<LIFE13 ENV/IT/000590>

FINAL Report-Public version
Covering the project activities from 01/06/2014 to 31/12/2017

Reporting Date
<15/05/2018>

<Sustainable bio-based coating from tomato processing by-products for food metal packaging>

Project Data

Project location	Parma, Canneto sull'Oglio (MN), Burago di Molgora (MI)
Project start date:	<01/06/2014>
Project end date:	<31/05/2017> **Extension date:** <31/12/2017 >
Total Project duration (in months)	<43> months (including **Extension of** 7 **months**)
Total budget	€ 2,055,984.00
Total eligible budget	€ 2,039,484.00
EU contribution:	€ 905.020,25
(%) of total costs	46,92%
(%) of eligible costs	49,88%

Beneficiary Data

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2. Executive summary

2.1 Project objectives

The goal of the project was to prove and demonstrate the viability of an innovative technology for the production of a bio-lacquer obtained from tomato by-products and to be used as coating for food contact applications in metal cans.
The main objective of the project involved the design and building of a pilot plant on semi-industrial scale to prove the technical feasibility and the efficiency of the cutin extraction and production system developed and set up at laboratory scale in a previous project (FP7, BIOCOPAC). The tomato cutin is a polyester biopolymer interesterificated with potential to replace petroleum for the synthesis of polymer and for the production of thermosetting resins, the main component of the new eco-lacquer. The reproducibility of the extraction process was another important goal.
The second objective was the formulation and the application of a bio-lacquer, with quality and safety properties comparable with the standard oil based lacquers and with technological characteristics suitable for the application on standard line.
The third objective was to establish the shelf-life of different foodstuffs packed in the new cans in comparison with standard ones.
Secondary objectives were the optimization of the pilot plant for cutin extraction in terms of resources efficiency and saving (water, energy, emissions); the demonstration of the compliance of the new bio-lacquer with hygienic-sanitary and sensory requirements; the evaluation of yield of the process and cost of the new lacquer; the survey of the retail and consumer acceptance of the new lacquer and the willingness to pay more for a bio-packaging.
Finally the project aimed to study the environmental impact of the extraction process and of the eco-cans by LCA.
Both the main target and the secondary objectives of the project were achieved as originally planned according to the project proposal, and they are specifically described in the deliverables and outputs produced. Only one aspect related to the optimization of purified cutin is still under investigation and will continue to be evaluated in the coming months.
The scale-up of the extraction method has been successfully carried out; the pilot plant has been designed, realized and assembled. The extraction method has been transferred from a laboratory scale to a pilot level, modifying only some parameters of the process and obtaining cutin with good qualitative characteristics, high yield (10-15%) and reproducibility.
The production of the new eco-lacquer for food metal packaging has been completely achieved: after the commissioning of the pilot plant, the industrial production of cutin has been performed. Overall on the plant about 450 Kg of cutin has been obtained; of these about 100 kg has been employed for the industrial synthesis of bioresin and the formulation of the bio-lacquer, that has been applied on tinplate, TFS and aluminium on industrial line. Then the cans has been industrially produced and filled with different food products. The corresponding pack tests are ongoing since several months (depending on the product). The results obtained are positive and comparable with those of the standard cans. The compliance of the bio-lacquer with national and European legislation was positive, with migration values below the legal limits.
A green extraction protocol has been assessed by using energy from renewable resources, by recirculating the solution and by improving the biogas production of the exhausted peels.
A positive LCA output was obtained in terms of reduction of the uses of the resources and CO_2eq emissions. For each cans up to 730 mg/CO_2eq is avoided.
Through questionnaires and interview the interest of retailer and consumer for the new lacquers was confirmed.

Thanks to the cutin extraction prototype, the valorization of the tomato by-products by upgrading them to higher value and useful product has been achieved, at the same time offering alternatives strategies for the waste use and minimization in accordance with Directive 2008/98/EC.
The approach developed in the project is a concrete example of circular economy; a virtuous loop "from tomato to tomato" has been created: the by-products of the tomato industry has been utilized for cutin extraction, then used as starting material for the formulation of the bio-lacquer, that has been applied on the internal surface of the tomato cans (and not only of course).

2.2 Key deliverables and outputs

The main deliverables of the project can be grouped into height categories, namely: *1)* deliverables associated to background and preparatory studies on the characteristics of tomato wastes and on the most important parameters of the extraction process; *2)* deliverables associated to the design, assembling, optimization and start up of the prototype; *3)* deliverables associated to the synthesis of the resin and the formulation of the lacquer; *4)* deliverables associated to the filling of the cans and to the pack test; *5)* deliverables associated to the environmental and social impacts; *7)* deliverables associated to the dissemination activities; *8)* deliverables including the formal reports requested by the EU.
The complete list of the deliverables and outputs for each category is provided in Table 1 and of Milestones in table 2. Compared to the project proposal, included amendment, all the expected deliverables have been produced as planned and their full version is provided in the corresponding annexes (see last column in table 1).

Name of the deliverable	Output produced	Associated action	Due date	Status	Annex
The Project website	Website www.biocopacplus.eu and deliverable D.1.1	D.1	31-08-14	Completed on 23-01-15	Sent with the Inception Report
Study evaluation of the quantities of tomato production and the related waste in different European geographical area including an evaluation of the periodicity of the tomato waste production	Deliverable A.1	A.1	30-09-14	Completed on 29-10-14	
Communication and Dissemination Plan	Deliverable D.1.2	D.1	30-11-14	Completed on 27-01-15	
Identification of the system necessary for the realization of the extraction pilot plant and its key-drivers	Deliverable B.1.1	B.1	30-12-14	Completed on 13-02-15	
Definition of the conditions for the extraction process on the prototype	Protocol of extraction	B.1	30-12-14	Completed on 13-02-15	
Authorization application and dossier field for prototype installing	Obtaining of environmental authorization	B.1	31-12-14	Completed on 12-11-15	Sent with the Mid-Term Report
Flow-sheet of the Prototype	Deliverable B.2.1	B.2	31-01-15	Completed on 24-02-15	Sent with the Inception Report

Flow-chart of the technologies chosen for the extraction procedure on pilot plant	Flow-chart of the prototype	B.2	31-01-15	Completed on 24-02-15	
Project Brochure	Brochure	D.1	28-02-15	Completed on 24-06-15	Sent with the Inception Report
Project Brochure & Multimedia Project Presentation	Video of the project and deliverable D.1.3	D.1	28-02-15	Completed on 24-06-15	Sent with the Mid-term Report
Report on the characteristics of the extraction process: time, temperature, capacity, yield, stability	Deliverable B.3.1	B.3	30-09-15	Completed on 24-11-15	
Layout of the Prototype	Deliverable B.2.2	B.2	31-10-15	Completed on 23-02-16	
Layout utilities of the Prototype	Deliverable B.2.2.1	B.2	31-10-15	Completed on 24-02-16	
Update of layout of the Prototype	Deliverable B.2.2.2	B.2	Not foreseen	Completed on 09-03-16	
Design and set-up of the pilot plant for the bio-resin's production	Deliverable B.4.1	B.4	31-10-15	Completed on 21-12-15	
Project Impact Monitoring report	Deliverable C.1.1	C.1	30-11-15	Completed on 19-01-16	
Dissemination and Exploitation plan Update. An update of D.1.2 with more detailed plans based on experiences gathered in the course of the project	Deliverable D.1.2	D.1	30-11-15	Completed on 26-02-16	
Participation to Tomaca Fest-Conference "Institutions reward the research" - Award for research and commitment to innovation in the field of economic, social and environmental sustainability	Award	D.1		Received on 27-08-16	
Inauguration of pilot plant	Dissemination event	D.1		Achieved on 27-10-16	
Update of the report on the characteristics of the extraction process: time, temperature, capacity, yield, stability	Deliverable B.3.1.1	B.3	Not foreseen	Completed on 02-12-16	Sent with the Progress Report
LCA Report on the valorization of the tomato by-products for the cutin extraction	Deliverable B.6.1	B.6	31-03-17	Completed on 30-04-17	
Definition and planning of the Pack Test	Protocol of Pack test	B.5	31-05-17	Completed on 30-06-17	
Start up and Industrial Production Technical Report	Deliverable B.2.3	B.2	30-06-17	Completed on 31-07-17	
Unido International Award 2017 for the Women category as the winner innovative idea	Award	D.1		Received on 10-05-17	

Green Oscar 2017, CREA category (Coldiretti Giovani Impresa Lombardia)	Award	D.1		Received on 06-06-17	
Layman report –the project in a nutshell – for outreaching and bridging the gap between the science and society	Deliverable D.1.5	D.1	31-08-17	Completed on 30-12-17	Deliverable D.1.5 annexed to Final Report
Report on the optimization of the environmental properties of the process	Deliverable B.3.2	B.3	30-09-17	Completed on 14-12-17	Deliverable B.3.2 annexed to Final Report
Report about the production of bio-resins and related bio-lacquer performances	Deliverable B.4.2	B.4	30-09-17	Completed on 23-12-17	Deliverable B.4.2 annexed to Final Report
LCA report of the new eco-cans and on the production of the bio-lacquer	Deliverable B.6.2	B.6	31-10-17	Completed on 30-11-17	Deliverable B.6.2 annexed to Final Report
Report on the final results of the Pack tests	Deliverable B.5.2	B.5	31-12-17	Completed on 30-12-17	Deliverable B.5.2 annexed to Final Report
Report on the overall and specific migration tests	N° 3 Report of analyses	B.5		Completed on 30-12-17	Annexes 1,2,3 of Deliverable B.5.2
Project Impact Monitoring report	Deliverable C.1.2	C.1	31-12-17	Completed on 30-12-17	Deliverable C.1.2 annexed to Final Report
Socio-economic impact report	Deliverable C.2.1	C.2	31-12-17	Completed on 30-12-17	Deliverable C.2.1 annexed to Final Report
After Life communication plan	Deliverable E.3.1	E.3	30-12-17	Completed on 30-12-17	Deliverable E.3.1 annexed to Final Report

Tab.1: List of deliverables and outputs

Name of the Milestone	Associated action	Due date	Status	Annex
MS1 Kick-off: Action lists, Organisation Guidelines, Financial Reporting Handbook and Working documents templates, Knowledge Management Platform and document management system implemented (M1)	E 1	30/06/2014	Completed	Minute of the meeting annexed to IR
MS3 Flow-chart of the technologies chosen for the extraction procedure on pilot plant (M7)	B 1	30/12/2014	Completed	Layout annexed to Deliverable B.2.2

MS4 Roll-out and implementation of the Dissemination Plan and early awareness raising activities (M6)	D 1	31/12/2014	Completed	
MS9 Evaluation framework for analysing the socio-economic impact: methodological plan and grids (M8)	C 2	31/01/2015	Completed	
MS5 Definition of the environmental and socio-economic indicators for impact monitoring: selection criteria, evaluation framework, guidelines and grids for indicators data collection (M9)	C 1	28/02/2015	Completed	
MS6 Analysis of the data related to the yield and the composition of cutin coming from the extraction process (M17)	B 3	29/09/2015	Completed	
MS6 Assembling and startup of the prototype plant for cutin extraction and running at semi-industrial scale (M18)	B 2	30/11/2015	Completed	
MS7 Design and set-up of the pilot plant for the bio-resins' production and Bioresins production based on optimized pilot plant design and set-up (M18)	B 4	31/05/2017	Completed	
MS8 Prototype plant evaluation and demonstration (M30)	B 3	31/05/2017	Completed	Inauguration October 2016 annexed to Progress Report
MS10 Lacquers' production based on optimized formulae and process parameters (M26)	B 4	30/06/2017	Completed	Lacquers production on May 2017 annexed to Deliverable B.4.2
MS11 LCA of the global process for the production of new eco cans for food (M29)	B 6	30/06/2017	Completed	Calculation of the Carbon Footprint annexed to Deliverable B.6.2
MS12 Survey, Data collection and analysis (M36)	C 2	31/12/2017	Completed	
MS14 Shelf-life for each kind of lacquer and foodstuff (M36)	B 5	31/12/2017	Completed	Assessment of the shelf-life: 24 months for tomato passata and 18 months for beans annexed to Deliverable B.5.2

MS15 Final Review Meeting and demonstration validation, after-life plan established (M36)	E 1	31/12/2017	Completed on 15/12/2017	

Tab.2: List of Milestones

The main output achieved during the lifetime of the project are listed in Table 1. They include deliverables and other activities, mainly of dissemination, not foreseen in the proposal. The corresponding technical documents reporting about the individual outputs are also referenced in the last column of the table. It is also emphasized from the information provided in Table 1 that the number of outputs produced during the project in some cases turned out to be larger than originally planned.

2.3 Summary of the report

The present report describes the results of BIOCOPACPLUS project. The project lasted 43 months.

The report is structured in the following parts: Summary, Introduction, Administrative, Technical– containing the Technical progress per task- Dissemination, Evaluation of the project Implementation, Analysis of long-term benefits and finally Comment on the Financial report.

All the technical actions A.1, B.1, B.2, B.3, B.4, B.6, C.1 and C.2 have been completed. The action B.5 is in progress and will continue after Life, but the results already obtained are interesting and has given important indication on the shelf-life of the eco-cans.

After an update of the industrial tomato wastes produced at national and European level and on their potential reuse (A.1), in the Action B.1 the evaluation and the selection of the correct systems/technologies necessary to realize the extraction procedure as a unit process with a capacity of 100kg/h of peels have been performed, with the aim to design a cutin extraction pilot plant with performances comparable with those obtained in laboratory. The extraction process is divided in some steps; the examination of each process steps has been performed. For each step, the experimental variables of the extraction process have been evaluated and studied in laboratory to optimize the process and to find the best compromise among yield, energy, environmental sustainability and costs. At the end of this work the flow-sheet of the pilot plant has been prepared, together with a list of all components of the items mentioned in the flow-sheet.

The activities of the Action B.2 concerned the design, assembling, start up e implementation of the prototype. In particular the P&ID of the prototype has been defined and the Layout of the Utilities has been prepared based on the calculation and quantitative analysis of the expected consumptions in terms of operating fluids, steam and water, electrical power and compressed air. Moreover the definition of the mass balance of the process for each unit operation allowed to calculate the dimensioning of the main components of the process line (heat exchangers, pumps, hydro - cyclones, pipes, rotating filters, steam and condensate groups, etc.), the production for each cycle and the consumables and reagents consumptions. Based on the layout, the positioning of the equipment has been identified. After a pre-assembling phase the mechanical installation by the realization of the connecting lines has been performed and the validation of the prototype has been carried out by means of water test. Finally n° 3 trials with the products have been performed to set the line.

