech	
Overall summary of main results, discussion, and conclusions of WP1 The WP1 investigated the development of a prototype smart drier equipped with single-board computers, microcontrollers and sensors, and fully connected to a data management system (DMS) developed using Elasticsearch as open-source analytics engine for structured and unstructured data (i.e., textual/numerical and raw data, respectively, both acquired in-line). The infrastructure for the DMS was provided by the subcontractor ENEA (Italian National Agency for New Technologies, Energy and the Sustainable economic development), which also collaborate with the WP leaders in defining the structure of the computational databases. The resulting DMS allowed to store data as CSV file and JSON documents. The Elasticsearch software was chosen for its compatibility with client written in Java, JavaScript, Go, .Net, PHP, Perl, Python and Ruby, and, thus, to fulfil any need from partners in terms of programming languages skills. In addition, the Kibana software was also added to the DMS as open-source user interface to visualize and navigate data with basic computer skill requirements. Regarding the prototype development, the HTmini dryer (Innotech) was provided with a Jumo Dicon Subsequently, UNITUS modified the dryer for the implementation of (i) a darkroom on the top of dryer; (ii) in LED based illumination system into the darkroom; (iii) an industrial digital camera; (iv) a cooling system for the darkroom; (v) a load cell capable to work at a maximum temperature of 70 °C; (vi) a	

microcontroller Arduino UNO to be interfaced with the load cell and the already existing Jumo Dicon Touch controller; (vii) a single board computer NVIDIA Jetson Nano. Parallel, UNITUS also started the development of the Monitoring and Control System (MCS). For the intended purposes, only open-source software was used. Specifically, all peripherals, controllers and sensors were wired to the micro-computer and connected the DMS service using APIs and a series of scripts written in Bash, Python and JavaScript. The Node-RED programming tool was used as orchestrator. Deep learning models for the (i) semantic segmentation of images acquired from the dyer and (ii) the recognition of inlet wet foods into the drying process were also developed. In addition, segmented linear models were developed to predict changes in moisture content from spatial features extracted from the product images scanned during drying. The obtained prototype laid the foundations for a smart dryer capable of (i) recognising the inlet wet product to the dryer, (ii) automatically setting the initial parameters of the drying process and (iii) monitoring quality changes in the product during drying by implementing product-specific prediction models.

After critical consideration of the market situation it was decided to also develop solutions which do not necessarily depend on permanent connection to a cloud. Therefore, the work of Uni Kassel, SINTEF and Innotech has focussed on the development of Soft Sensors (sensor data fusion of environmental and product relevant measurements) and the determination of critical control points which then can be used as the basis of the dynamic control algorithms within the controller.

Report on the results obtained (A), and fulfilment of objectives (B) comparing to the original project proposal

A- results obtained and structured in relation to the user groups they are relevant for:

Task 1.1: Development of data management system: The developed DMS is fully operative and data has been provided by the involved partners to populate the DMS. Particular focus is laid on user friendliness of the human-machine-interface.

Task 1.2: Development and integration of smart monitoring and control systems: Convolutional Neural Networks (CNNs) were used to address the following tasks: (i) the semantic image segmentation of the inlet product (i.e., recognition between background and product pixels); (ii) the inlet product classification through the segmented image (Moscetti et al., 2019a). As first step, the CNN models were developed using offline data, while the second step consisted in in-line tests using the smart dryer. Nine species of fruits (i.e., apple, apricot, banana, cherry, kiwifruit, lime, nectarine, pear, plum) and nine species of vegetables (i.e., bell pepper, carrot, champignon mushroom, cherry tomato, cucumber, onion, plum tomato, potato, zucchini) were used. Specifically, (i) the conventional image segmentation was carried out with the OpenCV3 library, while both (ii) semantic segmentation and (iii) image recognition models (SSM and CM models, respectively) were computed using the fast.ai library running on top of the PyTorch library. The development of the first version of both CNN models was performed on desktop computer. Subsequently, the development was moved on the High Performance Computing unit of UNITUS due to the need of an higher computational power. Data augmentation was used to make CNN models invariant to noise, translation, viewpoint, size, illumination, and background of image through small random transformations. The SSM model performance was evaluated through the Intersection over Union (IoU) loss function.The final SSM model showed a high Intersection over Union (IoU > 99%), while the CM model showed low total error rate in calibration (~ 0.66%), cross-validation (~ 0.99%) and prediction (~0.81%). In other words, both CNNs produced excellent results without any image pre-processing

Task 1.3: Development of machine learning models: UNITUS developed linear models to predict changes in moisture content of apple slices during the drying process using shape and size features extracted from the image of product (Moscetti et al., 2019b). The models were superior to thin-layer models (i.e., Newton-Lewis, Pages, Henderson & Pabis, and logarithmic models) in terms of RMSE (< 0.01), BIAS (close to 0), reduced χ^2 (close to 0) and R^2 (close to 1). The SML has also the potential to circumvent the dependence on process parameters of the thin-layer models. The drying tests were conducted on blanched and not blanched carrot slices, using the prototype for the in-line monitoring of changes in [i] colour, [ii] spatial and [iii] weight features. The in-line sensors acquired precise data, able to catch small changes in physico-chemical features, allowing treatment comparison. The SML model also enabled the smart dryer to (i) predict the drying rate of product and (ii) evaluate the homogeneity of the drying process (Moscetti et al., submitted and under preparation, Raponi et al., submitted).

Additionally, investigations of the application of non-invasive monitoring (based on hyperspectral imaging) was conducted by UniKassel for apple (Shrestha et al., 2018, 2020a,b), carrot (Md Saleh et al., submitted), submitted) and beef drying (von Gersdorff et al., 2021a,b) and hops (Sturm et al., 2020) regarding simple and cost-effective continuous real-time monitoring and future smart drying strategies.

Task 1.4: Setup transferability tests on existing process units: All the developed models were loaded in the single-board computer and additional scripts, written in Python and JavaScript languages, were incorporated in the orchestrator (i.e., Node-RED) to allow the MCS to use them in real-time. Then, the system was tested on additional carrot samples for its capability to acquire, analyse and share data in real-time through the DMS. The used approach makes the smart setup expandible with further additional models developed with generic intent as well as to be product specific. In general, the final setup is retro-fittable, but some adaptations can be required based on the old dryer characteristics, which must be carefully evaluated. Figure 1 shows the schematic of the already described smart dryer prototype. During the project period the system was tested, and prediction models were developed to be embedded in the single-board computer.

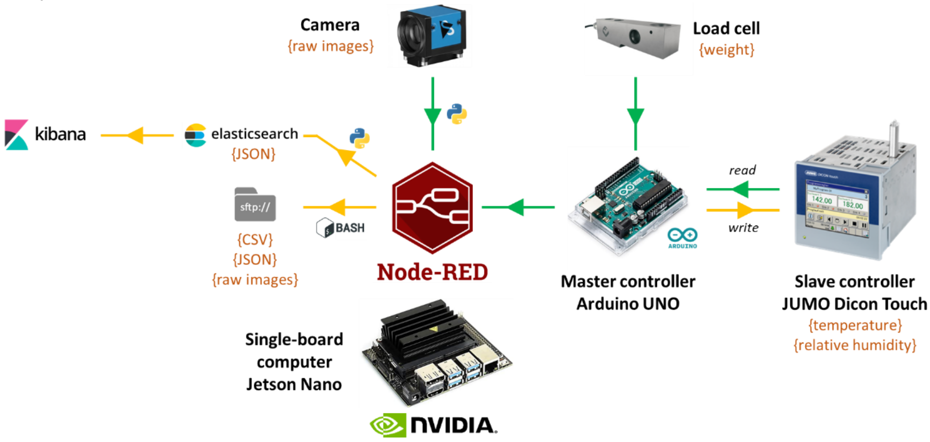

Figure 1. *Schematic of the smart dryer prototype.*

Task 1.5: (New): Development of dynamic control algorithms: Extensive studies have been conducted to determine critical points in the dynamic development of product quality. This information has been used for the development of critical-control-point driven drying. This involves the investigation on intermittent drying of carrots (daucus carota cv. laguna) (Md Saleh et al, 2019, 2020), where the drying process was interrupted at predefined moisture levels and continued after tempering time of 1 or 3 hours. The results obtained showed that intermittent drying can reduce the drying time as well as increase the carotenoid retention compared to continuous drying. Additionally, a model dryer was developed with Innotech at Uni Kassel equipped with cameras for color measurement and an infrared camera to enable both air and product temperature controlled drying as well as sensors to and controllers for air velocity and rel. humidity, which leads to reduced drying times and thus more efficient drying processes with regard to product quality and energy consumption. Figure 2 shows the results for air, product and step-wise controlled drying (Raut et al., 2021, Raut 2021, submitted))

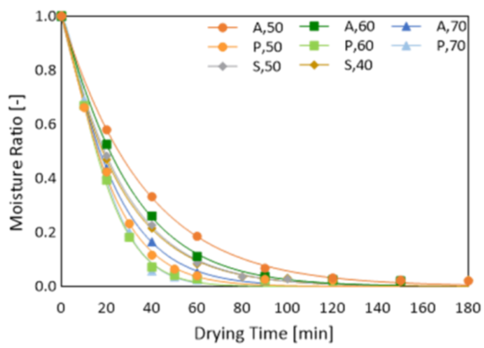

Figure 2: Drying curves for air (A), product (P) and step-wise (S) drying strategies

However, also strategies based on experimental investigations showed a high potential to improve the drying process and do not require the utilisation of permanent monitoring devices. Therefore, the drying air temperature is set above the critical temperature of the product and is decreased after a predefined time (based on experimental investigations) to avoid case hardening and to minimize quality losses. At the same time, the drying time and energy demand is decreased. Additionally, it has been shown that the control of the relative humidity can lead to more efficient drying processes. Therefore, circulating air applications provide a useful tool controlled by air temperature and humidity and can further be combined to recuperators to maximize this effect lead to comparable results like product temperature controlled processes and finally can be simplified by controlling the process only by time. Innotech and Uni Kassel further developed a remote control system and thus demonstrated the feasibility for cloud solutions that a mandatory for smart applications. Besides the proof of concept via an Ethernet interface of the location-independent control based on humidity and temperature measurements, also a real-time monitoring of drying parameters became possible.

B- fulfilment of objectives:

All deliverables and milestones were fulfilled; some delays were experienced due to the covid19 emergency, which was responsible for some scheduling rearrangements.

3.1.2 WP2

WP2	*Climate neutral drying of organic products*

WP leader: SINTEF

Responsible partners: Innotech, UNI KASSEL, UNITUS

Overall summary of main results, discussion and conclusions of WP2

A heat pump drying system with natural refrigerants and energy storage for utilising waste heat recovery has been developed, installed and demonstrated (b) Organic apples and seaweed has been processed and dried in the new demonstration unit, (c) Organising a Norwegian stakeholder event for dissemination of the results (d) active participation at SusOrgPlus workshops throughout the project lifetime (4 in numbers) and, (e) development of surface temperature controlled drying process.

Results obtained (A), and fulfilment of objectives (B) comparing to the original project proposal

Task 2.1: Design of the heat pump dryer and Task 2.2: Building of prototype and approval tests: Main objective was to install a demonstration unit which enables to evaluate the concept of HP drying in an industrially relevant environment (TRL6). Together with Innotech GmbH (a supplier of novel drying systems) and a Norwegian supplier of HP's, a demonstration unit was designed for validation of an energy efficient drying system suitable for producing high quality organic products (Jokiel et al., 2019). The demonstration unit, including the dryer, a HP with R744 as working fluid including two thermal storage tanks, was installed in the HighEFFLab at SINTEF (2019). The design and construction of the installation has resulted in a HP dryer which can be operated in conventional mode as well as HP mode. The determined KPIs allow a direct comparison of the two modes. Also, the repeatability of the tests was documented. The installation was financed by the infrastructure project HighEFFLab. The demonstration unit is of a relevant size for smaller producers of dried organic foods, and the concept was validated through drying of organic apples and seaweed. Quality measures of the end products were performed by the Romanian partner UASVM (University of Agronomic Science and Veterinary Medicine of Bucharest), and will be published in a journal paper after the end of the project. The demonstration unit is available for future R&D projects. Instead of a physical workshop with Norwegian stakeholders an online seminar with focus on heat pump drying was performed. The seminar had around 50 participant and the records are available post-project. SINTEF also contributed to the online seminars of USAMV, UniTeramo and UniKassel.

Task 2.3: Development and implementation of control strategies: A novel control method for the convective drying was developed. In conventional drying the air temperature is controlled by setting a constant value for the air temperature, which is in most cases is the maximum allowed temperature of the product. However, the product temperature is often lower than the set point or maximum allowed temperature, especially in the first drying period when the surface of the product is still wet. The new control strategy is based on a constant measurement of the surface temperature of the product by an infrared camera. The measured product temperature is used as a control parameter for the air temperature (Bantle et al., 2019). This concept allows for a significant reduction in drying time (up to 50%) while maintaining or even improving the product quality. The concept of surface temperature-controlled drying is now integrated by the SusOrgPlus partner Innotech as an option in their commercial drying system.

A Data Acquisition System (DAQ) was developed and tested in which the drying progress is documented by optical analyse. For this concept pictures of the drying product are taken at certain time steps and analysed with respect to colour change and shrinkage already during the drying process, in addition to the weight reduction. This data can be used as control parameter of the drying process. However, the control algorithm is not finalized, and it is not clear which drying parameter (mainly temperature, humidity or velocity) must be altered when the shrinkage or the colour change is too high.

Task 2.4: Drying tests on climate neutral organic dried products: A Modelica based dynamic HP-assisted dryer model was developed with respect to heat transfer, pressure loss and flow requirements. The simulation results show that a closed loop HP-assisted drying process reduces the energy demand by up to 84% compared to open loop drying processes with fossil resources as the energy source. This input was used for dimensioning the dryer and the HP-system for the demo unit.

Drying experiments were performed to analyse the assessment and the HP dryer performance, using apples as the main food product (Jokiel et al., 2020). The main results showed a uniform drying on each tray, both horizontal and vertical and it is possible to dry approx. 100 Kg of apples in one batch, taking 5-6 hours. Since the drying chamber applied in the developed HP dryer is rather short only a small temperature glide over the trays was observed, and the increase in relative humidity of the drying air was smaller than expected. This was not considered in the design phase. By running the drying system in bypass control, it was expected a decrease in drying time compared to normal drying. Compared to normal mode, the drying process was the same for the HP drying but compared to conventional drying, the decrease in drying time was approx. 15% due to the heat pump. The use of CO_2 as a refrigerant has shown to be not the most efficient solution for energy recovery from drying air with low relative humidity. Using another natural refrigerant may affect the efficiency of the system positively.

Fulfilment of objectives:

All objectives were fulfilled and reports were written.

3.1.3 WP3

WP3	*Development of value added natural extracts/colourants*
WP leader: UNITE **Responsible partners: SINTEF/UNI KASSEL/UASVM**	
Overall summary of main results, discussion and conclusions of WP3 The WP 3 developed dried products made of plant extracts/juices and fruit pulps by the use of drying and encapsulation techniques to use as natural preservatives, colorants, flavorings or for nutritional fortification in the production of organic foods (WP4) with high added value. The research activities were focused on four plant products i.e. tomato, nettle, hops and seaweeds. Tomato was selected since it is the most diffused vegetable worldwide and it is well recognized for its biological activity in preventing and reducing risks of cancers, Alzheimer's disease, cardiovascular diseases. For the investigations an autochthonous variety of the Abruzzi region (Italy) namely "Pera D'Abruzzo" was selected due to its fleshy pulp, reduced number of seeds and high lycopene content. Nettle was selected since is a wild underused plant which besides the high colouring power, represents a valuable source of in vitro and/or in vivo antioxidant compounds such as chlorophylls, carotenoids, and phenolic compounds. Hops was chosen	

since it is a high valuable crop, particularly rich in secondary metabolites (bitter acids, polyphenols and prenylated phenols, essential oils) with flavoring, antioxidant, anti-inflammatory, antimicrobial, and in vitro- antitumoral activity. Finally, seaweeds were selected for their high ecological value, technological functionalities, and content in antioxidant compounds. The production of the organic dried **tomato** products i.e. freeze-dried tomato extract (juice and pulp obtained from fresh and blanched fruits) and oven dried pomace (skin and seeds) was carried out using as raw material an autochthonous variety of the Abruzzi region (Italy) namely "Pera D'Abruzzo" characterized by fleshy pulp, reduced number of seeds and high lycopene content. Results showed that tomato cv. Pera d'Abruzzo represents a high-quality source for the production of dehydrated products to be used in food formulations as natural coloring and flavoring agent and/or for nutritional fortification of food products. Encapsulation of tomato extract with maltodextrin positively affect the thermal and physical properties of the extract improving its handling, dosage, solubility, and stability over storage. For the production of the organic dried **nettle** *(Urtica dioica* L.) extracts, a blanching treatment for the inactivation of endogenous enzymes was optimized, thus mechanically extracted nettle juice was subjected to freeze-drying to produce powdered nettle extract. Freeze-drying microencapsulation of nettle juice was also applied by using maltodextrin. Results highlight that encapsulated nettle juice powder (NJ-MD) presents higher solubility than the non-encapsulated one (NJ) while in terms of physical and chemical stability over storage no significant differences were observed between NJ and NJ-MD. Both the products can be exploited in food formulations as natural colouring and flavouring agents. The extraction of functional and flavouring compounds from **hops** was optimised by the evaluation of conventional (dynamic maceration) and green technologies (high hydrostatic pressure and ultrasounds), and different times and temperature of extraction. Results highlighted that the selection of the cultivar to use for the production of hop extracts must be carried out on the basis of the desired sensory profile, functionalities and final destination. Freeze-drying microencapsulation, irrespective to the carrier used, allowed the production of powdered extracts easy to handle and dosage, characterized by very low moisture content and water activity values, high water solubility, and to retain the content of the bioactive compounds over processing. Organic **seaweeds** (*Saccharina latissima)* powders to use in organic food formulations and products were obtained by grinding dried seaweeds obtained within the activity of WP1 by freeze-drying (FD) and heat pump assisted drying technologies (HPAD). The evaluation and comparison of FD and HPAD powders with respect to the physical (color, glass, transition temperature), technological(water and oil holding capacity, swelling properties, water adsorption isotherms, solubility), and functional (in collaboration with UASVM) properties was performed.

Report on the results obtained (A), and fulfilment of objectives (B) comparing to the original project proposal

A- results obtained and structured in relation to the user groups they are relevant for:

Task 3.1: Extraction and encapsulation of organic raw materials: Tomato: The effect of different blanching thermal treatments was evaluated before extraction. Among the investigated conditions, blanching at 90 °C for 2 min was found to be sufficient to inactivate quality degradative endogenous enzymes such as POD and PME enzymes, while the quality and bioactivity was not significantly affected. In order to obtain an ingredient physically and chemically stable, the tomato extract was dehydrated by freeze-drying (FD). After FD, the extract in powder showed low glass transition temperature resulting at room temperature sticky and with poor physical and chemical stability; thus, the addition of a structuring and encapsulating agent with high glass transition temperature such as maltodextrin (DE= 8-10) at different percentages (1, 3, 5, 10, 20 %) was investigated in order to increase the techno-functional properties of the product and its stability at room temperature (Giancatarino et al., in preparation). Among the formulation investigated, the addition of 10% w/w of maltodextrin (MD) to the tomato extract allowed, after FD encapsulation, to increase the T_g of the tomato powder from 3 °C (without MD) up to 38 °C and, thus, to obtain at room temperature an amorphous and easy handle powder. The use of maltodextrin led to the increase also of the water solubility (from 60% to 85%) and to the reduction of the powder' moisture content and water activity. Both the tomato powders (encapsulated and non-encapsulated) showed remarkable content of lycopene, total phenolic content and antioxidant activity, although samples encapsulated with MD showed decreasing values of these parameters as a results of a dilution effect due to the MD addition, and also the colour of the powders changed to lighter white-reddish with increasing concentration of MD. Shelf-life tests were carried out on the FD extract and 10%

MD encapsulated powders for 120 days at 10, 25 and 35 °C. Encapsulation allowed to preserve the colour of the tomato extract, presumably by avoiding non-enzymatic browning and oxidation of secondary metabolites. Lycopene stability was not significantly affected by encapsulation and showed a fast and almost complete decay during the first 20 days of storage. However, a significant stabilisation effect of maltodextrin was observed in terms of total phenolic preservation at 35 °C (minor losses at 10 and 25 °C), with maximum loss of 5-10% in encapsulated form, while 45% losses after 120 days were observed for non-encapsulated powders. Similarly, in-vitro antioxidant activity (FRAP) decreased at a higher rate in non-encapsulated tomato powders reaching around 70% losses after 60-120 days at all temperatures, while those encapsulated showed a loss of 20% after 120 days.

Nettle: The effect of different blanching thermal treatments was evaluated before extraction. Among the investigated conditions, blanching at 100 °C for 1 min was found to be sufficient to inactivate quality degradative endogenous enzymes such as PPO and POD, negatively affected the total phenolic content, antioxidant activity and Chlorophyll-b, while improved the extractability of Chlorophyll-a and carotenoids (Nallan et al., 2021). Nettle juice was freeze-dried in the absence or presence of maltodextrin (Neri et al., in preparation) in order to obtain amorphous powders with higher physical and chemical stability, although in this case, the freeze-dried raw nettle juice resulted in amorphous, free-flowing powder with a Tg of 44 °C (3% moisture content) probably due to the high content of high molecular weight compounds like celluloses and hemicelluloses. Addition of MD slightly increased the Tg to 52 °C with 5% MD. In terms of solubility, blanching had a negative effect on powder solubility (44%) while encapsulation in maltodextrin showed increasing solubility values with higher maltodextrin concentration. The encapsulation efficiency of chlorophylls ranged from 67% to 80% when 3 to 5% MD was added. MD had a protective effect on carotenoids and chlorophylls during freeze-drying. As concerns the powders' colour, blanching had a positive impact on the preservation of colour during extraction and drying as it preserved the bright green colour of nettle juice. Encapsulated powders showed a less intense green colour because of juice dilution and white colour of maltodextrin. Similarly, a shelf-life analysis of selected powders (non-encapsulated and 5% MD encapsulated) was carried out for 95 days at 5, 20, 35 and 50 °C and their tecno-functional and functional properties were evaluated, namely moisture sorption, solubility, colouring power and bioactive compounds i.e. chlorophylls, carotenoids, total phenolics (TPC) and antioxidant activity (FRAP). During storage, solubility, luminosity L*, hue angle, and FRAP remained constant and this occurred at all temperatures investigated. On the contrary, chroma (C*) and a* chromatic parameters were influenced by temperature of storage, showing at 50 °C a decrease of the former and an increase of the latter, resulting in a shift of color from green to green-yellow. The content of carotenoids and chlorophylls decreased during time depending on storage temperature with the order carotenoids > chlorophyll a > chlorophyll b. In particular, carotenoids and chlorophyll-α content remained constant at 4 and 22°C and decreased with a first order kinetic at 35 and 50°C. Chlorophyll-β content, instead, remained constant at all temperature excluding 50 °C at which decreased with first order kinetic.

Hop: Conventional extractions were carried out under dynamic maceration at 25 °C and 60 °C (CONV 25 °C; CONV 60 °C), while non-conventional extractions were performed using a laboratory bath (US), a high-power ultrasound bath (HPUS), and a high hydrostatic pressure (HHP) equipment (Santarelli et al, submitted, Santarelli et al., in preparation). Experimental results showed that extraction method, temperature, and time affect to a different extent the phenolic profile and have a significant effect ($p<0.05$) on the total phenolic content, total flavonoid content, antioxidant capacity (ABTS), chlorophylls, and total carotenoids content. Both the US and CONV 60 °C extractions led to the highest extraction of bioactive compounds. The highest content of AA and BA was found in HPUS and CONV 60 °C extracts, regardless of the extraction time. By comparing the volatile composition of the differently obtained hop extracts dynamic maceration (CONV 25 °C and CONV 60 °C) showed a higher selectivity towards sesquiterpenes, UAE (US and HPUS) towards esters and some monoterpenes, and HHP extraction towards humulene, β-pinene, α-ylangene, α-copaene, methyl-geranate and cis-Z- α-bisabolene epoxide. The pre-optimised extraction solvent (ethanol/water 50:50 v/v) and conditions i.e. ultrasounds (100 W, 50 KHz) treatment for 30' were thus exploit in order to evaluate and compare the functional and flavouring properties of different dried hop cones of different cultivars (Santarelli et al., in preparation) i.e. Cascade, Magnum, Opal, Herkules, Hallestauer, Mandarina Bavaria, Cascade and Perle (samples were provided by UNIKASSEL or purchased by local organic farmers). Results showed that Magnum and Herkules variety were those ones with the highest content of bioactive compounds and bitter acid content. Concentrated and free solvent hop extract (11 % moisture content) was produced by evaporation under vacuum (T= 45°C). The encapsulation of the hop extract was performed by freeze-drying, previous formulation with different carriers, i.e through the addition (+12 %) of maltodextrin (MD), arabic gum (AG), or MD in combination (ratio 1:1) with AG solutions. Results on the hop concentrated extract showed as this product has a very high content of bitter acids and a content of antioxidants. Results showed that the carrier materials influenced the moisture content, the a_w, the color and the coloring power of the powders while did not affect their solubility. All the powdered were amorphous at room temperature and showed sigmoidal WSI with those containing AG showing higher equilibrium moisture content than that formulated only with MD. The encapsulating agents differently affected the colour of the powders with samples containing AG showing the lowest L* and h° values or rather a darker and greenish colour, while the water solubility resulted equal (99 %) irrespective of the carrier used. A reduction of all the investigated parameters was observed after encapsulation. However, over storage at all the investigated temperatures, maltodextrin compared to arabic gum showed a higher protection towards bioactive compounds and antioxidant properties as a result of their highest encapsulation efficiency (94% vs 64%). The results of this task show how encapsulation with maltodextrin by freeze-drying, in particular for tomato and hop extracts, offers the possibility of obtaining high quality and stable powder extracts, offering a new opportunity to valorise and use these plants for the production of organic food products and nutraceuticals. Overall, these results showed that the selection of the cultivar and of the extraction method to use for the production of hop extracts must be selected on the basis of the desired sensory profile, functionalities and final destination.

Task 3.2: Powders from organic fruits and vegetables: The tomato by-products resulting from mechanical extraction of both blanched and non-blanched tomatoes (task 3.1), mainly peel, seeds and other fibrous tissue, were characterized for their techno-functional properties. Blanching resulted in higher lycopene extractability, as a consequence of thermal cell disruption. Powders obtained from oven-drying of tomato by-products showed a high content of lycopene, phenolic content and antioxidant activity, but poor solubility (22-24%). Residues resulting from the juice extraction from fresh and blanched nettle (task 3.1) were evaluated for their functional properties in terms of TPC, antioxidant activity (FRAP, TEAC), chlorophylls and carotenoids content before and after oven-drying. Dried samples showed a higher content of total phenolics and antioxidant activity compared to the wet sample (data of both dry and wet samples expressed in g of dry matter), while there were no significant differences in chlorophylls and carotenoids content. Blanched samples showed lower values of all parameters except for the antioxidant activity evaluated by the FRAP assay. Dried hop cones of different varieties (Cascade, Magnum, Opal, Herkules, Hallestauer, Mandarina Bavaria, Cascade and Perle) were processed to powders and evaluated for their potential usage as ingredients in organic formulated products based on their flavouring properties (volatile organic compounds, bitter acids), colour, content of antioxidant compounds (chlorophyll α and β, carotenoids, flavonoids and phenols) and antioxidant properties. Other analyses and/or methods were carried our by UASVM within the activity of the WP5. Overall, results highlighted that among the investigated cultivar, Magnum and Herkules varieties showed the highest content of secondary metabolites with antioxidant and antimicrobial activity such as polyphenols and α and β acids, and thus were particularly suitable for the production of ingredients/additive with technological functionality and potential healthy properties. Results showed that FD seaweed had slightly higher residual moisture and water activity than HPAD seaweed. With regard to moisture sorption, both seaweed powders showed similar sorption profile with a notably higher sorption under high relative moisture conditions (Aw > 0.65) reaching values of 67 g/100 g and 79 g/100 g for HPAD and FD, respectively, showing its extremely high hygroscopicity. Solubility of FD samples was slightly higher than HPAD (38% and 33%, respectively), as well as the swelling capacity (9.5 and 13.4 cm^3/g respectively). Similarly, FD samples showed superior water and oil holding capacity than HPAD powders. These results showed that the drying process applied had an impact on the techno-functional properties of the resuting seaweed powders, that in this case could be attributed to the highly intact and porous structure of the FD seaweed in comparison to the HPAD samples that underwent a drying process at higher temperatures that results in shrinking of the tissues and presumably chemical changes like Maillard reaction. In terms of bioactive properties like total phenolic content and antioxidant activity, HPAD samples showed slightly higher total phenolic content than FD samples, while the opposite was found for antioxidant activity (FRAP). Extraction of antioxidant compounds was performed using different solvents of extraction, resulting 30 % MeOH

(v/v) the best choice.
The results of these tasks are under publication and are reported in detail in documents uploaded on the organic eprint archive with restricted access.
B- fulfilment of objectives:
All deliverables and milestones of task 3.1 and 3.2 were fulfilled; some delays were experienced due to the covid19 emergency, which was responsible for some scheduling rearrangements.