During the Action B.3, concerning the optimization of all the experimental parameters involved in the extraction process, several trials have been performed and different analytical techniques have been used to evaluate the chemical.-physical characteristics of the products obtained at each step and of the final cutin. The scale-up to a semi-industrial phase gave rise

to some problems that did not occur at a laboratory level, but they led to new technological solutions, which were useful to define the changes and additions to the prototype, described in Action B.2, with the final goal of obtaining cutin with the same performances obtained in laboratory and to find the best experimental conditions for quantitative yield, purity of final extract, consumption of energy and environmental impact. More work than expected has been done, described in n° 2 deliverables.
The Action B.4 allowed to develop a cutin resin at pilot plant level and to formulate n° 4 lacquer suitable for the application on standard industrial line.
The activity has been focused on the following items: optimization of the formulations and process conditions for the pilot production of bio-resin and lacquers in a continuous feed-back about characteristics of the various batches of raw cutin produced by Canneto pilot plant, in order to provide indications for the optimization of the extraction process parameters and consequently to improve quality and workability of the cutin; preparation of pilot batches of bio-resin and semi-industrial batch of lacquers; laboratory and industrial application on various substrates of bio-lacquers and their characterization.
Finally in the Action B.5 the validation of the new eco-lacquer has been performed by means of the evaluation of chemical-physical characteristics of the applied lacquer, electrochemical impedance test to study the insulating and the corrosion properties of the lacquer in model solutions and pack test with different food products to obtain indication on the shelf-life of the new lacquer in standard condition and in comparison with oil-based lacquer. Until the end of the project the duration of the pack tests, performed at 20, 37 and 50°C, ranged between 3 months and 18 months. The results were positive and promising as well as the results of the overall and specific migration tests carried out in compliance with the EU and national Regulation and of the sensory analysis performed according to EN 10192/2000 to study the influence of the lacquer on taste and flavour of the foodstuffs.
As regarding the Action B.6, the environmental impact of the production process of the bio-based lacquer, which is produced exploiting tomato by-products, has been evaluated. To achieve this goal the development of the LCA has been carried out by means of the software SimaPro. The results obtained have been compared with the results of the LCA of an epoxy-based lacquer, The results obtained were impressive concerning the resources consumption and the CO2eq emissions. Using cutin based lacquer up to 800 mg CO2eq could be avoided.
Aim of the action C.1 was to monitor the impact of the project paying particular attention to the environmental problems. At the beginning of the project, a list of environmental indicators has been drawn up, after bibliographic research; to get value of reference of these indicators some questionnaires have been prepared to address to the partners. During the duration of the action the indicators have been calculated and monitored and a comparison has been done between initial and final values.
Their employment helped the identification of hotspots in the processes and allowed to suggest improvements to reduce the environmental impact and in particular limit the non-renewable resources consumption. This tool suggested some improvements described in detail in deliverable B.3.2.
The aim of Action C.2 was to understand consumers and traders concerns and perceptions regarding the switch from traditional epoxy based cans to eco-friendly lacquered cans. To this goal some aspects have been monitored:

- Traders and consumers buying behaviour;
- Willingness of traders and consumers to pay more for safer organic food;
- Awareness and social acceptance of environmental protection benefits.

Several sociological and technical instruments have been used, in particular questionnaires and interviews. The action C.2 has proceeded for all the duration of the project. The

elaboration of the results of the questionnaires and of the interview have given important feedback on the perception of the new eco-cans and potential markets.
As regarding the Action D.1, the dissemination activities have been several and varied, in fact the project has been presented to many conferences and workshop, always achieving great success and arising interest and curiosity. Many and different articles about project have been published on local, national and international newspapers. Television interviews were also made on national channels.
The administrative part reports in detail the successful management process adopted. The management process has been facilitated by generally solid collaborative relationship among partners. In fact in the 43 months of the project, there were intense exchanges and all partners have participated to the activities of the project. SSICA has constantly supported the partners in the management activities as well as in the technical activities. To this regard numerous meetings were organized in order to discuss and solve any technical or administrative problem eventually encountered.
N° 1 amendment has been requested and approved.

3. Introduction

Description of background, problem and objectives

Environmental problem/issue addressed

Today's society, in which there is great demand for high nutritional standards, is characterized by rising costs and often decreasing availability of raw materials together with much concern about environmental pollution.
The food industry produces large volumes of by-products resulting from the production, preparation, and consumption of food. These by-products pose increasing disposal and potentially severe pollution problems and represent a loss of valuable biomass and nutrients. Consequently there is a considerable emphasis on the recovery, recycling and upgrading of by-products.
In Europe, the packaging market is growing year after year and, specifically, food packaging accounts for 65% of the total packaging market, of which 1.9M tonne worth of metal packaging, for approximately €8 million.
The total tomato production in the EU-28 is estimated in about 17.9 million tons in 2016, that each year in the EU-28 generates more than 200000 tons of solid tomato residues (peels and seeds).
BiocopacPlus identifies a new and different possibility to exploit industrial tomato wastes to higher-value and useful products, **using of non-conventional carbon sources to produce biolacquers rather than fossil sources.**
On the other hand the food metal packaging industry for the protection of containers uses organic coatings obtained from oil, depleting natural resources. The production process of the synthetic resins, mainly epoxy based, are processes generating high CO_2 emissions. Moreover, in line with greater attention paid to hygiene/health and the environment, synthetic lacquers have been the subject of several cases of alert. The problem of the migration of residues of polymerisation, monomers and oligomers, as well as of additives, has given rise to press campaigns and has raised doubts and uncertainty in **consumers**, with consequent damage to the image of the can-making industry.
Among others, recently great attention has been focused on BPA, that has considered to have endocrine disrupting effects also at low doses. There is a growing interest to develop BPA-free lacquer able to meet more safety and environmental sustainability requirements

advocated by both consumers, food industries and large-scale retailers and required by always more restrictive laws (EU Reg. 213/2018).
BIOCOPACPLUS promotes the solution to above mentioned problems by carrying out a demonstrative project which, by means of an innovative technology, aims to obtain cutin-based lacquer from industrial tomato by-products, to be employed in the manufacture of metal packaging, that doesn't contain BPA and valorize industrial agro-wastes.

Outline the hypothesis to be demonstrated/verified by the project
The main goal of the project, the realization of a pilot plant for the cutin extraction from industrial tomato by-products, by using a process with a low environmental impact, good qualitative characteristics of the extract and an elevated yield, has been accomplished. The extracted cutin had to have characteristics suitable for the industrial production of the new bio-lacquer. This objective was achieved, as the results of chemical and physical analyses (FTIR, Dry Residue, GC-MS) show, although there are still some problems on the degree of cleaning of the final product. Finally the demonstration of the suitability of the new eco-lacquer to pack different type of food has been performed, by means of pack-test in tinplate and aluminium cans, with tomato, vegetables and meat foodstuffs.

Technical and methodological solution
The approach used to define suitable treatment processes for tomato by-products was, as originally planned, to realize a demonstration pilot plant for cutin extraction and separation. To this aim, a prototype of a flexible pilot plant was designed, built and operated following different gradually steps, including:

- Definition of the protocol extraction (deliverable B.1.1)
- Definition of the design and assembling of the prototype (deliverable B2.1, B.2.2 and following updates)
- Trials on pilot plant (deliverable B.3.1 and its update)
- Industrial production of cutin (deliverable B.2.3)
- Validation and optimization of the prototype (deliverable B.3.2).

All these steps have been very challenging and they have requested a strong collaboration and engagement by all the partners of the project. The scale up of a process has requested a lot of time for each steps, creating even some delays during its assembling and set-up, that led to the request for amendment. Currently the prototype is operating/running and can treat at least 300kg/peels/day.
The extraction method of cutin, patented in the previous project FP7 BIOCOPAC, has been transferred from the laboratory level to a semi-industrial scale, not substantially modifying the procedure, keeping a yield moderately elevated and optimizing the process from an environmental point of view, through the recovery of liquid effluents, the recirculation of solutions, and the reduction of temperatures and time of treatment. The sizing of the plant was set-up at 10-20% of a future industrial plant. For the environmental impact, the LCA analysis has been performed during all the project collecting all the necessary data.
The cutin extracted was characterized by means of different physical chemical techniques to evaluate the degree of purity and the water content. The cutin with the best properties has been used for the synthesis of the bioresin; the protocol of polymerization has been standardized. Then some lacquer formulations has been developed and tested, using organic solvent a two types of curing agents. In particular adhesion and thermal resistance were evaluated. The new lacquer was validated by applying to the metallic materials, tinplate, tin free steel and aluminium, the production of the cans and their filling on the industrial line. The cans filled with tomato based products, legumes and meat have been storage at 3

temperatures, 20°C, 37°C and 50°C, and controlled at established time. The results obtained shown good adherence and barrier properties of the bio-lacquer.
All the on-going actions of the project were made available to the general public and to the potentially involved subjects through intensive dissemination activities that required the activation of different communication channels between project partners, potential users, industries as well as public and private academic institutions. These included a project website that was created as the main means of communication, containing periodically updated information on the results achieved and the outputs produced. Links to the project website were hosted in the web pages of the partners. Furthermore, the participation in thematic workshops and seminars, even organized by the partners was intended to disseminate the knowledge about the results attained, and dedicated publications (technical articles and conference proceedings, posters at conferences and thematic events, brochures) were produced.
The socio-economic evaluation of project outputs was conducted through questionnaires and interviews with different types of stakeholders.

Expected results and environmental benefits
A prototype with a capacity of 100 kg/h has been realized and finally cutin has been industrially produced, more than 450 kg. 50 kg of cutin based resin and lacquer have been synthetized and formulated in a standard pilot plant. Finally about 3000 cans have been realized on industrial line. They have been characterized, by means of mechanical and chemical tests, and evaluated for their hygienic-sanitary and sensory properties, since the cans have to be food-grade.
The obtained lacquer has good adhesion characteristics and high resistance to thermal treatments; it remains a problem of impurities, which create small defects once applied to the metal, which are still being studied and improved.
The project has numerous environmental advantages: valorisation of agro-industrial wastes, CO_2 reduction in the production of eco-cans in comparison with standard one and reduction in the consumption of natural resources. It also has advantages for the health of the consumer, as it does not contain dangerous substances, which can migrate into the food.

Expected long term results
The long terms outputs of the project are believed to have the following types of impact:
- Legislation and policy: support to the legislation action on the Food contact material and to the Waste directive;
- Replicability: application of the same process to different type of vegetables; promotion of locally source industry;
- Transferability: application of eco-lacquer in packaging of products different from foods and in other sector, as interior design or building; use of cutin to produce cosmetic;
- Market and costs: wide application possibilities all over the world, especially in emerging countries, where metallic packaging is growing; cost of the new lacquer will have to be competitive with that of oil-based lacquers.

4. Administrative part

4.1 Description of project management

Project management was structured so as to facilitate frequent communication among the partners and exchange of updated information to monitor the status of the project. A Project Steering Committee (PSC) was appointed at the beginning of the project according to the structure reported in figure 1 and operated in organization and monitoring of the evolution of the project activities, as well as evaluation and implementation of mitigation measures in case of problems. Its composition and organization is never changed. The Steering Committee, with representatives of all partners, has a transversal role with decision power and oversaw project implementation. This turned to be particularly efficient to overcome the problems encountered with some actions (mainly unexpected delays caused by construction of the prototype) and also implied intensive involvement of beneficiaries depending on the nature of the problem to be solved.

Project management and monitoring were conducted with the aid of internal communication tools that have been used both within the project consortium and within the PSC. The main systems used for communication and exchange of information among the partners include: *1)* circulation of e-mail messages on a need basis; *2)* phone contacts on a need basis; *3)* skype conferences on a need basis; *4)* general meetings (among all the beneficiaries); *5)* thematic meetings (among the coordinating beneficiary and the beneficiaries involved in specific actions). In periods of particularly intensive activities, contacts among the beneficiaries occurred weekly. The high frequency of contacts allowed to solve the encountered problems as promptly as possible within the area of the beneficiaries' competence/duties/responsibility, to coordinate the tasks of the subjects involved as well as to keep the other partners constantly informed on the evolution of the ongoing activities. Excluding phone/e-mail/web contacts, the formal meetings held during the project are listed in Annex I.

Internal documents and official reports were exchanged among the beneficiaries mainly via e-mail, through freeware file transfer tools (Dropbox, etc.). According to article 14 of the Partnership Agreements, hard copies of the administrative and financial documents (including time recording documents for the personnel involved) were periodically transmitted by each associated beneficiary to the coordinating beneficiary.

Intensive communication and dissemination initiatives were also undertaken. Participation of the project partners to events including workshops, conferences, fairs (where information points about the project were installed) and other public exhibitions addressed to audiences of various targets was organized on different occasions (see 5.2.2 for details).

The partnership structure remained the same of the project proposal. Accordingly, the list of beneficiaries involved has not been modified in respect to the project proposal either, although some tasks (and related costs incurred) shifted in a limited number of cases from one beneficiary to another. All such changes had already been authorized by the EC with approved amendment (approval date: June 30th 2017; document reference ENV-D-4 SW/LM Ares(2017) 3289087).

The personnel involved in the project activities has been subjected to some minimal changes during the project .

In terms of specific technical activities, the project was arranged into three different types of actions: 1) preparatory actions (studies/surveys [actions A.1], dedicated to the investigations of the characteristics of tomato wastes); 2) implementation actions [B.1-B.6] on the main parameters of the extraction process from lab-scale to pilot plant [action B.1]; on the design and assembling [action B.2]; on the set-up and trials on the pilot plant [action B.3]; on the

formulation and production of the biolacquer [action B.4], on the demonstration of the biolacquer, including pack test [action B.5]; LCA [action B.6]; 3) monitoring actions (monitoring of the impact [action C.1] and of socio-economic impact [action C.2]).
In principle, the implementation actions were sequentially arranged, while this on one side facilitated the pathway throughout the project, on the other side implied that a delay in one of the actions also affected the subsequent activities. However, after some initial tuning of management of the individual actions, some of the delays were partly recovered, so that (with the approved extension of the project duration) all the original targets were finally achieved successfully.
As regarding the monitoring activity both for environmental and social aspect, the related activities have been carried out during all the project.
The activities related to communication have been carried out during the whole duration of the project, from the beginning and they are continuing after the project. Many articles have been published especially on popular newspapers and many interviews have been released by the Coordinator and by other members of the Consortium (see 5.2.2 for details), especially after the inauguration of the pilot plant.
As regarding the role of the partners, the coordinating beneficiary of the BIOCOPACPLUS project has been the research center Experimental Station for the Food Preserving Industry (SSICA). The other associated beneficiaries have been: the CFT group, leader in the construction of food processing plants and in the project responsible of the pilot plant design and assembling, the SALCHI Metalcoat, a lacquer producer, in the project responsible of biolacquer formulation and production and the farm Chiesa, which has offered the site for the pilot plant.
Below the organogram of the project team is showed (Fig.1):

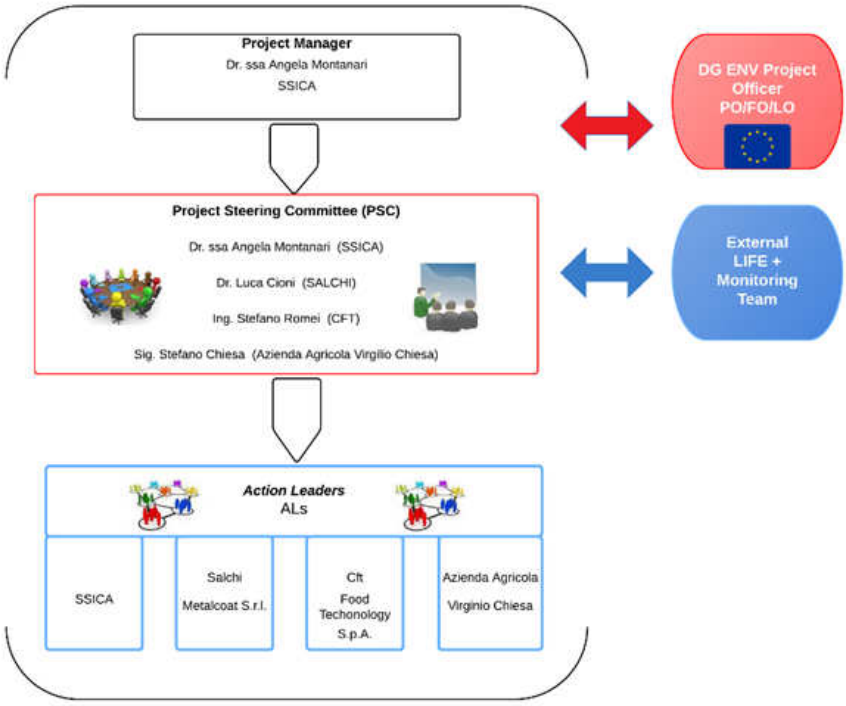


Fig.1: Organogram of the project team

An Amendment has been requested to the European Commission, for an extension of 7 months, in order to have sufficient time to realise the Pack tests, that need at least 9 months. The request of Amendment has been granted by the European Commission. The total duration

of the project has become 43 months, instead of the initial foreseen 36. In figure 2 the updated Gantt chart, approved by the EC, is reported (Annex II).