3.1.4 WP4

WP4	*Application of the natural additives and colourants, and development of innovative organic products*

WP leader: UNITUS
Responsible partners: UNITE, UNIKASSEL and UASVM

Overall summary of main results, discussion, and conclusions of WP4
The WP4 investigated the feasibility of application of natural additives and colourants for development of innovative dried and/or formulated organic products for the market.
In the preliminary task, value-added natural additives (green tea extracts, GTE and trehalose, T) were used for dried foods with blanching (B) and vacuum impregnation (VI) as pre-treatments. The objective was to evaluate the effects of pre-treatments (B, VE) and additives (GTE, T) on the drying characteristics and quality of dried carrot (*Daucus carota* L. var. Romance) slices. The optimal combinations were identified based on the results of physico-chemical analyses and functional properties. For the product development task, suitable vegetal matrices for organic and value-added additives production were identified based on literature study and internal committee discussions. Three vegetal matrices identified for development of value-added innovative products were: stinging nettles (*Urtica dioica* L.), tomato (*Lycpersicon esculentus* L. var 'pera d'abruzzo) and hops (*Humulus lupulus* L.).
The second task was to benchmark the innovative products, and subsequently an online consumer survey was conducted to evaluate the perception and knowledge of consumers on functional foods and food preferences. This survey was conducted across EU nations with a total of 310 voluntary respondents, majorly Italians of ages 18-75 years. The questions were of variable scales and the responses were collected anonymously with strict adherence to EU privacy policies. Also, food choices among frequently available and consumed sweet and savoury snacks (cereal bars, yoghurts, crackers, and chips) were identified. Based on the results 'crackers' (savoury snacks segment) with low or no added salt were chosen to be developed with the addition of organic additives from WP3.
Prior to development of innovative products considering the technological gaps in use of nettle additives, an additional study in strict collaboration with UNITE (WP3) was conducted to develop and characterize nettle leaf powders utilizing different pre-processing and processing conditions. For this sub-task, nettle leaves both wild and commercially cultivated were chosen and subjected to two different drying conditions, convection and freeze-drying with or without blanching to give a total of 8 different nettle powders. Subsequently the powders were characterized for physico-chemical, technological, and functional characteristics to identify the eventual formulations (Nallan et al., submitted).
For the task 'development of innovative products', initially nettle powders and nettle extracts (provided by UNITE) crackers were developed using wheat flour, water, and yeast in collaboration with a local bakery (Forno Mari, Italy) without salt in conjunction to the consumer survey. A total of 12 formulations for nettles and 2 formulations for tomato and hop extracts were developed and tested, respectively. Further, the products were analysed for physico-chemical analysis and sensorial evaluation in strict collaboration with USVAM for screening, evaluating responses, and identifying the optimal formulations (based on nettles, tomatoes, and hops) for the market. Finally based on the sensory analysis results from UASVM (WP5) and physico-chemical analysis (UNITUS and UASVM) a total of 4 formulations for nettle crackers and 1 formulation for tomato crackers were chosen as optimal products for market placement.

Report on the results obtained (A), and fulfilment of objectives (B) comparing to the original project proposal
A- results obtained and structured in relation to the user groups they are relevant for:
The objectives of the WP4 were application of value-added natural additives/colourants developed by

WP3 as functional/ nutritional ingredients for (1) selected organic dried food stuffs and (2) the development of innovative organic foods.

Task 4.1: Test for the developed value-added natural additives and colourants: In this task green tea extracts as herbal ingredient and trehalose as a protectant were used as functional ingredients to improve the nutritional and overall quality of selected dried vegetable, carrots (Moscetti et al., 2019, Santarelli et al., 2021). For this purpose, carrot slices (*Daucus carota* L. var. Romance) were blanched in water or trehalose solution and subjected to vacuum impregnation with green tea extract solutions with or without trehalose prior to hot air drying. The fresh and dried samples were evaluated for physico-chemical (moisture, colour, texture, sugars) and bio-active (carotenoids, phenols, antioxidants) characteristics. The use of pre-treatments improved the drying rates of carrot slices from 2.25 to 3.38 g H_2O g DW^{-1} initially but did not affect the total drying time (8.5 h). The green tea extract vacuum impregnation improved the functional properties i.e., carotenoids, polyphenols, and antioxidant activities of dried carrot slices up to 3 times compared to the non-treated carrot slices. The use of trehalose was found to be beneficial during blanching and drying as it exerted protective effects by reducing the cellular damage during processing thereby better retaining the functional compounds. Optimal processing combinations for enriched dried carrots were identified to be trehalose blanching and green tea extracts impregnation.

Task 4.2: Development of innovative organic foods: The objective of this task was to (1) benchmark innovative organic products and (2) formulate innovative functional/ enriched organic products. An additional task (2.0) was carried out for development and characterization of nettle additives.

(1) Benchmarking of innovative organic products: This task focused on identification and comparison of innovative organic products by preliminary panel discussions, market-based consumer survey for food and purchase preferences and sensory evaluation feedback from WP5. In the panel discussions low water activity solid products like pasta, crackers and biscuits were proposed owing to their general storability and adaptable sensorial quality characteristics. In the survey a total of 310 voluntary respondents were questioned for their food product and purchase preferences for both sweet and savoury snack segments. The survey results showed good demographic distribution (18-75 years, 57 % females and 43 % males) with 60 % of urban living. and more than 54 % of them positively perceiving the important role of functional foods in diets. Of these, more than 50 % respondents highly preferred organic functional foods in snack forms, particularly savoury crackers with a strong preference for products without salt or added sugar. Additionally, more than 60 % respondents were willing to pay about 10 -15 % price margins more than a conventional product which is an incentive to the industry. These observations contributed to the understanding of consumer perceptions and were used as basis for identification of a **snack i.e, cracker** for enrichment. Finally, the sensory evaluation of the products was used as a second benchmark to select optimal formulations and reformulate to meet the consumer expectations of the products.

(2) Formulation of innovative organic products: This task aimed for the development of innovative organic products that are enriched with additives (powders, extracts) developed in WP3 as well as the additional task 2.0 to improve the nutritional as well as health-promoting characteristics of selected products.

For the additional task (2.0), wild and commercial (supplied by Vita Natural gel, Italy) stinging nettle (*Urtica dioica* L.) leaves were transformed to storable, low-cost functional additives (powders and extracts (*Figure 1*) to be used in bakery products. For the preparation of nettle powders (NPs), Convective drying (CD) at 40 °C for 12-14 h and freeze-drying (FD) at -50°C for 48-96 h were applied on unblanched (U) or blanched (at 90°C for 1 min, B) leaves, which were milled to give four types of powders (UCD, UFD, BCD and BFD). The obtained NPs were evaluated for selected physicochemical (moisture, colour), techno-functional (flow indices, hygroscopicity), phytochemical (pigments, phenols) characteristics and mineral contents. Similar results were observed for both wild and commercial nettle powders with both pre-treatment and drying methods affecting the NP characteristics. The product yields ranged from 10- 20 % (w/w) with moisture between 3 – 10 % and water holding capacity at 5 – 7 g/ g NP. The colorimetric parameters, particularly higher hue (h) and lower colour difference (ΔE*) were observed in blanching and freeze-drying powders indicative of higher bio-active components. For the wild NPs, blanching pre-treatment reduced the oxidative degradation of pigments during drying (Chlorophyll a - 549.50 ± 163.0, Chlorophyll b - 214.91 ± 58.34 and total carotenoids - 152.55 ± 44.48 mg 100g-1 NP, dry weight); but caused loss of phenolic compounds, reduction of antioxidant activity and potassium content. As for drying method, CD resulted in better flow properties while FD influenced positively colour, pigments, magnesium content (2.81 mg g-1 NP, dry weight), phenolic (9.08-16.72 mg GAE g-1 NP, dry weight) and antioxidant

parameters (FRAP-2.62- 4.40 mM TEAC g-1 NP, dry weight; ABTS-3.40-6.66 mM TEAC g-1 NP, dry weight). Overall, the evaluated processing methods resulted in different technological properties that allowed for better evaluation of NPs as a food additive or ingredient of which blanched and freeze-dried powders were selected as enriching additive owing to higher bio-active components. As for the extracts, principally two types of nettle extracts (NEs) were received from WP3, non-encapsulated freeze-dried (NFD) and maltodextrin encapsulated freeze-dried (MFD) extracts and evaluated for technological quality characteristics. In particular, the blanching, freeze-drying and encapsulation treatments in MFD extracts showed positive effects particularly on the values of chlorophyll a and b, total carotenoids, and total polyphenols with values of 259.4 mg/100 g, 71.29 mg/100 g, 105.83 mg/100 g, and 235.01 mg GA/ 100 g, although a minimal dilution effect of maltodextrins was observed. A total of **6 additives** (**4 NPs** and **2 NEs** from commercial nettles (*Figure 1*) were obtained.
As for the final task of developing functional and organic foods, unsalted, leavened wheat flour crackers as a savoury snack of bakery category based on results of task 4.2.1 were developed using nettle, tomato and hop additives. For nettle additive added products (Nallan et al., in preparation), briefly, two types of additives NPs and NEs were used at 3 and 5 % (w/w) wheat flour substitution levels for cracker preparation (*Figure 1*). The crackers along with a control formulation were subjected to analysis of physico-chemical (moisture, colour, texture) and functional characteristics (chlorophylls, carotenoids, total phenols, and antioxidants), while the sensorial characterization and additional analyses were conducted in strict collaboration with WP5 (USAVM).

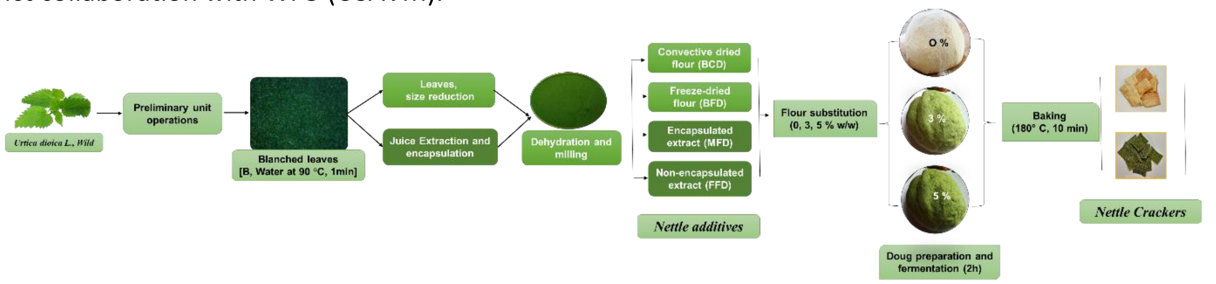

Figure 1. Schematic of nettle additives (Flours – BCD, BFD; Extracts – FFD, MFD) preparation and their subsequent use for production of crackers at 3 and 5 % w/w flour substitution.

A total of 12 different formulations were screened of which 4 formulations at 5% w/w flour substitution using BCD, BFD powders and NFD, MFD extracts were selected as optimized products for market placement (*Figure 2*). In general, the selected products showed an increase in bioactive components (chlorophylls, Chl a/ b; total carotenoids, TC; total phenols, TPC) as expected without detrimental effects on product texture. Particularly, crackers with BFD and MFD had significantly higher bioactive contents (ANOVA, $\alpha \leqslant 0.05$) with values ranging from 7.25-11.85 mg, 1.91-3.93 mg, 2.30-3.24 mg, and 17.17-19.57 mg GAE compared to 0.05 mg, 0.05 mg, 0.12 mg, and 2.71 mg GAE of Chl a, Chl b, TC and TPC for 100g of control product, respectively. Based on the sensorial results, the products of the second batch were reformulated with addition of salt and oil. The results obtained showed potential of processed nettles as a platform to promote localized production and use of under-utilized crops to improve the nutritional and functional characteristics of conventional food products.

Figure 2. Selected Nettle cracker formulations (at 5 % w/w substitution) Flours: BCD5, BFD5; Extracts: FFD5, MFD5.


Figure 3. Tomato and hop enriched Crackers at 5 % w/w substitution of wheat flour.

Based on the previous experiments and initial screening, tomato and hop encapsulated extracts (WP3) were used at 5% w/w substitution of wheat flour for preparation of salted crackers (*Figure 3*). The moisture content of all the products was lower than 10 % and the addition of extracts decreased the water retention with water activity lower than 0.60, i.e. within safe limits. The colour differences were perceptible in tomato extracts due to the red hues whereas, hops had only a slightly perceptible change due to low colouring properties. The thickness of samples was variable owing to the differential baking and tomato extracts prevented cracker puffing. The deformation in tomato crackers though higher was rated positively and ranked as the best product for sensory evaluation. As for hop based products the evaluation was lower than the threshold of consumer liking and is reformulated to be re-destined for a niche market.

B- fulfilment of objectives:

All deliverables and milestones were fulfilled; some delays were experienced due to the covid19 emergency, which was responsible for some scheduling rearrangements.