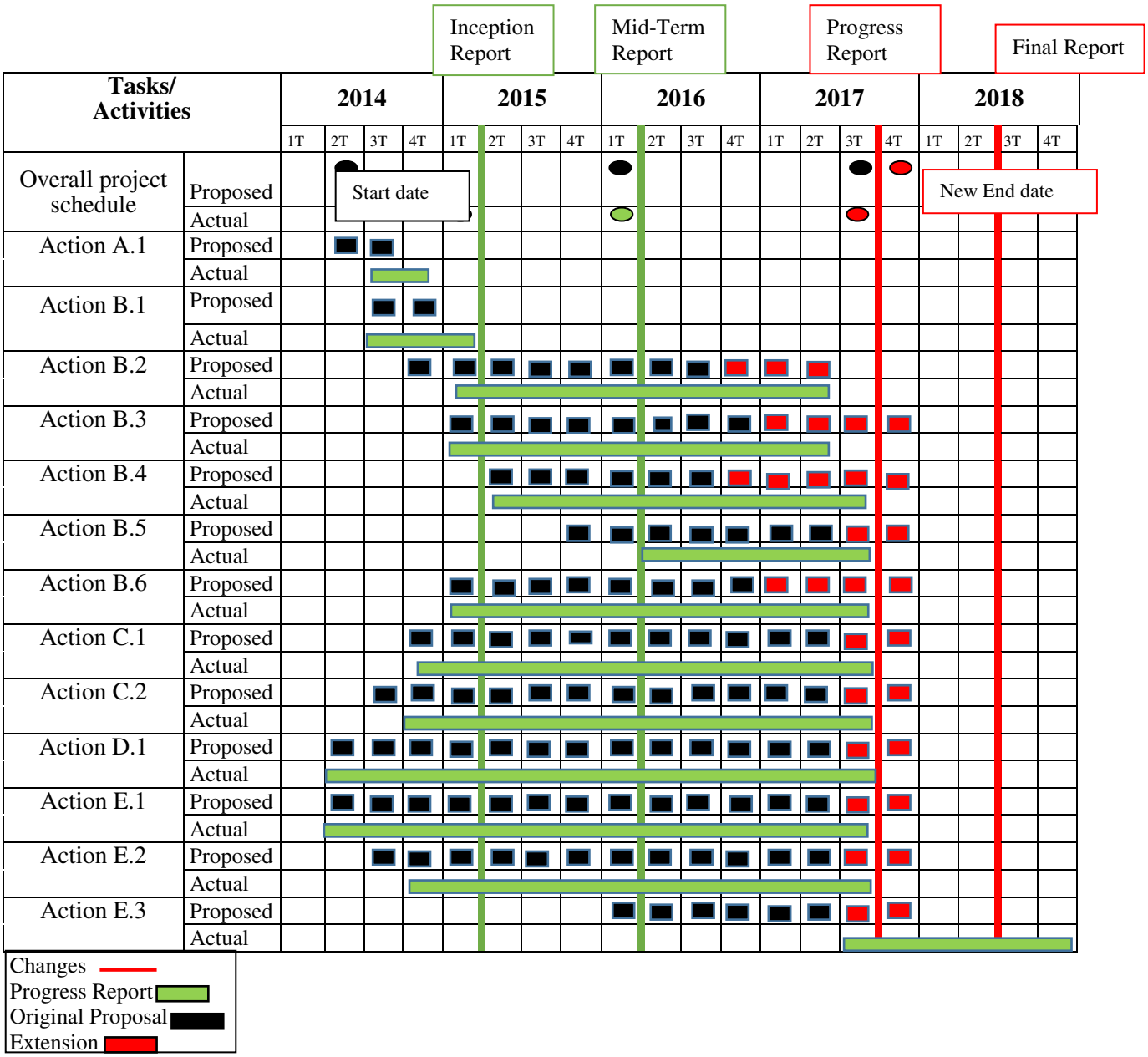


Fig.2: Updated Gantt chart after the approval of the project amendment

Reports on progress have been sent in regularly (see list in table 3) and the feedback from the Commission has been fast and clear.

Type of report	Deadline foreseen	Actual deadline
Inception Report	28/02/2015	28/02/2015
Mid-term Report	28/02/2016	14/04/2016
Amendment	28/02/2017	28/02/2017
Progress Report	28/08/2017	28/08/2017

Tab.3: List of Reports sent to the Commission

4.2 Evaluation of the management system

The project management system adopted during the whole duration of the project has been overall positive and successful. The contacts among all partners of the project have been always intensive and collaborative, trying to exchange all the possible necessary information in a continuous feedback. To exchange information and evaluation of samples, many meetings, involved all partners or bilateral meetings have been organized and carried out, as it is reported in the Annex I. The partners participated to technical meetings sharing their competence and experience. The management process has been facilitated by generally solid collaborative relationship among partners.

We would like to highlight that in the realization of a pilot plant, the communications, information exchange among the chemists who has the chemical knowing of the chemical processes involved, the engineers who transfer the process on a plant and the lacquer technician who evaluated the samples coming from the prototype, are essential and fundamental.

During the first phase of the project, a delay in the assembling of the pilot plant has been collected, due in general to the difficulty of the task. All partners have collaborated to overcome the difficulties, under the supervision of the Project Coordinator. As a consequences n° 3 deliverables, not originally foreseen in the proposal, have been added: the deliverable B.2.2.1, concerning the layout of the utilities of the prototype and sent with the Mid-Term Report; the deliverable B.2.2.2 concerning the detail of the pilot plant and the first trials and sent with the Mid-Term Report; and the deliverable B.3.1.1, concerning the trials on the pilot plant and sent with the last Progress Report.

Two external consultants have been active during the project, the first with Studio Cremaschini, concerning building and authorizations and the second on the development of bioresin, with the CNR in Pisa.

The Project Coordinator, in charge of keeping the contacts with the EC and the monitor, informed partners about specific requests and communication to/from the EC.

The relations between coordinator and the Monitoring Team Astrale-Timesis have been regular and positive by means of formal communication occurring via phone and mail. In particular the coordinator has always kept update the Monitoring Team about the status of the project through regularly monthly report.

Overall n°4 Monitoring visits have taken place during the project, where all the activities ongoing have been explained and discussed in details with the Monitoring Team.

5. Technical progress per task

The technical progress is composed by 11 actions (A.1, B.1, B.2, B.3, B.4, B.5, B.6, C.1 and C.2, E.2 and E.3). Every section explains in detail the work carried out during its development giving details on the way how each task has been implemented and the results obtained.

5.1 Actions

5.1.1 Action A.1 Evaluation of the tomato waste and its potential re-use

The preparatory action A.1 consisted in the preparation and elaboration of a quantitative study on waste derived from tomatoes and their potential reuse. After a brief introduction about the composition of tomato and its possible uses, via different sources, the data relative to the cultivation of tomato, its use in industry and the production of its waste at three different levels, international, European and national, have been analyzed.

The tomato fruit has been presented with all its botanical, morphological and structural characteristics, including the origin of the species, its composition, the principal variety cultivars, environmental needed and periodicity.
The study identified the geographical areas where the availability of tomato waste was greater and it quantified the volumes. The research was focused on 10 European countries, Italy, Spain, Portugal, Greece, Poland, Holland, France, Belgium, Romania, Hungary. From the data collected China is resulted the first tomato producers, while in Europe the two major tomato producers are Italy and Spain and in particular in Italy the main regions where the tomato is cultivated are Emilia-Romagna, Puglia and Campania.
More than a third of the tomato produced are used for the tomato processing industry, where the tomato are processed for the production of the tomato products, that are **Peeled tomatoes**, **passata**, **crushed tomato**, **tomato concentrate**, **tomato juice**. From the analysis of these products it has been possible to find that the main tomato wastes are constituted by skins, seeds and tomato pomace. The composition of these waste has been deeply investigated and it has been possible to conclude that the tomato skins are constituted by different and several chemical components and elements. They contain protein, in particular nine essential amino acids, fatty acids, of which the main is the linoleic acid, carbohydrates and even phenolic acids. Even though the skins are directly exposed to pesticides, these compounds were not found in skins.
The research has also examined the uses of the wastes already available on the market, with the aim to verify the innovative character proposed in the project.
The tomato residues actually can be used for animal feeding, edible oils or fertilizers, however the study outlined that tomato residues can be used even for non traditional application such as bioplastic film and biogas production. It is known that there is a great need to develop chemistry that is based on the use of biodegradable and renewable resources and to develop innovative biopolymer materials. Nevertheless, in literature there is a limited number of studies on the development of bio-polyesters using tomato cuticle as feedstock.
The data collected have been graphically and statistically elaborated, organizing and presenting them in tables, charts and statistical trends percentages.
At the end of the work the study has confirmed the feasibility of the project, in relation to the quantities of skins produced and in relation to the location of the plant, in an area where the availability of waste is high. The study also confirmed the innovative character of the project consisting in the scale-up of an aliphatic polyester (derived from cutin) process production, to use as a lacquer for foodstuffs packaging.
To carry out the study three databases have been consulted:

- FAOSTAT, for the data world
- EUROSTAT, for the European data
- ISTAT, for the Italian data.

These open-data sources are the official database respectively of the FAO Organization (Food and Agriculture Organization Corporate Statistical Database), of the European Union (EUROSTAT is the statistical office of the European Union) and of Italian Institute of Statistics, therefore the data published in these sources are the official data.
Moreover to find information about the production of tomato waste several national and international associations of tomatoes, as the AMITOM (Méditerranéenne Association Internationale de la Tomate) and AIIPA (Italian Association of Food Product Industries) have been contacted
All the indicators of progress of the Action A.1 have been achieved. According to the indicators the data were collected and processed in an articulated manner and in a form suitable for a publication.

Indicators of progress	Obtained results	Attachments
Mapping of source of information and data collection (30%)	3 databases consulted and 10 European countries mentioned in the data production	Deliverable A.1
Data processing and review (60%)	Statistical elaboration of data	
Data consolidation (100%)	Data output as tables and graphs organized for country and geographical area.	

5.1.2 Action B.1 Specifications and Requirements for Cutin Extraction Plant Production and Pre-polymerization

The action B.1 concerned the scale-up of the extraction process and the selection of the correct systems/technologies necessary to realize the extraction procedure as a unit process with a capacity of 100kg/h of peels. In order to design a cutin extraction pilot plant with performances comparable with those obtained in laboratory, the examination of each process steps has been performed. For each step, the experimental variables of the extraction process have been evaluated and studied in laboratory to optimize the process and to find the best compromise among yield, energy, environmental sustainability and costs. At the end of this work the flow-sheet of the pilot plant has been prepared.
The activity had 2 main starting points: the key-drivers defined in the proposal and the protocol of the extraction process set-up in laboratory in the previous FP7 Biocopac project:
Key-drivers

- Extraction efficiency, in order to verify if the procedure developed in laboratory is reproducible on semi-industrial scale the final cutin extracted have to present a sugar and fiber content <0.5%.
- The yield, which have to be comparable to that obtained in laboratory, so not <10%, good 15%.
- The constancy of the final product: this point is fundamental for the development of the resins and lacquers, which need a starting product with known characteristics; the composition of the final cutin must have a minimal content of about 80% of 10,16 – dihydroxyhexadecanoic acid, it must present a peak at 1706 cm^{-1} in the FT-IR spectrum
- Maximization of the number of solution recirculations: identification of the maximum content of salts/solids, which is acceptable/admissible for the extraction process.
- Energetic and environmental costs: thermal treatment with the lowest energetic consumption, lowest variations of temperature among the different phases and above all the possibility of recirculation and recovery of the used solutions, reducing in this way the water consumption, will be preferred.
-

Cutin extraction process' parameters.
0- Supply of waste and freezing;
1 – Peels separation;

2 – Thermal treatment: 100°C for 6 hours;
3 – Solid/liquid separation;
4 – Cutin precipitation;
5 – Solid/liquid separation;
6 – Reduction of the water content of the cutin.

For each phase the most significant variables were identified and evaluated at different levels and in various combinations with one another. A very high number of experimental tests, greater than expected, was carried out. In particular the test were performed considering more the 100 combinations of the following parameters

- Flotation as system to separate peels and seeds
- Ratio for the soda solution between wet peels/soda
- Thermal treatment (temperature and time)
- Centrifugation conditions. (rpm and temperature)
- Acidification with n° 3 type of inorganic acids
- Evaluation of salt content after recirculation
- Solubility of cutin in n° 3 organic solvents in different ratios: Dowanol PMA, MIBK, THF

In total n°65 combinations of the parameters indicated have been studied and n° 64 trials of solubility of the extracted cutin have been carried out.
The evaluation of the results obtained in each trial was based on the analysis of the properties and characteristics of final product, fundamental for the development and synthesis of the bioresins. Even the efficiency of the extraction process has been considered.
The analytical methods utilized are listed below:

- Yield %
- FT-IR spectroscopy
- Dry residue or total solids, %
- GC-MS analysis
- Solubility

For some selected samples, even the fiber content, the optical residue and the protein content have been determined.

The optimal values of the process parameters was identified, to be referred in the definition of different components of the plant, are reported in the table 5. The detailed values of the parameters are confidential.

Experimental Variables	Set Conditions
Separation skins/seeds	flotation system
Reaction stoichiometry (Pg_{bucce}/V_{NaOH})	xxxx
Thermal treatment parameters	xxxx
pH value for isolation of cutin	xxxx
Centrifugation parameters	xxxx

Tab.5: Optimized process conditions

For the condition of the thermal treatment, it was decided to modify temperatures and time compared to the laboratory to obtain a good compromise among temperature, time and extraction efficiency.

The choice of the acid to be used was based on the cost, since the inorganic acids tested had the same behaviour in relation to the yield and efficiency of extraction.
The centrifugation parameters were examined by monitoring in the FT-IR spectrum the peak at 1700 cm^{-1} and the formation of the shoulder at 1720-1730 cm^{-1}. Even speed, time and temperature of centrifugation have been considered and evaluated, helping to identify the most suitable component of the pilot plant among centrifuge, filtration and decanter.
The decision on the use of energy from renewable sources and its quantification has been postponed to Action B.3, when the flow-sheet of the plant was available. However, for heating it was decided to use the steam produced by an oil boiler.
The area of the plant has been identified. The procedure for the environmental authorization has been presented to the municipality of Canneto sull'Oglio on 29-07-2015, according to the new regulations ("www.impresainungiorno.gov.it") and it has been registered on 12-11-2015 (with the protocol assignment).

All the indicators of progress of Action B.1 were achieved (deliverable B.1.1.).
The decision about the most appropriate system/technology for each step of the extraction process has been done with the adequacy respect to the key-drivers.

Indicators of progress	Obtained results	Attachments
Drivers of the pilot plant identification (20%)	The key drivers of the pilot plant identification have been evaluated and confirmed	Deliverable B.1.1
Definition of basic requirement of the system technologies (40%)	All the basic requirements of Pilot Plant components have been defined, in particular the kind of peels separation, the concentration of soda solution, the combination time-temperature, the conditions of separation liquid/solid, the pH and the type of inorganic acid, the yield. The stability of cutin during the transport at room temperature will be studied and evaluated during the experimental work of the next Action B.2, because it depends on the type of separation technology adopted.	
Upscaling and revising requirements (60%)	An elevated number of trials has allow to analyse the studied parameters on a major number of levels to identify the different component of the prototype. In fact SSICA and CFT in close collaboration have identified the experimental conditions the most possible similar to the industrial conditions, by turning for help even to technologies of other plant sectors, as oenology.	
Authorization application and dossier field for prototype installing (100%)	The administrative procedure for the building part has begun and on the whole the necessary environmental authorizations have been defined.	Impresa in un giorno - SUAP application

5.1.3 Action B.2 Plant Design and Prototypes Assembling for Cutin Extraction and Polymerization

The performed activities concerned the design, assembling, start up e implementation of the prototype. The work was divided in subsequent stages.

1. Based on the analysis performed in Action B.1 for the identification and selection of the best technology to be used for an industrial scale up, the flow-sheet of the pilot plant has been defined (Fig.3) together with a list of all components of the items mentioned in the flow-sheet. The project has been divided in different sub-phases (Seeds separation; caustic solution introduction, heating process, peels extraction; Cutin precipitation; cutin extraction). For each of them the technology used and the referring components that implemented the corresponding technology have been described.

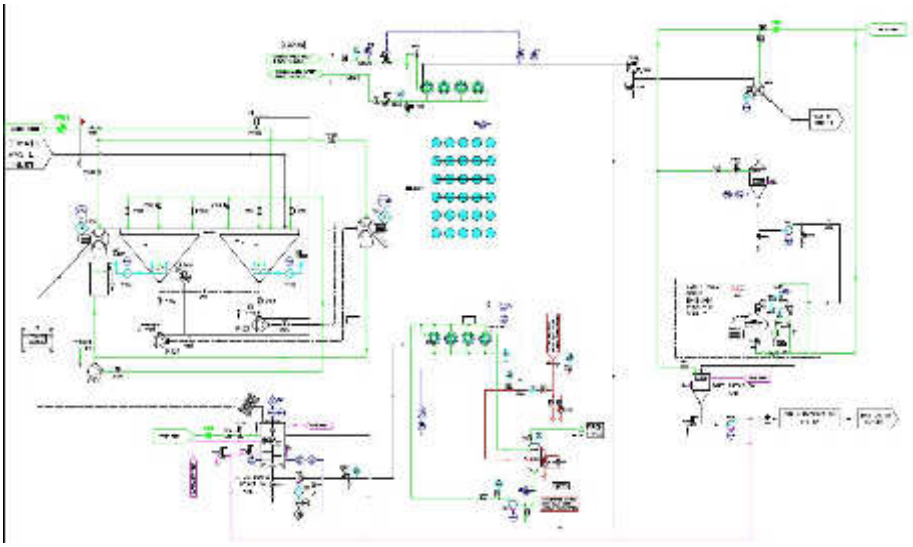


Fig.3: Flow-sheet of the pilot plant

2. The P&ID of the prototype has been defined. In order to make easier to identify the main sections of the process, the document was divided into some steps, and a detailed P&ID for each step was prepared: peels separation group with hydrociclones; thermal treatment; separation and precipitation.
3. The Layout of the Utilities has been prepared based on the calculation and quantitative analysis of the expected consumptions in terms of operating fluids, steam and water, electrical power and compressed air. The drainage points were also identified. For each fluid the requested main features from microbiological and chemical point of view were evaluated.
4. Definition of the mass balance of the process for each unit operation through the quantification of the main key parameters, ratio, percentage, flow rates, included in the mass balance. That allowed to calculate the dimensioning of the main components of the process line (heat exchangers, pumps, hydro - cyclones, pipes, rotating filters, steam and condensate groups, etc….), the production for each cycle and the consumables and reagents consumptions.
5. Based on the layout, the positioning of the equipment has been identified. Then by means of the 3D modelling the design of all the equipment were performed and the 2D constructive/operative drawing has been generated

6. After a pre-assembling phase the mechanical installation by the realization of the connecting lines has been performed. All the machines were connected to a control panel (Fig.4) to improve the pilot plant automation (feeding of peels, discharge of solids in centrifugal separation, acidification, cleaning operations).

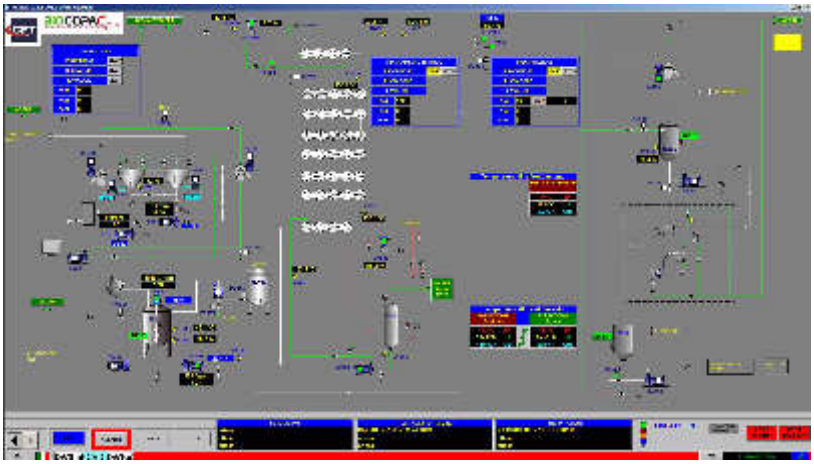


Fig.4: Control panel of the pilot plant

7. The assembled prototype was validated by means of water test of the equipment and a system cleaning and washing procedure has been defined.
8. n°3 trials with the products have then been performed to set the line. This part of assembling was very important to evaluate and fix the key process parameters in relation with the characteristics of the raw materials and of the final cutin. That allowed to make a reverse engineering analysis useful for the optimization of the different operational steps.
The prototype has been the subject of different and further implementation and changes that have been made throughout the period of duration of the Action, in connection with the Action B.3 in order to improve the final quality of the extract and to make the extraction process more automated.
Changes concerned both additions of some components such as pumps or valves, as well as the main equipment. Changes were introduced for technological, but also for safety reasons, such as the manufacturing of a closed tank for the acidification phase or the use of an automatic washing machine to clean the plates of the final centrifuge and reduce exposure to soda. According to the extract characteristics, also process parameters were changed (Action B.3), namely floating conditions, thermal treatment times and temperatures, number of discharging of the alkaline centrifuge.
The details of all upgrades are found in deliverables B.2.

The main problem, still unresolved, concerns the identification of the industrial system that implements adequately the final stage of the extraction process of cutin (separation of the precipitate after acidification). The problem of the implementation of this technology on an industrial level is connected to the very particular physical properties of the bio-resin desired, and in particular to a very high viscosity of the precipitate. Other solutions were tested, but none in a satisfactory way. Currently, cutin is packed manually in 5 kg plastic pails.
All the indicators of progress were achieved, as resulted from the deliverable produced B.2.1, B.2.2.1, B.2.2.2, B.2.3.

Indicators of progress	Obtained results	Attachments
Decision on the Separation method (30%)	The main components of the pilot plant have been chosen, the flow diagram has	Deliverable B.2.1

	been confirmed. The definition of the final phase of the extraction is still ongoing.	
Process control and management (60%)	Definition of the main layout and of the main Layout utilities of the cutin extraction pilot plant with relative drawings	Deliverables B.2.2 and B.2.2.1
Prototype assembling and set-up (100%)	Installation, test trials, start-up and industrial production	Deliverables B.2.2.2 and B.2.3

5.1.4 Action B.3 Plant testing and Cutin Extraction Analysis

The Action B.3 concerned the optimization of all the experimental parameters involved in the extraction process, that has been divided into successive and consecutive steps. Each step has been studied and adapted to the pilot plant, transferring it from a laboratory scale (Action B.1) to a semi-industrial scale. Several trials have been performed and different analytical techniques have been used to evaluate the chemical.-physical characteristics of the products obtained at each step and of the final cutin. The scale-up to a semi-industrial phase gave rise to some problems that did not occur at a laboratory level, but they led to new technological solutions, which were useful to define the changes and additions to the prototype, described in Action B.2, with the final goal of obtaining cutin with the same performances obtained in laboratory and to find the best experimental conditions for quantitative yield, purity of final extract, consumption of energy and environmental impact.

A part of the experimental activity has also been carried out at the pilot plants of SSICA. Several extraction tests have been performed, trying to evaluate the influence of a range of values of the main pilot plant process parameters (temperature, time, speed of centrifugation) and testing even some components of the prototype, provisionally located at SSICA. After that about n° 35 cutin extraction trials have been performed on prototype in Canneto. Details of all the trials are reported in the table 6.

	Trials number	**Skins processed (kg)**	**Cutin (kg)**	**Yield (%)**
Trial at prototype	35	5000	250	7-10
Trials at SSICA pilot plant	7	61.2	16.8	10-25
Trials at laboratory level	66	16.7	1.9	10-15

Tab.6: Number of tests performed

The analytical methods used to characterize and investigate cutin and other intermediates products are the same already described in the Action B.1, namely:

- Yield %;
- FT-IR spectroscopy;
- Dry residue or total solids, %;

- GC-MS analysis;
- DSC;
- TGA;
- GPC.

In a numerous series of tests the optimal process conditions of the different phases have been found as described below:

- *The flotation to separate the skins from the tomato seeds*

The technology chosen for flotation system has been two stages of flotation arranged in series, where the water flotation of the mixture of peels and seeds was performed. To improve the efficiency of separation some modification has been introduced. Also the right amount of peels has been evaluated. Finally the experimental protocol for flotation has been decided.

Fig.5: Flotation tank, first trial with water

- *The reaction stoichiometry*

In Action B.1 the initial reaction stoichiometry between peels and soda and the Soda concentration have been defined

The solution defined in Laboratory, was not able to move forward in the heating system. Different ratios were then investigated, to define the optimal ratio, based on FT-IR analysis of the cutin. The soda concentration has also been evaluated, in the wide range. Different combinations of ratio skins: soda and concentrations of soda have been experimented, the best results have been obtained performing the extraction with a ratio skins: soda equal to xxx and with a concentration of soda equal to approximately xxx.

- *Thermal treatment*

The thermal treatment has been studied and optimized to obtain a suitable cutin.

Different combinations temperature/time have been tested, always remaining in the specific range, indicated from the preliminary study. The influence of the cooling temperature has been also evaluated. The best experimental conditions have been found.

- *The elimination of exhausted skins*

The importance of the filtration's efficiency in the phase of exhausted skins' elimination, after the alkaline extraction was the most critical and most widely analyzed parameter, as it is the main factor that controls the reproducibility and the purity of the final extract and therefore the subsequent lacquer.

Several systems have been tested, including machines that separates any suspended solids by means of a dynamic tangential filtration with ceramic discs, usually used in oenology and a filter press, usually used for the separation of sludge. Finally, a centrifuge has been chosen,

successively replaced with one of greater capacity. The centrifuge works continuously. This clarification step was not originally planned on the prototype, but it has been inserted after the verification of its influence on the characteristics of the extract.

- *The addition of acid*

After several comparison tests the type of acid for acidification was decided. With this acid, a solid with features compliant with the standards of the cutin, as appearance, stickiness and FT-IR spectrum was obtained on the prototype (Fig.6).

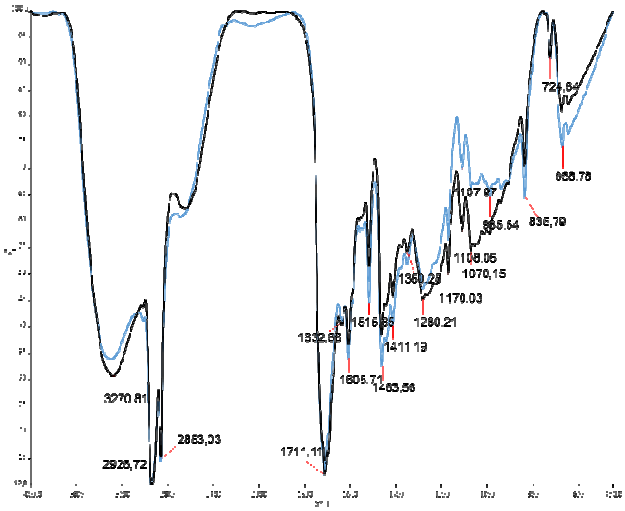


Fig.6: FT-IR spectrum of cutin obtained in trial 8 at Canneto (black) and at SSICA (blue)

We decided to monitor the pH not in continuous and indirectly, by inserting a volumetric acid doser.

For the acidification, a tank in 316 stainless steel was used. A volumetric control of the acid added has been inserted. Finally all the junctions for the acid have been realized in plastic (also the pump to enter acid in alkaline solution), to limit the corrosion of the materials and the contamination of the cutin.

- *Test with tap water*

All the extraction tests performed in laboratory have used distilled water, but in the pilot plant it was necessary to use tap water and in particular the water coming from the Chiesa reservoirs. After several tests, no significant difference has been observed in the samples treated with soda diluted in Chiesa water.

- *Pasty/ stickiness appearance of the final extract*

The last phase of the cutin extraction process, consisting in the separation of the solid precipitate after acidification, is an open problem, not simple to solve, because the final solid extract presents a particular appearance, namely as very sticky. Different solution have been investigated. After trying a machine that separates the solid of interest by means of ceramic disks, the use of a centrifuge has been decided. Moreover cutin was obtained (Fig.7), suitable for a positive bioresin synthesis.

Fig.7: Acidification and removal of precipitate-cutin

The insertion of a cleaning step with nitric acid and soda to be performed at the end of each pilot plant trial has revealed very useful and necessary for the success of the next extraction.

- *Final characterization of products*

The cutins extracted were characterized by means of different analytical techniques, such as the GC-MS analysis, GPC analysis. FT-IR spectroscopy, thermogravimetric analysis (TGA) and differential scanning calorimetry (DSC). In addition, several variables were studied, both experimental parameters of saponification reaction (different temperature/time combinations, extra additives etc.) both parameters of final products. Finally we were able to explain many characteristics and appearance of amorphous polymer obtained (the cutin).

- *Parameters optimized*

For each variables the operative conditions were selected; the corresponding values are not reported in the Table, due to confidentially reasons.