3.1.5. WP5

WP5	*Quality and sensory assessment and evaluation*
WP leader: UASVM **Responsible partners:** UNITUS, UNITE, UNIKASSEL, SLU, SINTEF	
Overall summary of main results, discussion and conclusions of WP5 The objectives of WP5 was to evaluate and assess the quality and sensory parameters of dried products (WPs1-2), of natural extracts/colourants (WP3) and innovative organic products (WP4) in order to assess the benefits of the smart process control in comparison to classical approaches, the benefits of the developed additives and colourants on shelf-life, nutritional and nutraceutical performance as well as consumer evaluation of the products. During the project the partners determined the physicochemical, nutritional, sensorial and shelf life characterisation of fresh and processed organic fruits and vegetable: apples (Gala, Golden, Red Prince and Pink Lady varieties), tomatoes (Red Cherry, Red Peach, Roman Speckled, Tigrella, Red Cherry, Golden Jubilee, Coeur de boeuf, Cher Ami varieties), raspberries (cv. Heritage), nettles, hops (Super alpha, Perle, Magnum, Herkules, Mandarina Bavaria, Hallertauer Tradition, Opal varieties) and aromatic varieties (dill and basil), as well as the quality of natural extracts/colourants from such raw materials. The physico-chemical analyses used for investigation of quality assessments was appropriate to sample analysed: firmness (penetrometer 53200), moisture content (MAC 50 PARTNER moisture analyzer), titratable acidity (AOAC 942.15), soluble solid content as °Brix (DR301-95 Digital Handheld Refractometer), colour (HunterLab MiniScanTM XE Plus colorimeter and the parameters were expressed in CIE L*a*b* system), vitamin C by HPLC, carotenoids and anthocyanins by spectrophotometric method and UPLC technique, total phenolic content by the spectrophotometric method (Folin-Ciocalteu test), antioxidant activity by DPPH method, α- and β-acids from hops by UPLC (EBC method 7.7) and volatiles by GC-MS. The results indicate that higher contents of quality parameters and bioactive compounds can occur depending on the applied drying processes and the raw material variety. Innovative organic product formulations enriched with natural ingredients and additives were developed by UASMV (Research Center for Studies of Food Quality and Agricultural Products) together with the UNITUS and the UNITE, and sensory analysis (the preferences test and an internal panel of trained evaluators) was applied to these products. Dried nettles, dill, tomatoes, hops, raspberries and apples in powder form with increased nutritional value were used as natural additives. The innovative organic products developed and evaluated in the sensory study were: crackers with nettle flour, tomato and hops extract (by UNITUS, UNITE), dill grissini, tomato pasta, yogurt enriched with raspberries and apple biscuits (by UASVM). Sensory quality of the developed products was evaluated by the intensity of smell, taste and aftertaste attributes. Acceptance and preference tests showed a perceptible influence of natural ingredients in the sensory quality of organic processed products depending on their concentration. Development and production of such products represents a great potential for value addition to raw materials of high product quality and thus, generating new income possibilities for producers and processors. These innovative products and formulations will help to open new markets for the stakeholders in the organic sector.	
Report on the results obtained (A), and fulfilment of objectives (B) comparing to the original project proposal **Task 5.1 Quality assessment:** The influence of the drying method on the quality and biochemical of organic apples was evaluated (Bantle et al., submitted). For this, organic Pink Lady apples (WPs1-2) were dried by SINTEF in three different vacuum freeze drying systems and with two different convective air drying concepts. The ascorbic acid content was strongly influence by the heat transfer method in vacuum freeze drying. The analyse of 13 polyphenols identified in all samples groups shows statistically significant differences for most of the polyphenols, while the flavonoids content was not influenced significantly by the different processing methods. Some of the observed quality effects indicate that a short processing time might be beneficial, while the processing conditions have a minor influence. The results indicate that	

an increased thermal stress to the product (either by higher air temperature or microwave application) does not reduce the product quality with respect to biochemistry as long as the product temperature is controlled. Additionally, acid treatments prior to drying were obtained to preserve discoloration throughout the drying process and drying temperatures should be chosen with regard to the apple cultivar used (Shrestha et al., 2020).

The nutritional quality parameters of the fresh tomato varieties (UASMV) cultivated in organic system revealed variety-dependent characteristics (Badulescu 2018). Red Cherry, Red Peach and Roman Speckled varieties have high pigments content (carotenes, lycopene), while the variety of the yellow one Citrina registered a small amount of carotenes, because of its high flavonoids content. Coeur de boeuf, Cher Ami, Red Cherry, Red Peach and Roman Speckled varieties, even Tigrella, could be recommended for processing, due to their high content of pigments, dry matter and total soluble solids. The analysis of organic tomatoes dried at 40°C (6 h) and 70 °C (3 h) with / without blanching at 95 °C, processed into powders or not, revealed that the total carotenoid content in blanched samples appears in lower concentrations than in unblanched (Bujor et al., 2019). By contrast, the total lycopene content is present in extremely higher amounts in blanched tomato powders and this could result from the oxidative degradation of lycopene in unblanched tomatoes during long drying. Antioxidant activity determined by DPPH method (% scavenging) was higher in Tigrella and Coeur de boeuf varieties, depending slightly the drying temperature. Tomatoes (cv Pera D'Abruzzo) made of freeze-dried and encapsulated powders, and dried residues were developed (UNITE, WP3) and investigated for their technological functionality. Compared to the freeze-dried extract, the encapsulated extract showed a lower content of phenolic compounds, flavonoids, single carotenoids and, consequently, a lower antioxidant capacity. This result is because of the dilution effect due to the addition of the encapsulating agent (maltodextrin DE 8-10) to the tomato extract. As regards dried tomato residues, the blanching pre-treatment positively affected the content of ascorbic acid and carotenoids while impaired the content of phenolic compounds, flavonoids and the antioxidant activity.

Raspberry fruits: Freeze drying was more effective in extraction of anthocyanins of organic raspberry (cv. Heritage) than hot-air drying (Badulescu et al., 2019). Processing such as milling before drying resulted in higher anthocyanin contents. Given these results, organic raspberries are valuable raw material for the development of innovative natural pigments. Cyanidin-3-O-sophoroside was the most abundant anthocyanin in raspberries.

Hops (Perle, Magnum, Herkules, Mandarina Bavaria, Hallertauer Tradition and Opal varieties) made of freeze-dried and encapsulated powders were developed (UNITES, WP3) and investigated for their functional parameters (color, Chlorophyll a, Chlorophyll b, total chlorophyll, total phenolic content, total flavonoid, antioxidant activity, α and β acids content minerals and contaminants). Magnum hop presented the highest total phenolic content and total flavonoid content. A significant antioxidant activity was determined for Perle, Hallestauer Tradition and Opal hops. All hop varieties contain both α-acids (humulones) and β-acids (lupulones), the former being predominant. Magnum and Herkules hop showed the highest α-acids content. It has further been observed that the storage time before drying impacts the valuable compounds negatively (Raut et al., 2020a) and the bulk properties need to be set proper to achieve the highest quality (Raut et al., 2020b).

Stinging nettle (*Urtica dioica* L.) provides a great quantity of bioactive compounds (polyphenols, flavonoids, vitamins) and minerals needed to maintain human health. Freeze-drying technique is most used nettle drying method because preserve better the nutrient quality and it is used especially for medicinal purposes such as production of encapsulated nettle products. Due to increased nutrient content, these natural products with high value are required more and more by industry and consumers. Nettles (UASMV) obtained from spontaneous flora, from a non-polluted village area of Cuca (Arges, Romania) were processed by freeze-drying at -55°C temperature. The average mass loss due to freeze-drying for the nettles was 84.36 %. All bioactive compounds increased in concentration for freeze-dried organic nettle except for ascorbic acid. Ascorbic acid content decreased with about 30% compared to fresh nettle. The total chlorophyll content increased from 65.6 mg / 100 g DM in fresh stinging nettle to 73.4 mg / 100 g DM in freeze-dried nettle, despite the decrease of Chlorophyll b content with 14.14% in freeze-dried samples. Nettle samples showed high content of Ca, K, Mg, Na, Fe. Based on the results obtained, it can be concluded that freeze-drying is a good process to obtained nettle product with high added value. Nettle powders made of freeze-dried nettle extract, freeze-drying encapsulated nettle extract, and dried extraction residue were developed (UNITE, WP3) and investigated for their technological functionality. Quality attributes such as color, total phenolic content, total flavonoid, antioxidant activity, carotenoids, minerals and contaminants content were evaluated. The encapsulated nettle extract compared to the freeze-dried extract showed a lower moisture content, a lower content of chlorophylls and of phenolic compounds, while the content of flavonoids and the antioxidant activity were higher. As concerns the powder made of dried extraction residue, it showed a content of chlorophylls similar to the freeze-dried extract while the content of phenolic compounds and flavonoids was higher.

Dill (*Anethum graveolens*) is an annual plant native to the Mediterranean region, cultivated in al over the world. It is known that α-phellandrene, the main constituent of dill aroma, greatly contributes to the sensory traits of dill. Dill also contains antioxidant phenolic and flavonoid compounds and pigments. The stems of organic dill purchased from Vegetables Research and Development Station of Buzau (UASMV) at commercial maturity in September 2019 were processed by drying, using freeze-drying technologies, at a temperature of -55 C, and further milled in order to obtain a fine powder which can successfully be used as food additives. After freeze-drying the samples reached a 71 % loss from the fresh weigh, with a final dry matter content of 98.14 %. The extraction ratio for stem volatile oil was 0.067% w/w for fresh stems and 0.158% w/w for dried powdered stems. The main volatile oil constituents identified in both fresh stems and freeze-dried stem powder were: α-phellandrene, β-phellandrene, and dill ether. Major variation in the composition of volatile oils of freeze-dried stems was identified after the processing compared with the fresh stems. A decrease of α-phellandrene with more than 50% was observed in the stem freeze-dried powders. In contrast, the dill ether composition increased with more than 38% in the stem powders.

Common basil (*Ocimum basilicum* L.), one of the most important aromatic perennial herbs due to its essential oil composition, belongs to *Lamiaceae (Labiatae*) family. Basil is an economically important herb and it is considered one of the finest aromatic herbs, being widely used as flavor in food industry. Basil samples (UASMV) were characterized in terms of chlorophyll content, total polyphenols, antioxidant activity, and volatile oil content. The fresh harvested leaves and the processed powder from leaves were hydro-distilled for 3 h in a Clevenger-type apparatus. The volatile oil was measured and collected for further GC-MS analysis. As drying technology, freeze-drying was used until the samples reached a loss of 85% from the fresh weigh, with the final dry matter content of 95.86%. Variations for the main constituents of volatile oil: 1,8-cineole, linalool, methyl chavicol, eugenol, α-bergamotene, and α-epi-cadinol were observed after processing.

Task 5.2 Sensory assessment: The sensory quality and parameters of the developed innovative organic products (UNITUS, WP4: tomato, hop and nettle flour crackers; UASMV: dill grissini, tomato pasta, yogurt enriched with raspberries and apple macaroons) were evaluated by the intensity of smell, taste and aftertaste attributes. For tomato, hop, nettle flour crackers, the preferences test using the simultaneous-comparative presentation was performed by 40 evaluators. The organic nettle crackers were higher appreciated for crunchy and pleasant taste with a slight herbal aroma and further work will continue to improve the sensorial parameters such as the appearance, the taste and the texture. Natural ingredient with the greatest influence in acceptance and preference of the organic processed products was freeze-dried encapsulated hop extract at 3% submission, even if didn't cross the acceptance threshold due to the bitter taste that wasn't on the Romanian consumers taste. Romanian consumers involved in sensory analysis ranked control crackers as first for their neutral taste and tomato crackers for their color. Regarding the quality assement, the incorporation of tomato and hop extracts improved the total phenolic content of the crackers but did not increase the DPPH antioxidant activity. The freeze-drying and the addition of maltodextrin improved the total phenolic content and the antioxidant activity.

For dill grissini, tomato pasta, raspberries yogurt and apple macaroons a specific sensory analysis was performed by an internal panel of ten trained evaluators. All products were presented sequentially monadic and in a balanced block with same sensory descriptors set to highlighting the differences in sensory perception between products. Obtained results shown that the new formulated organic products presented an intense perception for each attribute considered relevant in sensory quality discrimination of the tested products. Sensory analysis tests showed a perceptible influence of natural additives in the sensory quality of innovative organic products depending on their concentration. Quality characteristics of these products suggest that by incorporating natural extracts or powders, it can be possible to enhance functional parameters like colour, bioactive content and antioxidant activity of the developed innovative organic products.

Task 5.4 Data information fusion: Despite of the development of innovative organic products was finalized with only 2 months of delay (from 33 to 35), the entire activity was affected by (i) multiple quarantine periods (in Italy) and (ii) the restricted access to the UNITUS laboratories due to the covid19 outbreak. Consequently, the timeline of both the sensory analysis and the related reports was also affected. Finally, a tentative data-fusion approach at a low-level was tested by merging in a single matrix all chemical, physical and physico-chemical data from UNITUS and sensory data from UASVM. Both PCA and t-SNE analyses were computed but the results obtained did not evidenced any specific pattern among samples. Probably, mid-level or a high-level data-fusion approach should be further investigated.

B- fulfilment of objectives:

The objectives of the WP5 were integral fulfilled through the activities carried out within the project

3.1.6 WP6

WP6	*Value chain integration, Life Cycle assessment (LCA) and Life Cycle Cost analysis (LCCA)*

WP leader: Girma Gebresenbet

Responsible partners: SINTEF, UNITUS, & UNI KASSEL

Overall summary of main results, discussion and conclusions of WP6

The objective of WP6 was to assess and evaluate the selected organic food value chains using the approaches of integrated value chain management, LCA, and LCCA in terms of resource efficiency, through minimizing losses in the primary production and processing, and increase of energy efficiency during organic food processing taking into consideration organic additives. It aimed also to facilitate the extension of the database of SusOrganic project. In order to achieve these objectives, organic apple, carrot, pasta, and cracker products have been studied. In general, 8 value chains: organic dried apple (using conventional and Heat Pump assisted drying method); Dried organic carrot (without and with green tee as additives); Organic pasta value chain (without and with organic tomato as additives); Organic cracker value chain (without and with nettle powder as additive) value chains have been investigated.