Experimental Variables	Set Conditions
Separation skins/seeds	flotation system in two tanks
Reaction stoichiometry ($P_{Kg\ bucce}/V_{L\ NaOH}$)	confidential
Soda concentration	confidential
Thermal treatment parameters	confidential
Elimination of exhausted peels	confidential
Acid	confidential
Final separation of precipitate	Centrifugation

Tab.7: Set conditions defined

After the selection of the process parameters and the implementation of the prototype specific trials have been carried out in order to obtain a sufficient amount of cutin, about 50 kg, for the industrial production of bio-resin and for the industrial application of the bio-lacquer for the final Pack Test.

- *Environmental optimization*

The environmental properties of the cutin extraction process have been analysed and the critical points in the different phases have been discussed in order to find good solutions to reduce the total environmental impact without compromise yield and quality of the final extract. As the process does not use organic solvents the greatest impact comes from the consumption of energy and water and from the disposal of the exhausted peels. To improve energy consumption, the boiler fuelled with naphtha was replaced with one fuelled by LPG, a cleaner gas. For the reduction of energy consumption, already quite contained, hypotheses were formulated on the possibility of renewing some equipment, with lower consumption than the old model in use.

Higher water consumption occurs during flotation and in the discharge phase of the supernatant after cutin precipitation.
The results of the chemical and microbial analyses showed the possibility of using the same water to float until/for 5000 Kg of tomato by-products (peels and seeds), instead that for 1000 kg of tomato by-products. Moreover at the end the flotation waters could be used for the production of compost, as foreseen in a new project. Finally, laboratory tests in batches indicated that the production of biogas is more elevated with the same number of peels. The process has been improved to reduce environmental impact; of course, there are still wide margins for optimization.

All the indicators of progress have been completed and the definition of experimental protocol of the pilot plant process was established.

Indicators of progress	Obtained results	Attachments
Prototype plan roll-out and trialing protocol established (20%)	Every step of the extraction process has been studied, identifying the best technologies and machine necessary to perform each extraction process.	Deliverable B.3.1
Prototype plan roll-out and trialing protocol established (30%)	The installation is completed; the process protocol is established	Deliverable B.3.1.1
Prototype conducting, trialing and yield assessment (50%)	Several trials have been performed on prototype, realizing an industrial production necessary for the Pack Test of the project	
Prototype adaptations (75%)	The prototype adaptations are still in progress, depending on the results obtained from each extraction and from each final product.	
Prototype evaluation (100%)	Completed	

5.1.5 Action B.4 Bio-lacquer Formulation Production and Analysis

The Action B.4 concerned the study and the investigation necessary to scale up from laboratory cutin extraction conditions to pilot plant ones the use of raw cutin for the synthesis of the bioresin and for the applications in lacquer formulations. The plant design for the production of bioresin was defined.

All the stages of work planned in the action B.4 have been carried out in the period April 2015-December 2017.
The activity has been focused on the following items:

- go further in the evaluation of the extracted raw cutin, in order to optimize formulations and process conditions for the pilot production of bio-resin and lacquers;
- feed-back about characteristics of the various batches of raw cutin produced by Canneto pilot plant, in order to provide indications for the optimization of the extraction process parameters and consequently to improve quality and workability of the cutin;

- design and validation of the characteristics of the industrial/pilot plant for bio-resin production;
- preparation of pilot batches of bio-resin and semi-industrial batch of lacquers;
- laboratory and industrial application on various substrates of bio-lacquers and their characterization.

The activity was carried out directly at Salchi Metalcoat regarding evaluation of bio-resins and lacquers obtained from various batches of raw cutin coming from Canneto plant and evaluation of semi-industrial production of coatings.
Instrumental characterizations have been performed in IPCF (Pisa) and SSICA (Parma) labs.
Industrial pilot production of bio-resin and painting of the sheets and production and filling of related cans have been performed by specialized companies in the sector, under the supervision of Salchi Metalcoat.
The details are reported in deliverables B.4.1 and B.4.2, where all the tests and trials experimented in the different laboratories are described, the obtained results are discussed and the conclusions are drawn. Below the main results obtained are summarized.

- More in detail, over 30 samples of raw cutin obtained from pilot extraction trials conducted in the Canneto plant were evaluated. They have been treated (working on process conditions) and roughly 60 samples of bio-resin were tested by the lab. in coating formulations.

From this process of evaluation and optimization, formulas and production procedures for cutin based bio-resin (code 20600) and for 4 types of coating (codes 7249012 VI 1001 BIOCOPAC ORO, 7249013 VI 1002 S.S. BIOCOPAC ORO, 7484001 SM 2000 BIOCOPAC BEIGE, 7249010 VI 1000 BIOCOPAC ORO) have been defined in lab.
The goal to work with raw cutin using plant structure as similar as possible to those conventionally employed by the manufacturers of resins for coatings have been reached.
All the formulations are based on raw materials suitable for food contact and the global migration test on 7249010 and 7249013 gave positive results (within the limits).
These coatings have characteristics suitable for internal and external use, except for the drawback of the colour for the external lacquers (beige instead of white).
Other trials carried out in laboratory were the evaluation of solvents from renewable sources glycerine to replace those of oil origin and the development of powders to be used for welding protection, suitable to work as a side stripe with cutin-based coating (good results with a powder developed by Salchi Metalcoat, coded 8010699).

- At the pilot/semi-industrial level, resin 20600 (2 batches of about 50 kg each one), lacquers 7249010 (1 batch of about 50 kg) and 7249013 (about 10 kg) were produced and characterized.

Confirmed the reproducibility of the results between laboratory and pilot/semi-industrial production.
Some problems of dots e cratering on the films applied have been confirmed. Probably further work is required on the cleaning of raw cuticle coming out from the pilot extraction plant.
The lacquers have been applied in industrial plant and/or in laboratory on tinplate, TFS and aluminium and the painted panels processed industrially and/or in lab. to get cans and lids.
After quality control, the cans were filled with different foods and submitted, at different times, to pack tests.
The plan of this project action has been practically realized; only characterization by migration tests (and pack tests) on the industrially produced cans is still ongoing and it will serve to confirm the results obtained in laboratory tests.
For the next steps, it is worth investigating further the "cleaning of raw cutin" aspect, testing changes on the extraction process and verifying the effects on bio-resin and paint, all in view of an industrial development.

Comparison between indicators of progress and obtained results, expressed in quantitative terms (where possible)
All the indicators have been reached.

Indicators of progress	Obtained results	Attachments
Optimization of the formulation (25%)	Formula and process have been validated for bio-resin and 4 lacquers.	Deliverable B.4.1
Batch preparation (50%)	2 batches of bio-resin and 2 batches of lacquers (gold and side stripe) have been carried out.	Deliverable B.4.2
Coating evaluation (75%)	The characteristics of the pilot batches of lacquers have been evaluated and validated.	Deliverable B.4.2
Bio-lacquer application on tinplate (100%)	The pilot batches have been applied at industrial level on Tinplate and TFS.	Deliverable B.4.2 and annex III- videos of lacquer application

5.1.6 Action B.5 Demonstration of the Bio-lacquer Production and Application including Pack Test

The Action B.5 has been modified in the request for Amendment, approved by European Commission on June 2017.
This Action concerned the validation of the new eco-lacquer developed and produced both in laboratory and at industrial scale. To this goal different instruments have been used:

- evaluation of chemical-physical properties of the applied lacquer performed both on sheets and on empty cans.
- electrochemical impedance test to evaluate the insulating and the corrosion properties of the applied lacquer in two model solutions, weak acidic and sulphurating solutions;
- overall and specific migration tests in the simulants foreseen in the EU and national Regulation to verify the hygienic-sanitary properties of the lacquer;
- sensory analysis according to EN 10192/2000 to study the influence of the lacquer on taste and flavour of the foodstuffs;
- pack test with different food products to evaluate the shelf-life of the new lacquer in standard condition and in comparison with oil-based lacquer.

Due to the delay accumulated, to obtain significant results, n° 2 pack test have been realized, a preliminary pack test with a correct duration (12 and 18 months at 20°C) and a final pack test, with a limited duration, (3 and 6 months at 20°C) but useful to confirm the results of the first one on larger number of cans.
In detail, for the preliminary Pack Test a small batch of cutin of about 1.5 kg produced on the prototype has been used to synthesize 1 kg of the bio-resin and of the bio-lacquer at laboratory scale. The bio-lacquer has been applied manually on tinplate sheets by using a bar-coater, then about 110 three-pieces cans 0.5 kg have been produced on industrial line. The can body was lacquered with cutin-based lacquer, while the OT and EO ends were lacquered with a standard lacquer and the side-stripe was not applied. The cans were filled on industrial line

with a sulfurizing products based legumes, named lentils and with a food products of medium acidity, namely tomato "passata". The filled cans have been stored at three different temperatures, 20°C, 37°C and 50°C up to 18 months, depending on the storage temperature.
For the final Pack Test, n°2 batch of cutin of about 50 kg/each, coming from the industrial production trials carried out in March and April 2017, has been used to synthesize both the bio-resin and the bio-lacquer at pilot plant level. The bio-lacquer obtained has been applied on tinplate and tin free steel sheets industrially. Successively from the tinplate lacquered sheets, about 3000 three-piece cans 0.5 kg size have been obtained on industrial line; as from the tin free steel lacquered sheets, the can ends/lids have been obtained.
A small amount of cutin has been used to synthesize the lacquer for the protection of longitudinal welding, the side-stripe, that has been applied on cans industrially, by spray lacquering.
Therefore for the final Pack Test, the can in all its parts, the body cans, the side-stripe and the lids have been cutin-based lacquered, differently from what happened for the preliminary Pack Test, where only the body can was cutin-based lacquered.
Three different food products have been chosen, one sulfurizing product based legumes, namely borlotti beans, and two medium acid food products, namely tomato "passata" and diced tomato. About 350 cans have been filled with beans, 100 cans have been filled with tomato "passata" and finally 300 cans have been filled with diced tomato. All the filling have been realized on industrial line and stored at three different temperatures, 20°C, 37°C and 50°C up to 6 months, depending on the products.
The final Pack test have lasted shorter than the preliminary Pack test, however this doesn't affect the results because it is a validation of the preliminary Pack test's results.
Finally the Pack Test with aluminium cans has been developed and performed in a simplified way. Specifically a small amount of cutin coming from the prototype trials have been used to produce in laboratory the cutin-based biolacquer for aluminium alloy 3105, that has been manually applied on aluminium sheets in laboratory by using a barcoater. From the lacquered aluminium sheets, about 100 two pieces cans 95 g have been produced on industrial line. The cans have been filled with pieces of meat in beef broth at SSICA plant, reproducing an industrial filling. The lids used for aluminium cans were standards lids. The cans have been stored at two different temperatures: 20°C and 37°C up to 12 months.
The results obtained were interesting and highlighted that the new eco-lacquer developed has a chance to substitute oil-based lacquer for the protection of the tinplate and aluminium cans for food products.
The results obtained in the electrochemical measurements showed a greater corrosion resistance in a cysteine solution respect to the citric model solution, due to their different corrosiveness. The Rp values are higher at longer time of storage. The same happens for the Cdl values. Instead it is interesting to outline that the Cc values are high (E-10/E-09) for all the duration of the test regardless of the characteristics and the type of the metallic substrate; this is indicative of good insulating properties of the lacquer. Due to manual application of the lacquer the presence of some discontinuities / defects in the lacquer were observed (Fig.8). In particular low values were measured for TP samples with low tin coating weight in comparison with samples BS, D11.2 and D5.6. Unlike the Rp and Rct values the capacity values are good, indicative of a proper insulating and adherence properties of the lacquer. In conclusion, the electrochemical test has given important indication on the good barrier properties of the biocopac lacquer, comparable with those of standard lacquers. The corrosion phenomena observed were mainly due to the porosity and discontinuities of the lacquer. So another important results of the test concerned the strategies to be pursued to improve the corrosion resistance. In particular, in acid foodstuffs it is critical to decrease the defects of the

lacquer, while for all other type of food the condition of application should also to be optimized.
The results of the preliminary and final pack test, that confirm the trend obtained in the EIS measurements, allow some considerations.
Cans filled with legumes, lentils and beans: the vacuum values are in the standard for all the cans. No corrosion phenomena were observed, only tin sulphuration phenomena developed in the cutin cans and increased over the time due to the lack of the zinc oxide pigment. In conclusion the eco-lacquer showed acceptable behaviour with sulphurating products (Fig.9).

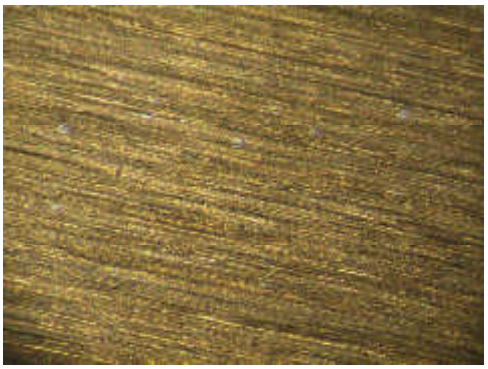


Fig.8: 40x, defects on the lacquer (TFS)


Fig.9: 20x, cutin cans, beans, 3 months, 20°C

Cans filled with tomato products: in the preliminary pack test, where the cutin lacquer has been applied in laboratory, the cutin cans showed good corrosion behaviour, comparable with the standard cans; the swelling of both type of cans was due to the lack of protection of the longitudinal welding. In the final pack test the lacquer applied on industrial line showed some defects, that are at the origin of the corrosion phenomena observed together the low tin coating weight adopted. The corrosion process was more intense for the cans filled with diced tomato, due to the higher aggressiveness of this product (Figg.10 and 11).

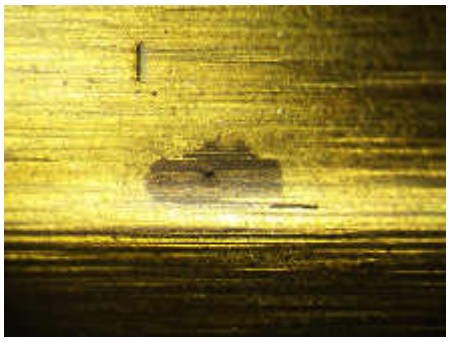


Fig.10: 30x, cutin cans, Diced tomato, 6 months, 20°C


Fig.11: 30x, cutin cans, tomato passata, 6 months, 20°C

The adherence of the lacquer was good. The standard cans didn't show any corrosion phenomena. In conclusion the cutin lacquer can be used in contact with acidic products, provided the application is done correctly.
Cans filled with meat: the cutin cans showed good behaviour, comparable with standard cans; no corrosion phenomena were observed. In conclusion aluminium cans coated with cutin lacquer can be used in contact with meat product (Fig.12). The pack test controls will continue after LIFE at the expense of the partners in order to have a significant shelf-life.
However based on the results of both the pack tests and taken into account the lack of zinc oxide pigment, a shelf-life of 36 months for tinplate and aluminium cans filled with sulphurating products (legumes, fish or meat) equivalent to that of standard cans, can be

considered realistic. For acidic products the recommended standard shelf-life is 28 months. Considering the results of the visual examination of the can body obtained in the first pack-test after 12 months at 37°C, score 2, the recommended shelf-life could be possible, provided that the defect of the lacquer will be significantly reduced also in the industrial application.


Fig.12: 20x, cutin aluminium cans, meat, 9 months, 20°C

Concerning the sensorial test carried out the results obtained are described below and detailed in the deliverable B5.2. Reference sample means "absence of lacquer".
The olfactory tests revealed that there was no significant differences between the sample and the reference. In one case a score equal to 2 has been assigned to the sample, however, the provided description showed that the scent of the sample is not annoying.
The taste tests revealed that there was no significant differences between the sample and the reference. The table, Statistical expression of the results for the triangular examination, reported in the Rule UNI 10192/2000 has been consulted in order to evaluate the differentiation tests. The number of correct answers is lower than the minimum value required for a significance level of 5%. As in the olfactory test, one answer scored a value equal to 2. The description of the flavour perceived, revealed that the sample didn't confer an unpleasant flavour to the simulant.
It can be concluded that the bio-lacquer **doesn't cause sensorial modification** of the food product, it is inert from the organoleptic point of view.

Finally the compliance of the new lacquer with the national (DM 21-3-73) and EU Regulation (Reg. 10/11; Reg. 1985/2004) has been evaluated by means of overall and specific migration test.
The tests have been performed on two type of samples:

- Empty TP cans (n° 5)
- TP specimens of area 1 dm2 cut from TP sheets for the body cans production (n° 12)

For the test 3 simulants have been used:

- Distilled water, Simulant A
- Acetic acid 3% (w/v), Simulant B
- Corrected olive oil, Simulant D

The overall migration limit in the food simulants is 10 mg/dm2 or 60 mg/kg.
The results are reported in the Annexes of the deliverable B5.2. In the specific migration test the determination of the substances subjected to a SML (Specific Migration Limit) were performed, in particular BADGE, BADGE.H2O, BADGE.2H2O, BADGE.HCl, BADGE.2HCl, BADGE.H2O.HCl, Cyclo-diBadge and BPA. The SLM for Bisphenol-A is 0.6 mg/kg, while the sum of the migrations of BADGE, BADGE.H2O, BADGE.2H2O, shall not exceed the limit of 9 mg/kg in food or in food simulants, or 9 mg/6 dm2 and the sum of

the migrations of the BADGE.HCl, BADGE.2HCl and BADGE.H2O.HCl shall not exceed the limit of 1 mg/kg in food or in food simulants, or 1 mg/6 dm2. The Cyclo-diBadge does not have a SLM.
All the samples were below the overall migration limit. All the values obtained in the specific migration test are the LQ (Quantification Limit) except for the BADGE.2H2O in simulant B, which is 0.004 mg/dm2 (LQ= 0.003 mg/dm2). The results are reported in the Annexes of the Deliverable B.5.2.

Comparison between indicators of progress and obtained results, expressed in quantitative terms (where possible)
All the indicators have been reached.

Indicators of progress	Obtained results	Attachments
Biolacquer production (25%)	1 kg of bio-lacquer obtained at laboratory level for preliminary Pack test 1 kg of bio-lacquer obtained at laboratory level for aluminium Pack test About 50 Kg of bio-lacquer obtained on industrial level for final Pack test	
Production evaluation (50%)	Chemical-physical characterization of the bio-lacquer application	Deliverable B.5.1
Can manufacturing (75%)	About 110 tinplate cans cutin lacquered produced on industrial line for preliminary Pack Test. About 150 aluminium cans cutin lacquered produced on industrial line for aluminium Pack Test About 3000 tinplate cans cutin lacquered, with also side-stripe cutin-based and about 2400 tin free steel lids cutin-lacquered produced on industrial line for final Pack test	
Pack Test (100%)	Two Pack tests in progress, the preliminary and the final	Deliverable B.5.2

5.1.7 Action B.6 Life Cycle Assessment (LCA)

Aim of the action B.6 was to determine the environmental impact of the production process of the bio-based lacquer, which is produced exploiting tomato by-products. To achieve this goal the development of the LCA has been carried out by means of the software SimaPro. The results obtained have been compared with the results of the LCA of an epoxy-based lacquer, that has been selected as a standard.
During the first part of the project, the analysis focused on the disposal of tomato by-products (deliverable B.6.1). The first evaluation concerned the current exploitation of these by-products as animal feed and organic matter for biogas production. In this study, it has been calculated the possibility of depleting an established quantity of by-products through both scenarios. The related information has been provided through bibliographic research and ad-hoc questionnaires address to Chiesa, which currently carries out this kind of disposal in his farm.

In parallel, the environmental impact of the extraction process of cutin has been assessed. To achieve this goal, data related to resources and materials consumption has been collected during the tests performed on the prototype. Some information acquired had been not always homogenous as for example the wastes produced; the tests on the pilot plant has been performed to evaluate the prototype performance and to optimize the process, for this reason in some cases the quantity of wastes undergone variations. Concerning the energy consumption, the data has been collected on the production site and consulting the layout description of the pilot plant.
In table 8, the data acquired are listed; the corresponding values collected during each tests are confidential.

Input
Tomato by-products
Water from well
Energy (thermal treatment, decanter, centrifuge)
NaOH
Acid
Output
Exhausted skins
Acidic solution
Biogas

Tab.8: Data of cutin extraction process

The processing of this data with the software SimaPro, revealed that the energy consumption has a great influence on the impact of the extraction process and for this reason the non-renewable resources depletion is higher than the expectation. This first result has been attributed to the fossil fuels consumption for the prototype operation and to the process that has not yet been optimized. The impact assessment of the cutin extraction process has been analysed trough 17 impact categories (ILCD midpoint method) and 3 damage categories (ReCiPe endpoint method). In figure 13 the effect of materials and processes, involved in the cutin extraction, on the three damage categories Human Health, Ecosystem and Resources is reported. It can be noticed that fuels, LPG (bordeaux) and diesel (grey), are the major responsible of the impact in all the categories.

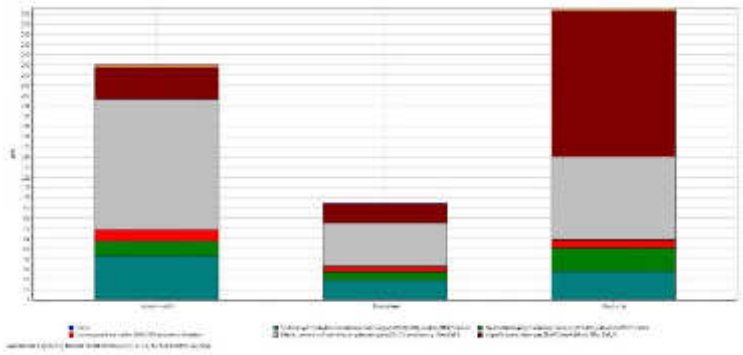


Fig.13:Normalized-weighted impact of cutin extraction process calculated with ReCiPe Endpoint H/A method

The tests performed on the pilot plant provided a suitable quantity of cutin to produce the bio-lacquer at semi-industrial scale. After the production of the cutin polymer and the bio-lacquer, Salchi provided the data related to the processing. This data allowed the development of the second part of the LCA, which is the impact assessment of the bio-lacquer production and the

cans coating (deliverable B.6.2). The information related to the production process of the bio-lacquer is limited, because it has not been possible to perform a substantial number of tests due to the high quantity of cutin required for each trial. However, the evaluation has been carried out using the available data.
A first evaluation has been carried out on the lacquers production starting from the production of the resins which have been employed in the formulation. The study has been performed for two different cutin-based lacquer and for two standard coatings. The cutin-based lacquers have been synthetized by cutin polymer crosslinked with an A resin or a B resin. The standard coatings instead are gold epoxy-based lacquer and white enamel. This first evaluation highlighted the importance of the optimization of the processes, because the consumption of fossil fuels in the extraction process of cutin turned out to be the main responsible for the environmental impact of both the cutin-based lacquers. The second evaluation dealt with the cans production and the comparison of their environmental impact. The evaluation considered two types of cans respectively coated with cutin-based lacquer and gold epoxy-based lacquer. A 3 pieces tinplate can, 0.5 kg size, and a 2 pieces aluminium can, 95 g size, have been selected for the comparison. Concerning the 3 pieces cans, two different calculation has been performed; the first one considered a 3 pieces can coated with the lacquer and protected in the welding area with the side stripe, while the second calculation excluded the impact generated by the side stripe. This choice has been made because the standard and the cutin-based side stripe are significantly different in terms of formulation and quantity applied, for this reason the impact of the standard side stripe turned out to be significantly high.
The comparison between the impacts of the standard and the eco cans has been performed despite the processes related to cutin have been not optimized and the materials involved are not on industrial scale. The results achieved revealed that the production of cutin-based cans is less impacting than the standard one. The evaluation of the 3 pieces cans with side stripe and the aluminium can got a positive result, despite the processes considered are not optimized. In figure 14, the histogram reports the comparison of the impact assessment developed for both type of 3 pieces cans. The cutin-based cans with side stripe (in red) scored the lower value in all the three damage categories, comparing their results with the reference (in grey).
The 3 pieces cutin-based cans without side stripe (in green) got the worst score; the comparison with the standard can (in blue) shows that the production of this type of can is not significantly advantageous, but an improvement is expected after the optimization of the processes, in particular concerning the resources consumption.

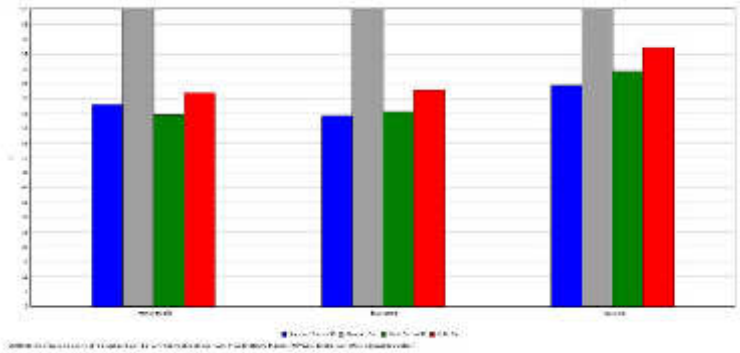


Fig.14: Damages impact of a 3 pieces tinplate cutin-based can versus gold standard can calculated with ReCiPe Endpoint H/A method

A second calculation has been performed assuming the optimization of the processes related to cutin, in order to verify the improvement achievable in terms of environmental impact, in particular concerning the resources consumption. For optimization has been intended the

processing of 100 kg/h of tomato skins, the reduction of water used and the recovery of the acidic supernatant.
As expected, better results have been obtained and for all the cases evaluated, the cutin-based cans are advantageous compared to the reference. A significant improvement has been noticed in the category Resources, especially in the comparison of 3 pieces cans without side stripe (Fig.15).

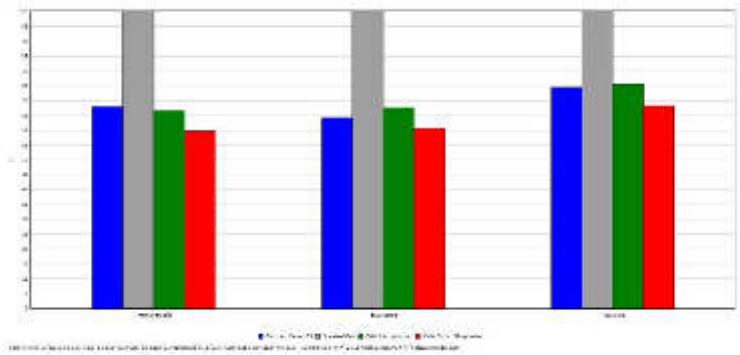


Fig.15: Damages impact of a 3 pieces tinplate cutin-based can versus gold standard can without side stipe calculated with ReCiPe Endpoint H/A method

The optimized processes have been used to develop the LCA in order to have a scenario as close as possible to the industrial one and compare it to the LCA of a standard can. This evaluation included the extraction of raw materials, the lacquers production, the cans production and their end of life that corresponds to the disposal after the consumer use. As described in deliverable C.1.2, an alternative disposal of the eco-cans has been not developed during the project, due to the limited number of cans produced. Instead, for the optimized scenario, the analysis has been developed focusing on the increase of the recycling percentage, thanks to the application of a trademark on the eco-cans, informing the consumer of the exploitation of a bio-based lacquer, which does not release toxic substances during its disposal. The percentage of recycling used for the LCA has been defined as follows: 85% for the 3 pieces cutin-based cans compared to the 75% for the standard cans and 75% for the 2 pieces cutin-based cans compared to the 65% for the standard cans. These percentage has been deduced from the RICREA website. The remaining percentage for each disposal scenario has been considered as municipal solid wastes allocated to incinerator. The LCA has been outlined for a number of cans equal to the number produced in one day (8 hours) by one industrial line with a speed production of 600 cans/min. The comparison of LCA revealed that the most impacting process is the production of the cans, in particular the metal extraction and production. However, the waste scenario contribute to the reduction of the final score. In detail, it has been determined that both the 2 pieces (in green) and the 3 pieces cutin-based cans (in yellow) achieved the better results in all the damage categories, despite the differences with the standard cans (in red the 2 pieces cans, in blue the 3 pieces cans) are very small (*fig.16*). The benefits determined can be attributed to the higher percentage of the recycling together with the exploitation of the bio-based lacquer.

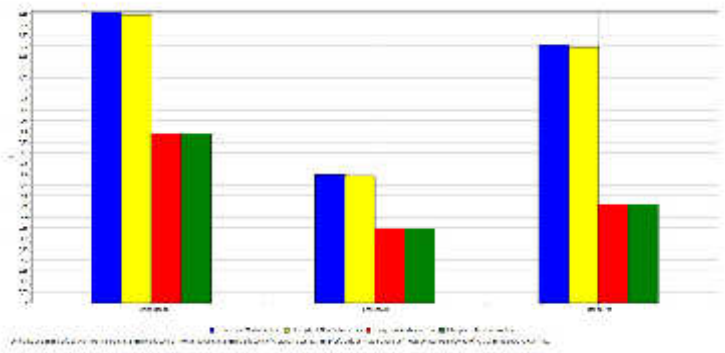


Fig.16: Damages impact of cans LCA calculated with ReCiPe Endpoint H/A method

To complete the evaluation, the emissions of CO_2 eq have been calculated for each type of cans with the IPCC GWP method. In table 9, the results achieved are listed. Each value has been calculated through the difference between the emissions of the standard and the cutin-based cans. The emissions have been calculated considering the current performance of the pilot plant (second column) and those expected after the optimization (third column). An improvement in the results is evident. In addition, the emissions that could be avoided by one day production on one industrial line, have been calculated in order to quantify the entity of the advantage once the process will be on industrial scale (fourth column). At last, the emissions avoided have been also calculated for the LCA (last column). This calculation has been performed considering the same number of cans as one industrial line production. The most significant improvement has been achieved by the 2 pieces cans and can be attributed to the recovery of aluminium. The processing of aluminium, for the cans production, is very expensive in terms of resources consumption, for this reason the recycling of this type of metal packaging probably contribute to avoid an impressive amount of GHG emissions.

Type of can	***Avoided emissions***			
	Pilot process	***Process optimized***	***Industrial line/day***	***LCA-industrial line/day***
3 pieces tinplate can with side stripe	730 mg CO_2 eq/cans	840 mg CO_2 eq/cans	242 kg CO_2 eq/day	288 kg CO_2 eq/day
3 pieces tinplate can no side stripe	10 mg CO_2 eq/cans	120 mg CO_2 eq/cans	34.6 kg CO_2 eq/day	Not evaluated
2 pieces aluminium can	18 mg CO_2 eq/cans	42 mg CO_2 eq/cans	12.1 kg CO_2 eq/day	58 kg CO_2 eq/day

Tab.9: Avoided emissions of kg CO_2 eq calculated with the IPCC GWP 100 a method

Comparison between indicators of progress and obtained results, expressed in quantitative terms (where possible)
All the activities have been completed.