Value chain analysis (VCA) was carried out to assess the 4 selected product value chains mentioned above. The main activities and material flows in each value chain have been mapped out in the VCA study have been used as basis for LCA and LCCA studies. The role of resource efficient food processing such as Heat Pump (HP) assisted drying and introduction of organic additives has been synthesized based on results of LCA and LCCA and discussed from sustainable organic food production and processing point of view. The VCA studied identified major constraints along value chains and opportunities for future improvement and further development of the organic food products under consideration.

The standardized LCA study assessed the environmental impacts of the 8 organic food value chains described above. The LCA was conducted with in a defined scope i.e. from agricultural production up to consumer gate. However, the focus was on processing stage of organic food with and without organic additives. For dried organic apple and carrot cases, 1 ton fresh product at farm gate was considered as functional unit (FU). This enabled to discuss the environmental impacts (life cycle impact assessment results) of dried apple and carrots in comparison to the impacts of fresh apple and carrots (Bosona, 2021) as reported widely in previous studies including SusOrganic project. For organic pasta and cracker 1 ton dry pasta and 1kg cracker were used. In this LCA study, energy efficiency was assessed using cumulative energy demand (CED) approach which converts all energy inputs from different sources along the value chain into primary energy and quantifies it. Other impact categories included in the analyses were Global Warming Potential, Terrestrial Acidification, and Eutrophication.

The LCCA study has assessed the costs along the 8 value chains considering main stages (agricultural production, post-harvest handling and processing, and transport). The life cycle cost inventories were carried out based on the scope and functional unit described in the case of LCA. The life cycle costs have been quantified and presented in Euro per functional unit i.e. Euro per 1 ton of fresh apple and carrot at farm gate, 1 ton of dry pasta at consumer gate, and 1 kg cracker at consumer gate. In all cases, LCC values were determined using year 2020 as base year.

Data compiled from life cycle inventory and results of environmental life cycle impact assessment (LCIA) and

LCCA have been used to develop a Database for future use of similar environmental and economic performance evaluation of organic food value chains. The database includes the quantified environmental impacts of the 8 food value chains described above. Similarly, LCC data related to the same 8 food value chains have been quantified at the major life cycle stages and documented and compiled in excel based digital files with a brief user manual. For dried apple and carrot, the current data base was developed using database of SusOrganic project as a basis. For organic pasta and cracker new database has been created.

Report on the results obtained (A), and fulfilment of objectives (B) comparing to the original project proposal

A results obtained and structured in relation to the user groups they are relevant for:

The results from integrated studies (VCA (Task 6.1), LCA (6.3) and LCCA (6.3)) enables to understand the value chain characteristics of selected organic food value chains (dried organic apple and carrot, organic pasta, and organic cracker from wheat). VCA results indicated that organic food production and consumers demand have been increased. Improvements in organic food processing techniques (with efficient resource use and reduced food loss and waste) and secure supply chains are being introduced which in turn increase the sustainability of organic food value chains.

From results of LCA study, the total CED value of dried apple was reduced from 7.29 GJ (conventional drying) to 5.12 GJ per functional unit (HP-assisted drying) due to the increase in energy efficiency in the later case. Regarding emission, it was reduced from 130 kg CO2 eq to 120 kg CO2 eq respectively (see Figures 1 and 2). In dried carrot case, the total CED value was increased from 6.77 GJ (without additive) to 12.81 GJ (with green tee) per functional unit due to additional energy use for production and supply of additive whereas the emission was increased from 122 kg CO2 eq to 633 kg CO2 eq per functional unit respectively.

Regarding organic pasta, the CED values were found to be 8.86 GJ and 42.30 GJ for pasta without and with additive respectively whereas, the emission values were about 580 kg CO2 eq and 889 kg CO2 eq respectively. In case of organic pasta with tomato additive, the energy consumption and emission values were highly increased due to the fact that greenhouse based tomato production was considered which is energy intensive. For organic cracker without additive and with additive, CED values of 12.51 GJ and 13.72 GJ per 1 t of cracker were found while the emission values were determined to be about 379 kg CO2 eq and 464 kg CO2 eq per 1 t of cracker. The LCIA results also indicated that HP-assisted apple drying method reduced the acidification and eutrophication impacts while the organic additives could increase the acidification and eutrophication impacts in the carrot, pasta, and cracker value chains.

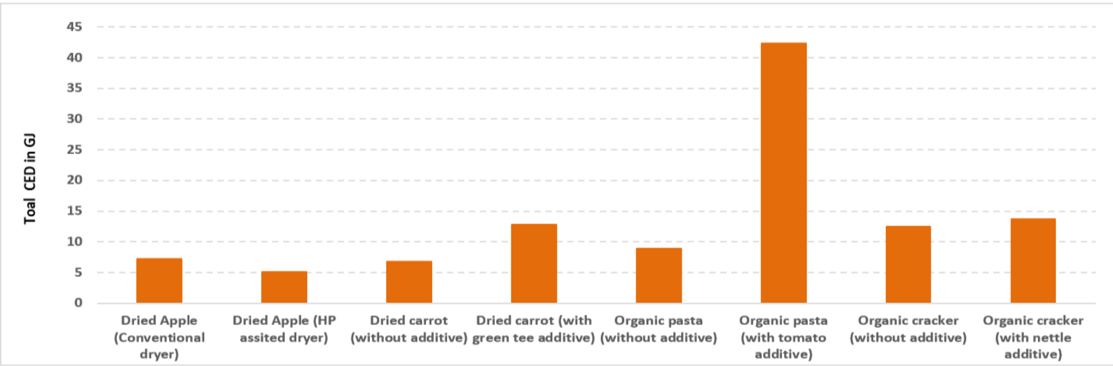

Figure 1. Summary of total CED values for different organic value chains under consideration. The values are in GJ per FU (for apple, carrot, and pasta) and GJ per kFU (i.e. per 1 t of cracker instead of 1kg).

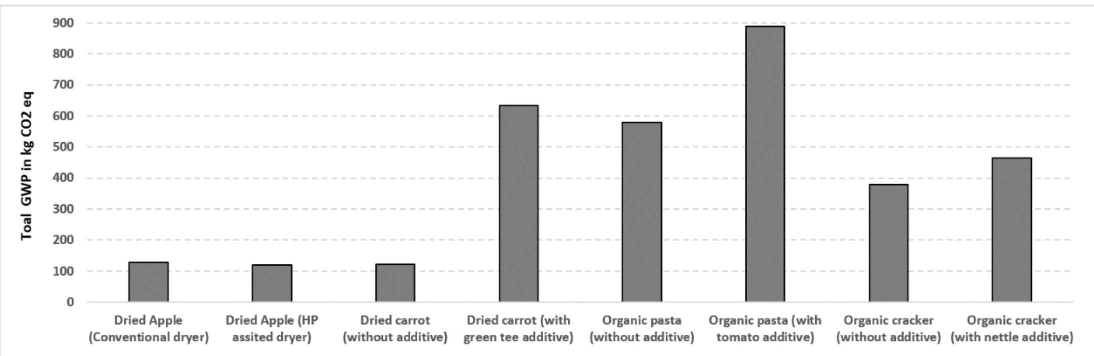

Figure 2. Summary of total GWP_{100} values for different organic value chains under consideration. The values are in kg CO2 eq per FU (for apple, carrot, and pasta) and kg CO2 eq per kFU (i.e. per 1 t of cracker instead of 1kg).

From LCCA study, the HP-assisted apple drying method has reduced the cost by about 1.2% due to reduced energy consumption (see Table 1). In the case of other products such as dried carrot, organic pasta and cracker, the cost was increased in cases of value chain with additives when compared to products without additives (See Table 1). However, the economic value of the products with organic additives is higher than products without additives that could lead to economic benefit for food producers.

In general, the results of environmental impact and cost assessments indicated that the introduction of additives could increase the negative environmental impacts and incur more costs. Therefore, other aspects such as food quality and health benefits as well as economic benefits (increased selling prices) should be considered during decision making.

Table 1: Summary of LCCA result

Product value chain	Unit	Total LCC
Dried Apple (Conventional dryer)	€/FU	2862
Dried Apple (HP assisted dryer)	€/FU	2828
Dried carrot (without additive)	€/FU	1380
Dried carrot (with green tee additive)	€/FU	2529
Organic pasta (without additive)	€/FU	1402
Organic pasta (with tomato additive)	€/FU	3307
Organic cracker (without additive)*	€/kFU	2353
Organic cracker (with nettle additive)	€/kFU	3444

*-for organic cracker, FU is 1kg; kFU= 1t cracker

B- fulfilment of objectives:

Based on the objectives of WP6, dried organic apple, dried organic carrot, organic pasta, and organic cracker were assessed using different methods. Accordingly, the following major studies have been carried out and reported in 4 deliverables: Value chain analysis (D6.1); Environmental impact assessment (D6.2); Life cycle cost assessment (D6.3); and Database for environmental impact assessment and cost implication (D6.4). In addition, as part of training activities, WP6 has involved students (3 completed and 2 in progress MSc Theses).

3.1.7 WP7

WP7	*Development of smart processing chains*

WP leader: UNITE

Responsible partners: All

Overall summary of main results, discussion and conclusions of WP7*)*

Objective of this WP is to co-design all elements of the dissemination of the project with the relevant stakeholders, i.e. farmers and food processors, researchers, equipment manufacturing, professionals and students. In order to enlarge the potential impact of the project for the future, students are also planned to be involved in the scientific work and events/exchanges. Overall all the activities under the different tasks have been carried out according to the plans with all the main limits imposed by the COVID-19 pandemic starting from February 2020 that severely affected all the “in presence” dissemination events and students exchange among the partners.

The following activities have been carried out: Stakeholder Engagement, student involvement, articles and publications, dissemination events, seminars and training events organised by the partners, virtual dissemination tools and social media:

1. Website and logo: these two main dissemination tools were developed at the beginning of the project. A dedicated website has been set up (https://www.susorgplus.eu/) and regularly updated, containing all

the relevant information on the project and its activities. An intranet section has been also set to upload information and other documents of interest only to the partners; this section is currently under renewal to upload the deliverables and all the dissemination activities, thesis made by students, events to avoid external database sheets.
2. As regards the social media, at the first project meeting partners agreed to not invest time and resources in managing both social and professional virtual networking tools (e.g. Facebook, LinkedIn, ResearchGate) but to use the personal or institutional ones to disseminate events and publications to get profit of existing pages and profiles of the partners. The setting of new ones, actually, could be rather time consuming and requires a main effort to keep it alive and active.
Overall by the different dissemination activities we managed to organise:
- contributions to dissemination events: 91
- scientific and technical publications: 25
- Training events: 5
- webinars/seminars: 6
- Students involved: 15

By the webinars and online training events, the project partners were able to disseminate the results of the project and to transfer knowledge about processing of organic raw materials to the already set stakeholders, namely: farmers and food producers, equipment/plant producers, professionals/consultants, students, researchers and academics.
Each partner at national level has developed a good dissemination activity, also by the organisation of the seminars and trainings and allowed a proper knowledge of the project in general; by the scientific publications in international journals and the presentations (oral and poster) at scientific conferences, it was possible to disseminate the new knowledge that has been developed within the project.

Report on the results obtained (A), changes to the original plan/ WP aims (B) and fulfilment of objectives (C)

A- results obtained
Task 7.1 Stakeholder Engagement: A new core stakeholder community made of processors, associations, policy makers including those already involved in the network built in SusOrganic (e.g. Bioland, LfL Bayern, FibL, AIAB, IFA, BNN etc.) has been created. This community has been engaged in the dissemination, knowledge transfer and in the development and scaling up of the planned project activities including the webinars and online training events.
Task 7.2 Student involvement: 15 Students of all levels of the partners` universities have been involved in the development of the project activities and corresponding reports and theses.
Task 7.3 Articles and publications:
a. 16 scientific articles have been published in high impact peer reviewed journals and via http://www.orgprints.org, some of them also as results of collaborative activities between the partners. Several are under submission.
b. 8 stakeholder-oriented technical articles have been written submitted for publication to associations, journals and magazines of national and EU/international impact.
News and short contributions for the newsletter of the COREORGANIC have been prepared by all partners.
Task 7.4 Partners contributed with 91 presentations to events. The number is rather significant as COVID-19 reduced the attendance to scientific conferences with oral and poster presentations due to cancellation or postponement of events and fairs to dates beyond the end of the project.
Task 7.5 Virtual dissemination tools and social media:
- project website: A dedicated website has been set up (https://www.susorgplus.eu/) and regularly updated, containing all the relevant information on the project and its activities. An intranet section has been also set to upload information and other documents of interest only to the partners; this section is currently under renewal to upload the deliverables and all the dissemination activities, thesis made by students, events to avoid external database sheets.
Task 7.6 Training activities: The training activities planned within the project have been implemented and developed in the last 12 months of the project and were carried out mostly online due to covid-19 pandemic.
They have been addressed to improve the competences and skills of the practitioners in the production of

organic food, including seminars/workshops for farmers and processors (at least one seminar/workshop per country for participators in the market, namely on- and off-farm processors); and at least one onsite training course for the end users in each participating country for the stakeholders (farmers and organic processors) and the demonstration of the HP drier (with WP2).

B - comments on deviations from the original plan:
Task 7.1. Despite the list of the contacts included in the database, the COVID-19 has severely limited the interaction with them, limited them mostly to online meetings or exchange of emails and thus limited the complete fulfilment and development of some activities (e.g. additional meetings, events, etc.).
Task 7.2. Exchange of students between partners was hindered by lockdown and COVID-19 pandemic. So, students were involved and worked mainly in their own university/research lab.
Task 7.3. no main changes.
Task 7.4.: Until February 2020 the attendance at events both scientific (e.g. conferences) and technical was in presence with a rather active participation by all the partners. After February 2020, due to COVID-19 and the strict lockdown and the cancellation of many events or the postponement of 1-2 years, this activity showed a main and significant reduction and/or delay.
Task 7.5.
a. website: contrary to what was planned, the website has been developed only in English, language as all partners recognised this as common for all. In the website only the training material (the full e-learning module) has been translated in 3 languages (English, German, Italian) to allow a better dissemination and usage.
b. Project pages on social and networking platforms for professional and scientists (eg. LinkedIn, Research Gate) have been under discussion at the meeting held in Viterbo (Italy, May 2019) and after following discussions it was agreed to not proceed to set specific new profiles dedicated to the SUSORG+ project, but to get profit of the existing pages of both the researchers and the institutions involved in the project to disseminate events, publications and outcomes of the project.
Task 7.6: all seminars and trainings were held online except two held before the start of the COVID-19 pandemic. Nevertheless, all events had a very good participation and representativeness of the different target groups of the project.