Indicators of progress	**Obtained results**	**Attachments**
Inventory analysis 30%	Determination of input and output of cutin extraction process and bio-based lacquer	Deliverable B.6.1

Impact assessment 60%	Impact assessment of the extraction process of cutin and cutin-based lacquer	Deliverable B.6.1/B.6.2
Data interpretation, quantification and conclusions 100%	Impact assessment of cutin-based cans compared with impact assessment of standard cans	Deliverable B.6.2

5.1.8 Action C.1 Monitoring of the impact of the project actions

Aim of the action C.1 was to monitor the impact of the project paying particular attention to the environmental problems. At the beginning of the project, a list of environmental indicators has been drawn up, after bibliographic research, in order to perform a correct monitoring and the environmental assessment of the processes involved in the project. The environmental indicators identified are listed below.

1. Reduction of non-renewable raw materials use
2. Recycled tomato-based waste employed
3. Reduction of CO_2 emission
4. Reduction of carbon footprint
5. Energy from renewable resources
6. Reduction of water use
7. Consumption of electrical and thermal energy
8. Reduction of wastes and wastewater
9. Percentage of recyclability of the product at its end of life, reduction of pollution during the recycling.

The employment of these indicators helped the identification of hotspots in the processes and allowed to suggest improvements to reduce the environmental impact and in particular limit the non-renewable resources consumption. This tool suggested some improvements described in detail in deliverable B.3.2.

In order to carry out the monitoring, the indicators have been expressed with a reference value, whose calculation has been performed after the collection of necessary data. This action mainly focused on the extraction process of cutin, because this process is the fundamental difference between the standard and the bio-based lacquer production.

The data required for the calculation of the environmental indicators has been collected through ad-hoc questionnaires address to the project partners and during the tests on the prototype. The reference values have been calculated considering two different cases: the current performance of the process, achieved at the end of the project, and the expected results after the optimization of the extraction process of cutin and the improvement of the cutin-base lacquer formulation, that will be reached during the following years. In table 10, the results of both calculation have been reported and respectively classified as *Current Value* and *After Life Value*. The calculation of most of the indicators considered the entire process, from the cutin extraction to cans coating, for this reason they have been calculated after the LCA evaluation, which has been carried out in action B.6 by means of the software SimaPro.

Below are some observations on some of the environmental indicators. The detailed description of the calculations and the discussion of results have been reported in deliverable C.1.2. In table 10, the environmental indicators are listed with their respective reference values.

The attention has been focused on the non-renewable resources consumption and consequently on the emissions of CO_2 and GHG. The first and the second indicator express the quantity of non-renewable material substituted with the tomato by-products in the lacquer production process. The After Life Value reports the expected results after the optimization of the formulation that is the increase of the exploitation of cutin in the bio-lacquer production. In the table, the indicators 3 and 4 are expressed with three different values, which correspond to three different scenarios, described in detail in deliverable B.6.2. Each value has been calculated through the difference between the emissions of the standard cans production and the cutin-based cans production. The results reported in the table represent the emissions avoided by the substitution of the standard cans production with the cutin-based ones. The first value shown corresponds to the avoided emissions of a 3 pieces tinplate can, 0.5 kg size, coated and protected in the welding area by the side stripe, the second one considers the same type of can, but without side stripe and the last value represents the emissions avoided for a 2 pieces aluminium can, 95 g size. The value 0 mg CO_2/cans no side stripe reveals that the production of the 3 pieces cans without side stripe, in the case considered, does not reduce the emissions of CO_2. The main reason for this result is the non-optimized process of the cutin extraction. Moreover, the exclusion of the side stripe contribution showed that in the standard can, the current formulation of the powder side stripe and the quantity employed are very impacting. It can be noticed the improvement of the same indicator in the After Life Value; after the optimization of the processes; the avoided emissions increase from 0 to 90 mg/cans no side stripe.
Indicators 6 and 7 are strictly related to the prototype performance; at the end of the project, the water and energy exploitation proved to be excessive, because the prototype has worked at a lower level than the actual capacity. In the After Life Value, the improvement is evident. The optimization of the extraction process of cutin has been considered, therefore the performance of the pilot plant has been assumed at 100 kg/h of processed skins, which corresponds to the prototype capacity.
The indicator 8 represents the wastes and wastewater produced during the extraction process and allocated to biogas plant for energy production. The value reported in After Life Value, is lower, because it has been planned to recover part of the acidic supernatant and reuse it in the extraction process in order to reduce both wastes produced and water consumption. At the present, the supernatant is completely discarded and allocated to biogas.
Concerning the last indicator, related to the recyclability of the new eco-can, at the moment the disposal of the cans produced during BiocopacPlus is the same as the conventionally adopted, because the production of this type of cans is limited to the project objective and an alternative disposal can not be developed. For the calculation of this indicator, the alkaline treatment of the cans has been considered in order to separate the lacquer from the metal before the melting phase. After this treatment, the disposal of the bio-lacquer will be less impacting due to the presence of a bio-compound and the absence of BPA, which can be released. In the After Life Value, the percentage of recyclability is expected over 80%, because it has been planned to code the cutin-based cans with a trademark, which will make aware the consumer to the presence of a bio-based coating. This initiative will promote the purchasing of these eco-cans and their recycling.
In general, an improvement for all values is expected after optimization of the processes related to cutin and the improvement of the lacquer formulation.

Environmental Indicator	Current Value	After Life Value
1. reduction of non-renewable raw materials use	2.5 kg non-renewable material avoided/ 1000 m^2 metal sheet	3.5 kg non-renewable material avoided/ 1000 m^2 metal sheet

2. recycled tomato-based waste employed	17 kg tomato waste/ 1000 m^2 metal sheet	23 kg tomato waste/ 1000 m^2 metal sheet
3. reduction of CO_2 emission	400 mg CO_2/cans with side stripe	500 mg CO_2/cans with side stripe
	0 mg CO_2/cans no side stripe	90 mg CO_2/cans no side stripe
	3 mg CO_2/Al cans	25 mg CO_2/Al cans
4. reduction of carbon footprint	730 mg CO_2 eq/cans with side stripe	840 mg CO_2 eq/cans with side stripe
	10 mg CO_2 eq/cans no side stripe	120 mg CO_2 eq/cans no side stripe
	18 mg CO_2 eq/Al cans	42 mg CO_2 eq/Al cans
5. energy from renewable resources	90 dm^3 biogas/ 150 kg skins	-
6. reduction of water use	7 kg water/ kg skins	4 kg water/ kg skins
7. consumption of electrical and thermal energy	68.5 kWh/150 kg skins 2 kg lpg/150 kg skins	59 kWh/150 kg skins 2 kg lpg/150 kg skins
8. reduction of wastes and wastewater	450 kg wastes/150 kg skins	216 kg wastes/150 kg skins
9. percentage of recyclability of the product and its end of life, reduction of pollution during the recycling	current metal disposal	>80%
	50%-70%	50%-70%

Tab.10: Environmental indicators and their reference values

Comparison between indicators of progress and obtained results, expressed in quantitative terms (where possible)
All the activities scheduled have been performed and successfully completed.

Indicators of progress	**Obtained results**	**Attachments**
Identification of specific environmental indicators (10%)	Definition of the indicators selected	Deliverable C.1.1
Preparation, distribution and collection of filled questionnaires (40%)	Editing of two ad-hoc questionnaires addressed to Salchi and Chiesa. Collection of data requested	Deliverable C.1.1

Necessary for data collection in order to calculate the defined indicators (80%)	Calculation of indicators.	Deliverable C.1.2
Statistical elaboration of the results in relation to LCA (100%)	Calculation of indicators.	Deliverable C.1.2

5.1.9 Action C.2 Monitoring the socio-economic impact of the project actions on the local economy and population

The aim of Action C.2 was to understand consumers and traders concerns and perceptions regarding the switch from traditional epoxy based cans to eco-friendly lacquered cans. To this goal some aspects have been monitored:

- Traders and consumers buying behaviour;
- Willingness of traders and consumers to pay more for safer organic food;
- Awareness and social acceptance of environmental protection benefits.

Several sociological and technical instruments have been used, in particular questionnaires and interviews.

The action, which has proceeded for all the duration of the project, has been focused on the following aspects:

- Research and selection of a figure competent in the preparation and processing of questionnaires, to which SSICA has entrusted a specific contract.
- Preparation and draft of the Evaluation framework to analyze the socio-economic impact: methodological plan and grids (Annex IV MS9 to the Inception report). The document have discussed the methodological approach adopted for the socio-economic evaluation of the project. The following points were considered and planned: analysis tools (questionnaires and interviews) and types of data sources, identification of the reference population, types of questionnaire for each group identified (n°4), data collection and analysis, presentation of the results. The above methodology have met the expected results related to economic and social indicators.
- Preparation and submission of questionnaires, preparation and submission of online survey and one-on-one interviews.
- An archive of surveys concerning the socio-economic context of large retailers and an archive of news related to BPA and other endocrine disruptors. Furthermore, specific attention has been devoted to recent developments that have taken place in re-use of tomato waste in other alternative ways, different from BiocopacPlus coating.

SSICA has led the action, defining the methods and tools for monitoring the socio-economic impact. CFT, SALCHI and CHIESA have provided market data and insights into business trends.

N°4 groups were identified, dividing the reference population as described below:

- Group 1: SSICA, CFT, Salchi Metalcoat customers, and the Chiesa suppliers. It has contained all the contacts of the first level, closer to the themes of the project, potential direct users of the project results; in this group the industries of lacquering and packaging manufacturers, steel, and metallurgical manufacturers have prevailed especially.
- Group 2: Retailers and supermarkets. It has involved the retailers and the retail purchasing managers, who take commercial decisions regarding supply in their outlets.

- Group 3: Consumers. It has involved Consumers' associations and Ethical Purchasing group, who are very responsive to topics related to quality of life and environmental issues.
- Group 4: institutional partners. It has included public and private authorities involved in the project for geographical proximity, for theme or for the actors involved in it.

The stakeholders of the four groups identified in the Evaluation Framework have been defined in collaboration with the partners, who have provided the necessary contacts. For the first two groups different questionnaires have been prepared, preferring and highlighting specific aspects (quality, cost, safety).

The group 1 was consisted of first-level contacts, closest to the issues of BIOCOPACplus, potential direct users of the project results. Specifically they were agro-food industries, that processed tomato products and companies producing food packaging.

In the questionnaire addressed to Group 1, the following indicators were used:

- Perception of the market orientation
- Current waste management (cost, disposal, revenues, etc.)
- Current level of attention to food safety
- Current level of care for the environment
- Potential competitors and / or stakeholders in the valorization of by-products

In the questionnaire addressed to the Group 2, the following indicators were used:

- Perception of the market orientation
- Focus on food safety
- Care for the environment
- Quality vs. price

It has been decided for the group 1 to conduct the survey at both national and European level, while for the group 2 the survey was extended even at international level. For the first group the questionnaires have been submitted by email addressing the Responsible of the Quality, while for the second group the questionnaires have been submitted by email addressing the Responsible of the Quality, the Marketing Director, the Purchasing Director, the Canned Food Buyers, the Press Office, the Sustainability Director, Institutional relations manager of large retailers. For the first group the response rate was 27% (32 of 118), for the second group the response rate was 3% (5 of 139). 81 Italian companies and 31 foreign industries were contacted. The response rate for Italian companies was about 26% and the response rate for foreign companies was 29%; so greater interest by foreign companies in comparison to Italian companies was revealed. The companies most involved in the project have been largely Companies with more than 500 employees (13 of 32 respondents), as shown in figure 17.

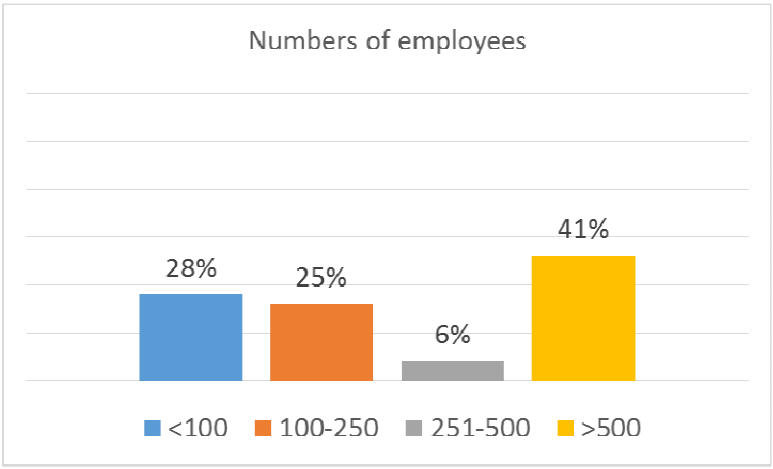


Fig.17: Number of employees of the Companies interested in the BiocopacPlus project

The results of the Group 1 have allowed some considerations (more details were reported in the Deliverable C.2.1):

- Food safety, the valorization of food waste and market orientation were the three most interesting aspects for the interviewed sample.
- The companies have perceived a growing interest in eco-friendly product lines within the large-scale organised distribution, so that the focused marketing tool is to be positioned in the direction of environmental sustainability.
- Faced with the prospect of a sustainable eco and safe product but with a higher price the consensus is only 50% of the surveyed.
- For group 2 it was decided to solve the lack of reply realizing a survey, updated to 2015, 2016 and 2017 on the socio-economic context of large retailers, on market orientation and on the buying behaviour of the consumer, in conjunction with the project's progress.
- The results of the Group 2 have allowed some considerations (more details will be reported in the Deliverable C.2.1):
- The companies have perceived a growing interest in eco-friendly product lines within the large-scale organised distribution, so that the focused marketing tool is to be positioned in the direction of environmental sustainability.
- Based on the low response rate and following the phone conversation with the respondents who were available to answer questionnaires, it seemed that Large Retailers may be interested in the BiocopacPlus lacquer only on a finished product, since the lacquer is just a component of the metal packaging and not the finished product
- Faced with the prospect of a sustainable eco and safe product but with a higher price the consensus was only 20% of the surveyed, as shown in the figure 18.