3.1.8 WP8

WP8	*Project Management and Coordination*
WP leader: Uni Kassel (Barbara Sturm, Gardis v. Gersdorff) Responsible partners: All	
Overall summary of main results, discussion and conclusions WP8 The aim of WP 8 is the project coordination and management. The email list of the SusOrganic project was completed and conference calls are held bi-monthly. The kick of (SLU), as well as the first interim meeting (UNITUS) have been held successful. Also the project coordinator participated in the 1st CORE Organic Cofund research seminar (Italy). The second meeting has been hold online in September 2020 as well as the final meeting in April 2021.	
Report on the results obtained (A), and fulfilment of objectives (B) **A- results obtained:** **Task 8.1 Project coordination and management:** The overall project coordination was carried out by Uni Kassel who took care of internal project monitoring, controlling, and risk management. Barbara Sturm coordinated the project for the majority of the project duration (29 month), the remaining 7 month were coordinated by Gardis von Gersdorff. An e-mail communication structure was provided (Susorgplus-partners@lists.uni-kassel.de). Bi-monthly project conference calls were organised to facilitate the communication on progress and support a sense of community. The role of the coordinator within this project was: (a) Preparation, organisation and chairing of the project meetings; (b) Control of work content in each work package with specifications and schedule; (c) Project monitoring using predefined indicators to follow up performance and impact; (d) Reporting. The midterm report was approved and	

required only minor improvement and the evaluation meeting was held successfully. **Task 8.2 Project meetings:** Four general project meetings of all partners including the kick-off and the final meeting were planned and conducted. **Task 8.3 Communication structure:** Each work package leader worked closely with the project coordinator and the other project partners. The work package leaders were responsible for the coordination of their respective work packages and the related reporting. Stakeholders were involved where possible in order to strengthen the output of the project. **B- fulfilment of objectives:** All objectives have been achieved.

3.2 Deliverables and milestones status

Deliverable No.	Deliverable name	Link to the document[2)], Journal articles (J), conference papers (C) (s. 4.1), future dissemination (F) (s. 4.5)	Planned delivery month[1)]	Actual delivery month[1)]	Reasons for changes/delay and explanation of consequences in case of delay, if any
D1.1	Operational DMS	Report (CO)	12	12	
D1.2	Functional and final version of the smart MCS	J3, J5, J7, J11, J15, J16, C12; C13, C14, C15, C18, C19, C21, C22, F2, F7, F8, F10, F11, F19, F20, F23, F24, F29, F31	18/30	18/34	COVID-19 pandemic
D1.3	Report on setup transferability	Report (RE)	30	30	
D2.1.	Report on design requirements and key performance indicators for heat pump drier	Conference paper C9,	6	15	The work was performed in due time, but the final document was then planned as a presentation at the IIR conference in Montreal, and a scientific article in a journal. This is more time consuming compared to a single Report delivery. No consequences for further work.
D2.2.	Report on the approval tests	Report (CO)	28	28	Well in time
D2.3.	Report on integration of the control strategies	Report (RE) J14, C4, C10, F7	32	36	Delay, the work is preformed, finalizing of report is delayed; no consequences for the project results
D2.4.	Demonstration to processors (with WP7)	Event	33	35	
D3.1.	Report on the quality, technological	Report (RE) F6, F13-F15, F30	32	35	Due to the COVID-19 emergency, the stability tests were postponed of 3

	characteristics and stability of the dried encapsulated extracts				months.
D3.2.	Report on the quality, technological characteristics and stability of the dried fruit/vegetable powders	Report (RE) J10, C11, F3, f9, F15, F18, F21,	35	35	
D4.1	Development of selected enriched organic dried products	Report J6, F5, F25, F27,	27	35	COVID-19 pandemic
D4.2	Innovative organic foods characterized by use of organic extracts	Report F4, F17, F28	33	35	COVID-19 pandemic
D5.1	Report on quality analyses of products	Report (RE) J1, J4, J8, J9, J12, J13, C1, C2, C3, C7, C8, C16, C17, F1, F22,	18/26/33	18/26/33	
D5.2	Report on sensory tests	Report (RE) F26	30	30	
D5.3	Report on information fusion from chemical/physical quality analysis, sensory evaluation and non-invasive assessment	Md. Saleh et al., F2 (submitted) Raponi et al. F11 (submitted) Shrestha et al., 2020a, b J11, J14 Raut et al., 2020a,b J8, J9 Von Gersdorff et al., 2021a,b J15, J16	33	36	The feasibility for non-invasive measurement of MC and laboratory measured product quality parameters was successfully proven and instead of a report published in journal articles. Due to COVID-19 pandemic, delays in WP4 effected the sensory evaluation and was not included into the development of non-invasive measurement systems.
D6.1.	Synthesized report on integrated value chain management	Report (RE)	36	36	
D6.2	Report on LCA	Report (CO) C5, F16	32	36	Delay in data inventory (including data from labs in partner institutions) in relation to COVID-19
D6.3	Report on LCCA	Report (CO)	34	36	
D6.4	Report on data	Report (RE)	36	36	

	base for LCA and LCCA				
D7.1.	Dissemination database with a stakeholder list, relevant dissemination events and activities	Database (RE)	4, 36	4, 36	-
D7.2	Report on dissemination of scientific project results, support documents for the CoP	Report (RE)	36	36	-
D 7.3	Website and virtual social platforms	www.Susorgplus.eu Research Gate	36	36	-
D7.4	Report on training activities (seminars, training courses)	Report (RE)	36	36	-
D7.5	Report on student engagement	Report (RE)	36	36	-
D8.1	Set up communication structure	Report (INT)	2	2	
D8.2	Minutes of the meetings	Report (INT)	1, 12, 24, 33	1/12	
D8.3	Midterm and final reports	Report (RE)	20, 36	20/36	

1) Measured in months from the project start date (month 1)
2) E.g. documents as orgprints.org/33121 or other types of deliverable (e.g. APPs or devices)

Milestone No.	Milestone name	Planned delivery month[3)]	Actual delivery month[3)]	Reasons for changes/delay and explanation of consequences, if any.
M1.1	Integration of data into DMS is finalised	18/30	18/30	
M1.2	Development and testing of MCS is finalised	30	34	COVID-19 pandemic
M2.1	Prototype on TRL 6 is up and running including DAQ and MCS	18	24	Approval tests were scheduled for 01/2020
M2.2	Dissemination of the system to industry and R&D Organisations	36	36	
M3.1.	Process conditions to obtain dried, encapsulated ingredients are optimised	24	24	
M3.2.	Process conditions to obtain powders from dried matrices are optimised	26	26	
M4.1.	Organic natural additives/colorants are	27	27	

	successfully implemented			
M4.2	Development of innovative organic products completed and reported	33	35	COVID-19 Pandemic
M5.1	Quality tests are finalised and reported to WP 1, 3 and 4	12/18/24	12/18/24/36	
M5.2	DMS is up to date	36	36	
M6.1.	Report on integrated value chain management and LCA/LCCA integration in DMS completed	36	36	
M6.2	LCA and LCCA methodology and system boundary determined	24	24	
M6.3	Report on LCA and LCCA completed	32	36	Delay in data inventory (including data from labs in partner institutions) in relation to COVID-19
M7.1	Supporting material for CoP finalised	7	36	
M7.2	Dissemination activities are finalised	7	36	
M8.1	Mid-term report is approved	20	20	
M8.2	Successful completion of the project	36	36	

3) Measured in months from the project start date (month 1)

4. Publications and dissemination activities

4.1 List extracted from Organic Eprints

(Date of extraction 20.07.2021)

Journal articles

J1 Dobrin, Aurora; Nedelus, Alina; Bujor, Oana; Mot, Andrei; Zugravu, Mihaela und Badulescu, Liliana (2019) NUTRITIONAL QUALITY PARAMETERS OF THE FRESH RED TOMATO VARIETIES CULTIVATED IN ORGANIC SYSTEM. Scientific Papers. Series B. Horticulture, LXIII (1), S. 439-443.

J2 Jokiel, M., Bantle, M., Kopp, C., Verpe, E.H. (2020) Modelica-based modelling of heat pump-assisted apple drying for varied drying temperatures and bypass ratios. Thermal Science and Engineering Progress, 19, S. 100575.

J3 Md. Saleh, R.; Kulig, B.; Emiliozzi, A.; Hensel, O. und Sturm, B. (2020) Impact of critical control-point based intermittent drying on drying kinetics and quality of carrot (Daucus carota var. laguna). Thermal Science and Engineering Progress, 20, S. 100682.

J4 Md. Saleh, R.; Kulig, B.; Hensel, O. und Sturm, B. (2019) Investigation of dynamic quality changes and optimization of drying parameters of carrots (Daucus carota var. laguna). Journal of Food Process Engineering, e13314, S. 1-17.

J5 Moscetti, Roberto; Raponi, Flavio; Monarca, Danilo; Ferri, Serena; Bedini, Giacomo und Massantini, Riccardo (2019) Effects of hot-water and steam blanching of sliced potato on polyphenol oxidase activity. International Journal of Food Science and Technology, 54 (2), S. 403-411.

J6 NALLAN CHAKRAVARTULA SS, MOSCETTI R, FARINON B, VINCIGUERRA V, MERENDINO N, BEDINI G, NERI L, PITTIA P, MASSANTINI R. Stinging Nettles as Potential Food Additive: Effect of Drying Processes on Quality Characteristics of Leaf Powders. Foods 2021.

J7 Raut, S.; Md. Saleh, R.; Kirchhofer, P.; Kulig, B.; Hensel, O. und Sturm, B. (2021) Investigating the effect of different drying strategies on the quality parameters of Daucus carota L. using dynamic process control and measurement techniques. Food and Bioprocess Technology, 14, S. 1067-1088.

J8 Raut, S.; von Gersdorff, G.J.E; Münsterer, J.; Kammhuber, K.; Hensel, O. und Sturm, B. (2020) Influence of pre-drying storage time on essential oil components in dried hops (Humulus lupulus L.). Journal of The Science of Food and Agriculture, n.n., S. 1-9.

J9 Raut, S.; von Gersdorff, G.J.E.; Münsterer, J.; Kammhuber, K.; Hensel, O. und Sturm, B. (2020) Impact of Process Parameters and Bulk Properties on Quality of Dried Hops. Processes, 11 (8), S. 1-23.

J10 Santarelli V., Neri L, Moscetti R., Di Mattia C., Sacchetti G., Massantini R., Pittia P. (2021). Combined use of blanching and vacuum impregnation with trehalose and green tea extract as pre-treatment to improve the quality and stability of frozen carrots. Food and Bioprocess Technology, 1-15

J11 Shrestha, L.; Crichton, S.O.J.; Kulig, B.; Kiesel, B.; Hensel, O. und Sturm, B. (2020) Comparative analysis of methods and model prediction performance evaluation for continuous online non-invasive quality assessment during drying of apples from two cultivars. Thermal Science and Engineering Progress, 18, S. 1-14.

J12 Shrestha, L.; Kulig, B.; Moscetti, R.; Massantini, R.; Pawelzik, E.; Hensel, O. und Sturm, B. (2020) Optimisation of Physical and Chemical Treatments to Control Browning Development and Enzymatic Activity on Fresh-cut Apple Slices. Foods, 9 (1), S. 1-21.

J13 Shrestha, L.; Kulig, B.; Moscetti, R.; Massantini, R.; Pawelzik, Elke; Hensel, O. und Sturm, B. (2020) Comparison between Hyperspectral Imaging and Chemical Analysis of Polyphenol Oxidase Activity on Fresh-Cut Apple Slices. Journal of Spectroscopy, n.n., S. 1-10.

J14 Sturm, Barbara; Raut, Sharvari; Kulig, Boris; Münsterer, Jakob; Kammhuber, Klaus; Hensel, Oliver und Crichton, Stuart O.J. (2020) In-process investigation of the dynamics in drying behavior and quality development of hops using visual and environmental sensors combined with chemometrics. Computers and Electronics in Agriculture, 175, S. 105547.

J15 von Gersdorff, G.J.E; Kirchner, S.M.; Hensel, O. und Sturm, B. (2021) Impact of drying temperature and salt pre-treatments on drying behavior and instrumental color and investigations on spectral product monitoring during drying of beef slices. Meat Science, 178, S. 108525.

J16 von Gersdorff, G.J.E; Kulig, B.; Hensel, O. und Sturm, B. (2021) Method comparison between real-time spectral and laboratory based measurements of moisture content and CIELAB color pattern during dehydration of beef slices. Journal of Food Engineering, 294, S. 110419.

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C1 Badulescu, Liliana und Bujor, Oana-Crina (2019) Valorificarea produselor agroalimentare ecologice pentru obținerea de produse naturale cu valoare nutritivă ridicată. In: Workshop-ul "Ecologic pentru sanatatea noastra", BIO LIFE & STYLE 2019, EXPOZIȚIE PENTRU O VIAȚĂ VERDE, 30 mai 2019, Bucuresti, Romania, Editura Ex Terra Aurum USAMV Bucuresti si Editura INVEL-Multimedia, Bucuresti, Romania.

C2 Badulescu, Liliana; Dobrin, Aurora; Bujor, Oana-Crina; Stan, Andreea; Mot, Andrei; Finti, Manuela und Lagunovschi-Luchian, Viorica (2018) Qualitative features of organic tomatoes. Poster at: Congress "Life sciences, a challenge for the future" 2018, Iasi, Romania, October 18-19, 2018.

C3 Badulescu, Liliana; Dobrin, Aurora; Stan, Andreea; Mot, Andrei und Bujor, Oana-Crina (2019) DRYING TREATMENT EFFECTS ON ANTHOCYANINS OF ORGANIC RASPBERRY (CV. HERITAGE) FRUIT. In: Goncharova-Alves, Svetlana und Alves-Filho, Odilio (Hrsg.) Third Nordic Baltic Drying Conference.

C4 Bantle, M.; Kopp, C. und Claussen, I.C. (2019) Improved process control by surface temperature-controlled drying on the example of sweet potatoes. In: Proceeding of Eurodrying 2019, July 10-12, 2019, Torino, Italy.

C5 Bosona, Techane (2021) Environmental impact of organic and conventional carrots. In: SLU (Hrsg.) Eprint.

C6 Bujor, Oana-Crina und Badulescu, Liliana (2018) SusOrgPlus – projet européen innovant dans le domaine des aliments biologiques: développement de technologies des traitements intelligentes, d'additifs et de colorants alimentaires naturels. [SusOrgPlus - innovative European project in the field of organic food: development of technologies of intelligent treatments, additives and natural food dyes.] Vortrag at: Atelier francophone sur "Les bonnes pratiques de la production agroalimentaire écologique: les macro- et micronutriments, la sécurité alimentaire, les comportements des consommateurs" INDAGRA 2018, Bucarest, Romania, le 2 novembre 2018.

C7 Bujor, Oana-Crina; Dobrin, Aurora; Stan, Andreea und Badulescu, Liliana (2019) Bioactive compounds and quality parameters in different organic apple varieties. Poster at: 4th International Conference on Natural Products Utilisation, Albena, Bulgaria, May 29 to June 2nd, 2019.

C8 Bujor, Oana-Crina; Dobrin, Aurora; Stan, Andreea; Mot, Andrei und Badulescu, Liliana (2019) Changes in carotenoid content of organic tomato powders depending in drying parameters. In: Proceedings of Eurodrying 2019, 10-12 July 2019, Torino, Italy, S. 413-414.

C9 Jokiel, M.; Bantle, M.; Kopp, C.; Claussen, I.C. und Tolstorebrov, I. (2019) Design of a CO2 heat pump drier with dynamic modelling tools. In: Proceedings of the 25th International Congress of Refrigeration, August 24-30, 2019, Montréal, Québec, Canada.

C10 Md Saleh, Rosalizan; Emiliozzi, Andrea; Kulig, Boris; Hensel, Oliver und Sturm, Barbara (2019) The effect of intermittent drying on drying kinetics and quality change dynamics of organic carrot (daucus carota v. laguna). In: Proceedings of Eurodrying 2019, 10-12 July 2019, Torino, Italy, S. 164.

C11 Moscetti, Roberto; Ferri, Serena; Neri, Lilia; Santarelli, Veronica; Pittia, Paola und Massantini, Riccardo (2019) Use of blanching and vacuum impregantion with trehalose and green tea as drying pre-treatments of organic sliced carrots. In: Proceedings of the Eurodrying 2019, 10-12-July 2019, Torino, Italy, S. 108.

C12 Moscetti, Roberto; Massaro, Simone; Chillemi, Giovanni; Sanna, Nico; Sturm, Barbara; Nallan Chakravatula, Swathi Sirisha und Massantini, Riccardo (2019) Recognition of inlet wet food in drying process through a deep learning approach. In: Proceedings of Eurodrying 2019, 10-12 July 2019, Torino, Italy.

C13 Moscetti, Roberto; Massaro, Simone; Monarca, Danilo; Cecchini, Massimo und Massantini, Riccardo (2019) Recognition of inlet wet food in drying process through a deep learning approach. Vorlesung at: 6th International Symposium on Modelling in Horticulture Supply Chain, Molfetta (Italy), 9-12 June 2019.

C14 Moscetti, Roberto; Raponi, Flavio; Cecchini, Massimo; Monarca, Danilo und Massantini, Riccardo (2019) Feasibility of computer vision as Process Analytical Technology tool for the drying of organic apple slices. Vortrag at: 6th International Symposium on Modelling in Horticulture Supply Chain, Molfetta (Italy), 9-12 June 2019.

C15 Moscetti, Roberto; Raponi, Flavio; Sturm, Barbara; Nallan Chakravatula, Swathi Sirisha und Massantini, Riccardo (2019) Feasibility of computer vision as Process Analytical Technology tool for the drying of organic apple slices. In: Proceedings of Eurodrying 2019, July 10-12, 2019, Torino, Italy.

C16 Oprica, Ioana; Lapadatu, Mihaela; Nicolau, Florin; Coanda, Marian und Badulescu, Liliana (2018) Valorizarea legumelor și fructelor ecologice sub forma de produse alimentare cu valoare adaugata - studiu de piata. [Valuation of organic vegetables and fruits as value-added foods - Market Survey.] Vortrag at: Symposium "Young Researchers in Horticulture, Forestry and Biotechnologies" - 5th Edition, Timisoara, Romania, November 22-23, 2018.

C17 Raut, Sharvari; von Gersdorff, Gardis; Wittkamp, Sarah; Münsterer, Jakob; Kammhuber, Klaus; Kulig, Boris; Hensel, Oliver und Sturm, Barbara (2019) Influence of storage time on essential oil components in dried hops. In: Proceedings ao Eurodrying 2019, 10-12 July 2019, Torino, Italy, S. 86.

C18 Shrestha, L.; Moscetti, R.; Crichton, S.O.J.; Hensel, O. und Sturm, B. (2018) Organic apples (cv. Elstar) quality evaluation during hot-air drying using Vis/NIR hyperspectral imaging. Poster at: 21st International Drying Symposium, IDS 2018, Valencia, Spain, 11-14 September 2018.

C19 Sturm, B.; Moscetti, R.; Crichton, S.O.J.; Raut, S.; Bantle, M. und Massantini, R. (2018) Feasibility of Vis/NIR spectroscopy and image analysis as basis of the development of smart-drying technologies. In: Editorial Universitat Politecnica de Valencia (Hrsg.) Proceedings of the IDS 2018, 21st International Drying Symposium, September 11-14, 2018, Valencia, Spain, S. 171-178.

C20 Sturm, Barbara; von Gersdorff, Gardis; Raut, Sharvari und Hensel, Oliver (2019) SusOrgPlus – Intelligente Lebensmittelverarbeitung, natürliche Zusatz- und Farbstoffe. [SusOrgPlus - Smart food processing, natural additives and colourants.] In: Mühlrath, Daniel; Albrecht, Joana; Finckh, Maria R.; Hamm, Ulrich; Heß, Jürgen; Knierim, Ute und Möller, Detlev (Hrsg.) Innovatives Denken für eine nachhaltige Land- und Ernährungswirtschaft. Beiträge zur 15. Wissenschaftstagung Ökologischer Landbau, Kassel, 5. bis 8. März 2019, Verlag Dr. Köster, Berlin.

C21 von Gersdorff, G. J.E.; Kirchner, S.M.; Hensel, O. und Sturm, B. (2019) First steps towards smart drying of beef slices seasoned with different pre-treatments. In: Proceedings of Eurodrying 2019, 10-12 July 2019, Torino, Italy.

C22 von Gersdorff, G. J.E.; Shrestha, L.; Raut, S.; Retz, S.K.; Hensel, O. und Sturm, B. (2018) Impact of processing temperature on drying behavior and quality changes in organic beef. Poster at: 21st International Drying Symposium, IDS 2018, Valencia, Spain, 11-14 September 2018**.**

4.2 Stakeholders oriented articles in the CORE Organic newsletter

- November 2019 With intelligent drying and heat pump drying towards more sustainability
- Februar 2020 Development of new organic ingredients from the tomato variety "Pera d'Abruzzo"
- May 2020 Smart and intelligent drying systems for organic foods
- September 2020 Heat pump drier for organic products offers new possibilities
- December 2020 Drying organic fruits to increase sustainability and food quality
- March 2021 Value added products from the forgotten crop - Urtica dioica
- March 2021 What about the consumer acceptance of organic products with natural food additives and colourants?

The articles are addressed to (organic) food processors

4.3. Practice abstracts

- Smart drying of organic products

4.4 Other dissemination activities and material

O1 Bădulescu Liliana, Bujor-Nenița Oana-Crina, Stan Andreea, Dragomir Nela, Dobrin Aurora, Zugravu Mihaela, Moț Andrei, Ion Violeta, Lagunovschi-Luchian Viorica, Sturm Barbara, Project SusOrgPlus - Intelligent food processing chains, natural additives and colourant, in the The 24th International Exhibition of Inventics INVENTICA 2020" Iași, Romania, organized by Universitatea Tehnică "Gheorghe Asachi" și Institutul Național de Inventică din Iași, 29-31 July Iași, Romania

O2 Bădulescu Liliana, Bujor-Nenița Oana-Crina, Stan Andreea, Dragomir Nela, Dobrin Aurora, Zugravu Mihaela, Moț Andrei, Ion Violeta, Lagunovschi-Luchian Viorica, Sturm Barbara, Project SusOrgPlus in the International Exhibition of Inventions and Innovations "Traian Vuia" 6th Edition, 13-15 October 2020, Timișoara, Romania

O3 Bădulescu Liliana, Bujor-Nenița Oana-Crina, Stan Andreea, Dragomir Nela, Dobrin Aurora, Zugravu Mihaela, Moț Andrei, Ion Violeta, Lagunovschi-Luchian Viorica, Sturm Barbara, Project SusOrgPlus in the International Exhibition of Research, Innovations and Inventions PRO INVENT, 18th Edition – ONLINE, 18-20 November 2020, Cluj-Napoca, Romania

O4 Liliana Bădulescu, Oana-Crina Bujor, Aurora Dobrin, Andreea Stan, Andrei Moț, Violeta Alexandra Ion Pudre liofilizate obținute din tomate ecologice ce pot fi utilizare ca ingrediente naturale nutriționale/funcționale și/sau coloranți pentru a spori stabilitatea produselor prelucrate și ca agenți naturali de colorare și aromatizare, in the International Exhibition of Research, Innovations and Inventions PRO INVENT, 18th Edition – ONLINE, 18-20 November 2020, Cluj-Napoca, Romania

O5 Liliana Bădulescu, Oana-Crina Bujor, Aurora Dobrin, Andreea Stan, Andrei Moț, Violeta Alexandra Ion Pudre liofilizate obținute din zmeură ecologică ce pot fi utilizare ca ingrediente naturale nutriționale/funcționale și/sau coloranți pentru a spori stabilitatea produselor procesate, ca agenți de colorare și aromatizare naturali, in the International Exhibition of Research, Innovations and Inventions PRO INVENT, 18th Edition – ONLINE, 18-20 November 2020, Cluj-Napoca, Romania

O6 Bădulescu Liliana, Bujor-Nenița Oana-Crina, Stan Andreea, Dragomir Nela, Dobrin Aurora, Zugravu Mihaela, Moț Andrei, Ion Violeta, Lagunovschi-Luchian Viorica, Sturm Barbara, Project SusOrgPlus în cadrul INOVALIMENT - Primul Târg Internațional de Invenții și Inovații din domeniul alimentar, 23-27 November 2020

O7 A. Dobrin, A. Nedeluș, O-C. Bujor, A. Moț, M. Zugravu, L. Bădulescu (2019). Nutritional quality parameters of the fresh red tomato varieties cultivated in organic system. "Agriculture for life, life for agriculture"
6-8 June, Bucharest, Romania (2019)

O8 Oana-Crina Bujor, Andreea Stan, Carmen Gabriela Constantin, Aurora Dobrin, Violeta Alexandra Ion, Mihaela Zugravu, Andrei Moț, Andrei Petre, Liliana Bădulescu (2020). Variation of antioxidant activity and bioactive compounds in organic tomatoes after different types of processing F&V Processing 2020 - Third Symposium on Fruit and Vegetable Processing, 24-25 November 2020, Avignon, France

O9 DRAGOMIR Nela, NICOLAE Carmen Georgeta, STAN Andreea, ION Violeta Alexandra, BĂDULESCU Liliana 2020 BISCUIȚII BIO CARANELA - Biscuiți ecologici cu semințe decorticate și făină de cânepă, bucăți și pulbere din măr deshidratat, pulbere din busuioc liofilizat at the International Exhibition of Inventions and Innovations ”Traian Vuia” 6th Edition, 13-15 October 2020, Timișoara, Romania

O10 DRAGOMIR Nela, NICOLAE Carmen Georgeta, BORDEI Iuliana – Ștefania, BUJOR-NENIȚA Oana-Crina, DOBRIN Aurora, BĂDULESCU Liliana 2020 BIO PRICONELA - Pricomigdale ecologice cu semințe decorticate de cânepă și pulbere din măr BIO deshidratat at the International Exhibition of Inventions and Innovations ”Traian Vuia” 6th Edition, 13-15 October 2020, Timișoara, Romania

O11 DRAGOMIR Nela, NICOLAE Carmen Georgeta, STAN Andreea, ION Violeta, BĂDULESCU Liliana 2020 BISCUIȚII BIO CARANELA - Biscuiți ecologici cu semințe și făină de cânepă, bucăți și pulbere din măr deshidrat, in the International Exhibition of Research, Innovations and Inventions PRO INVENT, 18th Edition – ONLINE, 18-20 November 2020, Cluj-Napoca, Romania

O12 DRAGOMIR Nela, NICOLAE Carmen Georgeta, BUJOR-NENIȚA Oana-Crina, DOBRIN Aurora, BĂDULESCU Liliana 2020 BIO PRICONELA - Pricomigdale ecologice cu semințe decorticate de cânepă și pulbere din măr BIO deshidratat in the International Exhibition of Research, Innovations and Inventions PRO INVENT, 18th Edition – ONLINE, 18-20 November 2020, Cluj-Napoca, Romania

O13 Violeta Alexandra Ion, Florin Nicolau, Andrei Petre, Oana-Crina Bujor, Liliana Bădulescu (2020). Variation of bioactive compounds in organic Ocimum basilicum L. during freeze-drying processing. "Agriculture for life, life for agriculture" 6-8 June, Bucharest, Romania (2020)

O14 Violeta Alexandra Ion, Andrei Petre, Oana-Crina Bujor, Liliana Badulescu (2020). Characterisation of bioactive compounds in organic dill (Anethum graveolens L.) stems processed by freeze-drying, ISEKI e-conference series: Food Quality and Texture in Sustainable Production and Healthy Consumption, 18 – 19 November 2020, Austria

O15 Moscetti R., Nallan Chakravartula S.S., Bandiera A., BEDINI G., Massantine R., 2020. Computer Vision Technology for Quality Monitoring in Smart Drying System, 2020. IEEE International Workshop on Metrology for Agriculture and Forestry, MetroAgriFor 2020 - Proceedings, 134-138.

O16 NERI L., SANTARELLI V., MOSCETTI M., MASSANTINI M., PITTIA P. Quality and stability of frozen carrots fortified with green tea polyphenols. 33rd EFFoST International Conference 2019, 12-14 November 2019, Rotterdam, The Netherlands

O17 Sturm, B: Trockenprodukte – intelligent und effizient herstellen. Workshop für Verarbeiter im Rahmen des "Organic Market Forums", ANUGA 2019 in Cologne.

O18 Sturm, B: Intelligent food processing chains, natural additives and colourants. Biofach Congress 2020: Careful, Gentle, Minimal: What are the principles of organic processing?

O19 Sturm, B. & von Gersdorff, G. Report in Lebensmittelbrief Juli/August 2020: "Intelligente Lebensmitteltrocknung / Intelligent food dehydration"

O20 von Gersdorff, G. SusOrgPlus: Smart processing chains, natural food additives and colorants. TP Organics’ Science Day 2021: Innovating for organic food processing. Biofach 2021.

O21 Project leaflet SusOrgPlus: „Intelligent food processing chains, natural additives and colourants“

O22 Press release UNI Kassel: "Code of Practice für die Produktion ökologischer Lebensmittel(Code of practice for processing of organic food", September 2018

O23 Article in HNA (regional daily newspaper): “Bio nicht nur auf dem Feld / Organic not just in the field”), November 2018, Uni Kassel.

Training and Workshops for stakeholders:

T1 Oral presentation at Workshop ”Ecologic pentru sanatatea noastra” Expoziția BIO LIFE & STYLE 2019, EXPOZIȚIE PENTRU O VIAȚĂ VERDE, 30 May 2019, ROMEXPO Bucharest held by UASVM.

T2 Workshop "Consumer acceptance analysis" at the INDAGRA International Fair 2019, October 30, 2019, ROMEXPO Bucharest http://usamv.ro/index.php/ro/component/dpcalendar/event/38 held by UASVM.

T3 Training course for students and practical exercises, „Sustainable food processing”, August 2019 held by Uni Kassel

T4 Training session for farmers, processors and certification bodies, UASMV, 3 December 2020.

T5 Training day 12/03/2021 (UNITUS/UNITE) – "Le produzioni agro-alimentari del settore biologico: aspetti legislativi, produttivi e di trasformazione per il miglioramento della qualità e l'innovazione". (English translation: "Agro-food production in the organic sector: legislative, production and processing aspects for quality improvement and innovation"). Organized by UNITUS in collaboration with UNITE. Participants: MIPAAF, CREA, UNITUS, UNITE, University of Perugia and 2 Italian stakeholders.

T6 Webinar: Sustainability concepts in organic food value chain: With examples of environmental and economic aspects of organic food products. Training webinar in Sweden for end users including food producers, 2021-03-22 organized by SLU.

T7 Final SusOrgPlus workshop "Smart and sustainable food processing of organic fresh produce – what´s promising, what´s new?" 15.04.2021 organized by Uni Kassel and ATB Potsdam with contributions of Innotech, SINTEF, UNITE, UNITUS and other stakeholders of the organic food sector.

T8 Training session for farmers, processors and certification bodies, UASMV, 22 April 2021.

T9 Webinar 30/04/2021 (UNITUS/UNITE) – "Sviluppo di processi di filiera intelligenti e a basso consumo energetico, additivi e coloranti alimentari naturali e codici di condotta per aumentare la sostenibilità e l'accettabilità dei prodotti alimentari biologici". (English translation: "Development of smart and energy-efficient supply chain processes, natural food additives and colourants, and codes of practices to increase the sustainability and acceptability of organic food products"). Organized by UNITE in collaboration with UNITUS.

T10 Webinar 28/04/2021 (SINTEF) – "Smart and Sustainable Food Processing of Organic Fresh Produce". Organized by SINTEF with contributions of: SINTEF, SLU, UNITE and UNITUS.

T11 Workshop "Sustainable and Organic Innovative Products: A Food Safety Key", 2020, Research Center for Studies of Food Quality and Agricultural Products & Faculty of Animal Productions Engineering and Management, 4 June 2020 16.00-18.00 in the International Conference "Agriculture for Life, Life for Agriculture" Organized by: University of Agronomic Sciences and Veterinary Medicine of Bucharest, Romania Oral presentations

4.5 Future dissemination actions

Several contributions to international journals and conferences have been prepared and are already accepted or under review:

Journal Articles

F1 Michael Bantle, Ingrid Camilla Claussen, Ignat Tolstorebrov, Oana-Crina Bujor, Andreea Stan, Violeta Alexandra Ion, Aurora Dobrin, Liliana Badulescu, "The influence of different drying systems and conditions on the biochemical changes of organic apples", Thermal Science and Engineering Progress

F2 Md Saleh, R.,Kulig, B., Arefi, A., Hensel, O., &Sturm, B. (2021). Method comparisons and model prediction performance of non-invasive measurement using hyperspec-tral imaging of total carotenoids, color and moisture content of dried carrot (Daucus carotavar. laguna). Submitted for Computers&Electronicsin Agriculture.

F3 GIANCATERINO M., NERI L., GONZALEZ ORTEGA R., VERONICA S, PITTIA P. Technological functionality and stability of microencapsulate extracts from organic tomato pera.

F4 Nallan Chakravatula SS, Moscetti R, Massantini R. Characterization of nettle powder to be used as food ingredients. (Journal to be defined)

F5 NALLAN CHAKRAVARTULA SS, MOSCETTI R, MASSANTINI R. Effect of stinging nettle additives on quality characteristics of enriched crackers (tentative title). (In development).

F6 NERI L., GONZALEZ ORTEGA R., GIANCATERINO M., FAIETA M., PITTIA P. Technological functionality and chemical characterization of microencapsulate juice from wild nettle.

F7 Raut, S., Kulig, B., Arefi, A., Kirchhofer, P., Hensel, O & Sturm, B. (2021) Methods comparison to understand the effect of process strategies on essential quality parameters of Daucus Carota var. Laguna using multivariate analysis. Innovative Food Science and Emerging Technologies (submitted)

F8 Moscetti R, Massaro S, Chillemi G, Sanna N, Nalla Chakravatula SS, Massantini R (work in progress). Tentative title: Smart drying of fruit and vegetables through a Deep Learning approach.

F9 MOSCETTI R, NALLAN CHAKRAVARTULA SS, NERI L, PITTIA P, MASSANTINI R. Vacuum impregnation of trehalose and green tea extracts: effect on drying and quality of carrot (var. Carvejo) slices. (In development – in collaboration with UNITE).

F10 MOSCETTI R, MASSARO S, MASSANTINI R. Use of deep learning in a smart dryer (tentative title). (In development)

F11 RAPONI F, MOSCETTI R, NALLAN CHAKRAVARTULA SS, FIDALEO M, MASSANTINI R. Computer vision to monitor the hot-air drying process of organic apple cylinders (cv. gala). Biosystems engineering (Under revision).

F13 SANTARELLI V., NERI L., CARBONE K., MACCHIONI V., PITTIA P. (2021). Food grade extraction of hop (Humulus Lupulus, L.) bioactive compounds: a comparison between conventional and non-conventional technologies. (Submitted).

F14 SANTARELLI V., NERI L., CARBONE K., MACCHIONI V., PITTIA P. (2021). Effect of conventional and innovative extraction methods on the volatile aroma pattern of hop extracts. (submitted).
NERI L., VERONICA S., GONZALEZ ORTEGA R., MARCO F., TATASCIORE S., DI MATTIA C., PITTIA P., 2021. Use of food grade hop extract for the development of innovative food ingredients. (In preparation).

F15 VERONICA S., NERI L., PITTIA P. Evaluation of hops cultivars for the production of functional food ingredients

Conferences

Abstracts of SLU, UniKassel, UNITUS and UNITE have been accepted for the **OWC 2020/21** in Rennes France:

F16 Bosona T., Gebresenbet G. Environmental impact assessment of organic carrot production and supply in Sweden.

F17 Moscetti et al. Influence of blanching and drying on colour of organic nettle flour.

F18 Neri et al. Influence of encapsulation on the technological functionality and stability of organic natural plant extracts.

F19 von Gersdorff et al. Development of sustainable drying strategies for beef drying.

The following abstracts have further be accepted for upcoming international conferences:

F20 BANDIERA A, BEDINI G, NALLAN CHAKRAVARTULA SS, MASSANTINI R, MOSCETTI R, (accepted) Computer Vision Technology for Quality Monitoring in Smart Drying System. Industrie Alimentari 2021

F21 GONZALEZ ORTEGA R., NERI L., GIANCATERINO M., FAIETA M., DI LABIO F., PITTIA P. Development of dry natural additives from stinging nettle (Urtica dioica) and evaluation of their quality and stability. 6th INTERNATIONAL ISEKI-Food CONFERENCE, June 23-25 (online event) 2021

F22 Violeta Alexandra ION, Andreea STAN, Aurora DOBRIN, Andrei PETRE, Andrei MOT, Liliana BADULESCU, effect of freeze-drying on organic Urtica Dioica bioactive compounds, ISEKI-Food 2021, 23 - 25 June 2021.

F23 MOSCETTI R., NALLAN CHAKRAVARTULA S.S., BEDINI G., BANDIERA A., MASSANTINI R., 2021. Computer vision technology for improving quality and sustainability of food drying systems. 6th International ISEKI Food Conference, 23-25 June 2021.

F24 MOSCETTI R., MASSARO S., NALLAN CHAKRAVARTULA S.S., BEDINI G., BANDIERA A., MASSANTINI R., 2021. The smart sustainable development of food drying. 6th International ISEKI Food Conference, 23-25 June 2021.

F25 NALLAN CHAKRAVARTULA S.S., MOSCETTI R., BEDINI G., NERI L., PITTIA P., MASSANTINI R., 2021. Stinging nettle (Urtica dioica L.): a potential indigenous source to unlock technologically adaptable nutritional and functional additives? 6th International ISEKI Food Conference, 23-25 June 2021.

F26 Nela DRAGOMIR, Carmen Georgeta NICOLAE, Andreea STAN, Violeta Alexandra ION, Mihai FRINCU, Andrei PETRE, Liliana BĂDULESCU, „Evaluation of sensory properties and consumer perception of blended teas obtained from organic freeze dried fruits and vegetable", Scientific Papers. Series B, Horticulture (accepted for publication).

F27 Nela DRAGOMIR, Carmen Georgeta NICOLAE, Oana-Crina BUJOR-NENIȚA, Andreea STAN, Violeta Alexandra ION, Mihaela ZUGRAVU, Liliana BĂDULESCU, Iuliana – Ștefania BORDEI, „Development of

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F30 VERONICA S., NERI L., GONZALEZ ORTEGA R., MARCO F., TATASCIORE S., DI MATTIA C., PITTIA P., 2021. Use of food grade hop extract for the development of innovative food additives. 6th INTERNATIONAL ISEKI-Food CONFERENCE, June 23-25 (online event) 2021
F31 von Gersdorff et al. (2020). Development of robust algorithms for non-invasive real time measurement of product status throughout the drying process of beef slices, International Drying Symposium 2020, 27.06.-01.07. 2020, Worchester, Massachusetts

4.6 Specific questions regarding dissemination and publications

- Is your CORE Organic Cofund project website up-to-date (Please contact the webmaster);
  Yes
- List the categories of end users relevant to the research results and how they have been addressed or will be addressed by dissemination activities (Please order them according to the user groups).

The results are of interest for several groups of stakeholders:

- On and off farm processors/associations: seminars, workshops and training in the respective languages, e-learning course (ISEKI Food Association e-learning platform) and processing and quality guidelines (available from SusOrganic)
- Scientific community: presentation at conferences, scientific publications, ResearchGate, Organic eprits
- Students: involvement in project research activities and thesis writing
- Suppliers of equipment: Newsletters, website, personal contact; the results of the project are relevant for suppliers of processing and measurement and control equipment in terms of offering improved technologies
- General public: better understanding of organic and sustainability aspects. Newsletters, articles in consumer journals

5. Project impact

The project greatly benefitted from the work conducted in the SusOrganic project. Approaches made could be intensified and new ideas concerning sustainable processing of organic food could be implemented.

The outcome of the project has a big impact for food processors as well as for technical suppliers of the organic sector. In the future, drying processes will be much more sustainable in terms of product quality and environmental impact which extends the sustainability of the value chain of organic food production. Further, processors will be sensitized to use products rejected from the market to enrich other products and in general it was shown that natural ingredients could provide an alternative to conventional food additives and the approaches are worth to be expanded to others than those investigated in the SusOrgPlus project. Additionally, the potential of climate neutral heat pumps to replace conventional, fuel-based energy sources was highlighted.
Processors were reached by several dissemination activities and the range of online activities necessitated in the second half of the project showed a great response, and shows an additional possibility to reach the relevant stakeholders.

Collaborations with several processors in Germany, Norway and Romania have been established and optimisation measures are discussed. While these do not fall under the long term goals of SusOrgPlus, the consortium is dedicated to supporting processors with any measures that can help them to increase sustainability of their production.
The scientific community has been reached by the attendance of conferences and publication of high quality and high impact publications. Discussions with several reputable colleagues are ongoing in terms of collaborating in the field of smart drying and smart processing in the wider context

6. Added value of the transnational cooperation in relation to the subject

On a national level it is very difficult to form a consortium with such a variety of backgrounds and find a funding stream that is suitable for the conduction of work with the scope of SusOrgPlus.
Most results of SusOrgPlus are relevant for the whole of the EU. National projects do not offer the same degree of dissemination, technology and knowledge transfer and training possibilities as an international one. In the SusOrgPlus project, the seminars and trainings built on one commonly defined base which is relevant for all countries and thereafter were adjusted accordingly to the particular needs of the respective country. To achieve the same impact, national projects would have to duplicate if not triplicate work and thus, would be very resource and finance inefficient.

7. Suggestions for future research

Climate change and limited resources will force the mankind to more sustainability and will lead to changes in the food sector. Thus, research to increase the efficiency of food processing, which means to use renewable energy resources and increase the efficiency of both processes and product quality is mandatory. The project has shown that processes need to be adapted to the individual product and the better understanding of changes occurring inside the product and in the processing environment are worth to be monitored and adjusted throughout the process. Thus, the approaches made will be relevant for future research.