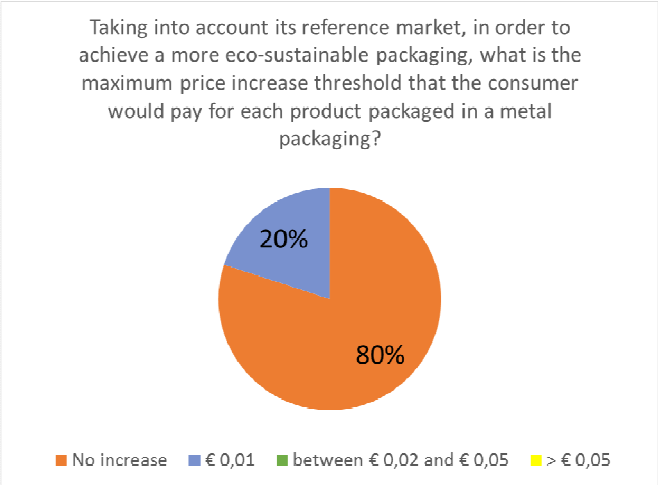


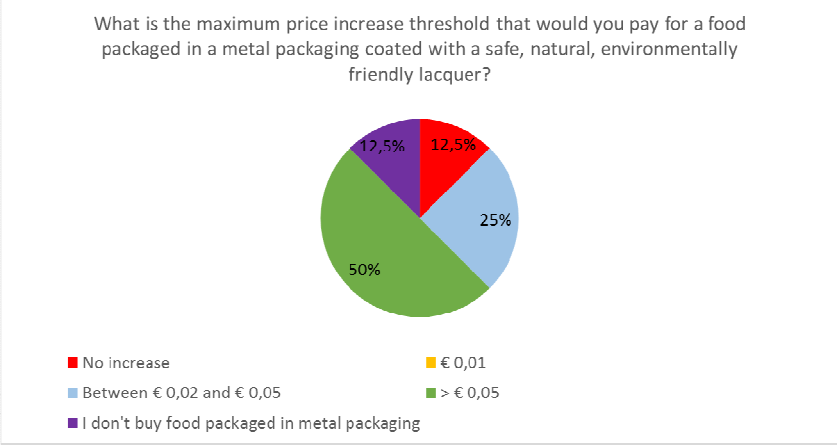
Fig.18: Maximum price increase for Group 2

From the analyzes carried out, it was possible to outline the strategy to be used to monitor the group 3 and group 4, for which the contact identification process has been initiated.
The third group was in turn subdivided into two subgroups: the consumer associations and the ethical purchasing groups.
In the questionnaire addressed to the Group 3, the following indicators were used:

- Focus on food safety
- Care for the environment
- Quality vs. price
- Orientation to purchase food packed in metal cans

For the consumer associations, a questionnaire and a related interview have been carried out while for ethical purchasing group the survey has been carried out in online form. The principal consumer associations have been contacted for the circulation of questionnaires and interviews availability. Various and different tools such as website, email, phone and direct visits have been used. For ethical purchasing groups, the questionnaires have been submitted by mail with the invitation to fill out an online questionnaire on the website www.survio.com. For the consumer associations, the response rate was 30% (5 of 20) while for ethical purchasing groups the response rate was only 11% (8 of 71).
The results of the Group 3 have allowed some considerations (more details are reported in the Deliverable):

- Consumer organizations are interested in food safety, but ask to be better informed and made more aware on product use;
- For consumer organizations and solidarity buying groups canned food is currently perceived as not very natural and for this reason it is not often purchased by consumers who usually buy organic products.
- For representatives of Solidarity Buying Groups, BiocopacPlus's most interesting characteristic is the enhancement and reuse of agri-food waste, a topic linked to the fight against waste. 75% of the contact persons of Solidarity Buying Groups stated to be ready to pay more for a food contained in a packaging coated with a safe, natural and eco-friendly lacquer, as shown in the figure 19.



The survey on the socio-economic context of the third Group has been integrated with sector studies of 2016 and 2017, in conjunction with the project's progress and with a survey published on the BiocopacPlus website and on social networks of the questionnaire addressed to other potential visitors.
With regards to Group 4, i.e. institutional stakeholders, the Municipalities of Canneto sull'Oglio, Parma and Collecchio, the Provincial Government of Mantova, the Councillorships for Agriculture of the Lombardy and Emilia Romagna regions and representatives of Coldiretti, ANFIMA (Association of Italian Metal Packaging Manufacturers), Metal Packaging Europe, the SPRING Cluster and the United Nations Organisation for Industrial Development showed interest in the project.
Feedbacks were recorded when interest was expressed and declared via the press.

The social analysis performed allowed to collect the necessary data for the calculation of the defined indicators.
For the first and second groups, the most important aspects have resulted the attention to food safety, and valorization of agro – food waste; for the third and fourth groups the most important points were the attention to the environmental theme and the circular economy. For all the groups in the open-ended question about BiocopacPlus the most recurring key words

were BPA and Safety. The necessity of alternatives of BPA for metal food packaging derived from analysis of socio-economic context was supported by the high response rate of the Group 1 and their positive feedbacks on the project. We can suppose that this topic will be more and more important due to the publication of the new UE Regulation on BPA in 2018.
The analysis highlighted the importance of the price of the eco-can. In the survey carried out, any increase in price for a new metal packaging resulted in an heterogeneity of answers. The scale varies from a low level of agreement of the large retailers, to a low-medium level of the Group 1, to a medium-high level of the associations of consumers until a real readiness of the Ethical Purchasing Groups. In fact, the 50% of respondents of Group 3b would spend more than €0.05 for each product packaged in a metal packaging coated with the bio-lacquer. As reported in the table 11 the final cost of the new bio-lacquer will be comparable with those of oil-based lacquers, about 7.0 euros/kg in comparison with 4.0 Euros/kg. Considering that with 1kg of lacquer about 5200 cans are lacquered, the incidence of the cost of the new lacquer would be 0.0006 Euros per can, practically negligible and decidedly lower than €0.05 indicated by consumers.
The direct economic value generated by the project haven't calculated in detail, however considering that the cost of disposal is volatile, if tomato by-product becomes the raw material for the production of the bio-lacquer, at worst the industry will not have to pay for their disposal and therefore will no longer represent a cost, but an economic advantage. Add that the exhausted skins produce more biogas (Action B3). In total, then, the economic value of tomato wastes could reasonably increase, at least 5%.
The reduction of workers' health risk for the lacquer production is another important issue to be considered. In fact if a company produces about 17000 tons/year of lacquer, substituting a little part of its production with the cutin lacquer, ex 2000 tons/year, a reduction of exposure to dangerous substance of 11% can be obtained. 2000 tons allows to coated about 15 mnl cans, that means a low percentage of the total cans used by one tomato industry during the tomato campaign.
Comparing the results of the questionnaire with the research on the socio-economic context, the importance of the environment preservation remains one of the most relevant factor for all the groups, with different emphasis on the environmental impact or on the valorization of wastes.
During these activity 37 stakeholders have been involved, of which 32 agro-food industries and packaging companies, 1 large retail chain, 1 consumer' association, 3 institutional stakeholders.
Moreover during the project new jobs position have been created, a biorefinery technician at Azienda Agricola Virginio Chiesa, and n°2 junior researchers at SSICA, while SSICA researchers and Cft engineers have trained Alessandro Chiesa and Stefano Chiesa for about 700 hours.
In the proposal a panel test was foreseen. The panel test was not carried out because of the difficult hygienic-sanitary to realize a taste test in a retailers; it was then decided to replace the panel test by the presentations of the project results and of the pack test to the retailers. The event was planned by sending an e-mail to Italy's 6 largest retailers following two criteria: previous feedbacks when submitting questionnaires to Group 2 and interest in environment related topics; the response rate was 16% (1 out of 6). The direct exchange with large retailers seemed to be promising for placing the BiocopacPlus lacquer on the market. The retailers demonstrated high interest in the opportunity of commercialize the new eco-cans. In conclusion the indicators expected have been reached, as shown in the table below.

Indicators	Value foreseen in the proposal	Current value

Direct economic value generated	increase of 5%-30% of the tomato waste value	at least increase of 5of the tomato waste value
Raw materials costs	equivalent to oil based product	higher than oil based product, from 7 € compared to 2 oil based product, however the influence on the final lacquer is negligible, 0.0006 Euros per can
N° new job positions regarding the application of the project	n° 1-4	N°3
Training activities for the employees involved:	at least 150 hours	700 hours
stakeholders involved in the project (at supply chain level);	up to 20	37
Reduction of workers' health and safety risks	10% (no handling of harmful compounds for lacquers and food cans manufacturing).	10-12% in the first phase of industrialization

Tab.11: Socio-economic indicators

The results obtained in this action C2 will be considered in the definition of the After life plan.

Comparison between indicators of progress and obtained results, expressed in quantitative terms (where possible)

Indicators of progress	**Obtained results**	**Attachments**
The preparation of the questionnaires (30% of the action)	The questionnaires have been defined. Group 1 and the questionnaire Group 2, the questionnaire Group 3, interviews, online surveys, questionnaire	Annex to Mid-Term report 1. Questionnaire group 1 2. Questionnaire group 2 Annex to Progress Report 3. Questionnaire group 3 4. Online survey group 3
Distribution and collection of filled questionnaires (60% of the action)	The questionnaires of Group 1, 2 and 3 have been sent and filled in	
Necessary for data collection in order to calculate the defined indicators (100% of the action)	Completed analysis of Group 1, Completed analysis of Group 1, Completed analysis of Group 3	Deliverable C.2.1 Socio-economic impact report
Statistical elaboration of the results of panel test	None for problems described in 5.3.1 but, as its replacement, an interview at the large scale retailers to acquire useful information for future commercialization.	Annex IV - Report of 15-12-17 COOP

5.1.10 Action E.2 Networking with other project

The Action E.2 began with 3 months of delay respect to expected data and lasted until the end of the project. The delay didn't have consequences both on the progress of E.2 and the other actions related to it.

The aim of Action E.2 was to find and cluster with similar projects in order to synergistically pooling and sharing resources and data fostering information and knowledge transfer activities.
The activity started from a definition of a methodology of work; in particular it was decided to proceed as shown in the graphical representation below (Fig.20).

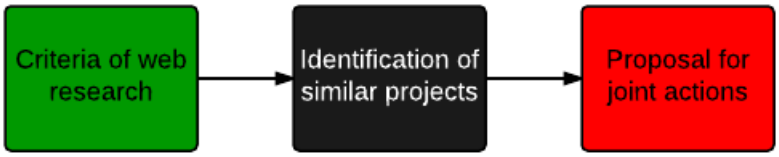


Fig.20: Graphical representation of the methodology followed

The networking research was based on the following step:

- definition of the criteria of web research: database, keyword, themes. The projects relative to the subject "valorization of food by-products for application in the food packaging" will be considered overriding.
- inventory of the relevant related projects, in relation to topics and geographical area.
- proposal for joint actions.

It is important to outline that SSICA, at the start of the project, was partner of the project Leguval ***(Leguval-Valorisation of legumes co-products and by-products for package application and energy production from biomass;*** *01/12/2013 to 30/11/2016, Spain)* and that Agrimax, a new H2020 project, has been started (in October 2016) thanks to the networking activities of Life BiocopacPlus project together with FP7 Leguval project.
During the project, a lot of projects and programmes on food safety, by-products, waste use, agricultural waste and environmental management were ongoing in Europe. To achieve synergies between BiocopacPlus and such initiatives, networking activities have been held through the presence in many events, such as projects communication conferences or meetings.
Some collaborators of networking have been identified thanks to web research of similar projects, which were considered relevant for clustering or joint collaborative task.
In particular, the database of the web site of Life + Program has been consulted, crossing themes and keywords. Based on this research we selected the most interesting projects at regional and national level, that have been contacted to share activities/events. A complete list of contacts and ongoing relationships is published on project website (http://www.biocopacplus.eu/2015/10/01/networking-actions/). Below some projects are reported:

1. Sustainable Additives for Paints & Coatings & Concrete (ECOADD)
    a. 01/09/2013 to 31/08/2015 UK, Germany, Italy
    b. http://ec.europa.eu/environment/eco-innovation/projects/en/projects/ecoadd

2. RenewPACK - RenewPACK: Demonstration of an Innovative Renewable Barrier Material for Sustainable Food Packaging
3. 01-JUL-2012 to 31-JUL -2017 Västsverige – Svezia
   http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=4208
4. AGROWASTE - Sustainable strategies for integrated management of agroindustrial fruit and vegetable wastes
   a. 01-JAN-2012 to 31-DEC -2014, Spain
   b. http://ec.europa.eu/environment/life/project/Projects/index.cfm?fuseaction=search.dspPage&n_proj_id=3919
5. LIFE PERSUADED: Phthalates and bisphenol A biomonitoring in Italian mother-child pairs: link between exposure and juvenile diseases LIFE13 ENV/IT/000482 –
   a. Initial exchange of networking letter, collaboration for the Persuaded newsletter, publication of the BiocopacPlus description on the Persuaded website, publication of BiocopacPlus brochure on Persuaded website.
6. LIFE iSEAS – Knowledge-Based Innovative Solutions to Enhance Adding-Value Mechanisms towards Healthy and Sustainable EU Fisheries LIFE13 ENV/ES/000131 –
   a. Initial exchange of networking letter, joining in Life iSEAS virtual community.
7. LIFE MASTALMOND – New biodegradable and eco-friendly almond shell based masterbatches for traditional sectors LIFE11 ENV/ES/000513
   a. Sending of the networking letter from BiocopacPlus, exchange of emails.
8. LIFE GREENZO – Demonstrative pilot plant for the valorisation of non-ferrous metal waste LIFE13 ENV/ES/000173
   a. Sending of the networking letter from BiocopacPlus, exchange of emails.
9. LIFE CARWASTE – A novel and efficient sorting process for post-shredder ELVs to meet and overcome ELV directive targets
   a. LIFE13 ENV/IT/000185
   b. Receiving the Carwaste newsletter.
10. LIFE EDESIA – Endocrine Disruptors in silico / in vitro Evaluation and Substitution for Industrial Applications
    a. LIFE12 ENV/IT/000633
    b. Initial exchange of networking letter, publication of the BiocopacPlus description on Edesia website.
11. Life FIBERS – Fibers innovative burning and reuse by shs
    a. LIFE12 ENV IT 000295
    b. Initial exchange of emails, poster session at the "International Workshop on Industrial Waste", 17 February 2016, University of Genoa.
12. LIFE LIVE-WASTE - Sustainable management
    of livestock waste for the removal/recovery of nutrients LIFE12 ENV/CY/000544
    a. Initial exchange of emails, abstract preparation for “4th International Conference on Sustainable Solid Waste Management” promoted by the project.
13. FP7-NMP OLI-PHA - A novel and efficient method for the production of polyhydroxyalkanoate polymer-based packaging from olive oil waste water
    a. 280604
    b. On May 2015, SSICA, as a lecturer, participated in a scientific workshop on “Biopolymers from waste valorisation”.
14. Expression of Interest for the LIFE 2015 project proposal by University of Milan, in partnership with Consorzio Italbiotec, Exenia Srl, OPOE, presented on the call "LIFE 2015 - Environment and Resource Efficiency". The proposal is called “Integrated

Tomato-based biorefinery: from by-prodUcts to obtain Lycopene high value Products-TULiP";

15. "LIFE ReQpro - A model to reclaim and reuse wastewater for quality crop production" exchange of emails, participation in Territorial Circular Economy
16. "BLUE AP - BLUE AP - Bologna Local Urban Environment Adaptation Plan for a Resilient City" - participation in Piattaforma della conoscenza, Exchange of emails, Exchange of contacts on Linkedin.
17. "LIFE RINASCE - Naturalistic Restoration for the integrated hydraulic-environmental Sustainability of the Emilian Canals"
    a. Exchange of emails
18. "Cip Eco-innovation WAP-WIR (WAll's Panel WIthout Resin)"
    a. participation in Piattaforma della conoscenza, exchange of emails.
19. "NOW - No more organic waste. A new integrated system to eliminate organic waste in the organised large scale distribution"
    a. participation in Piattaforma della conoscenza and workshop , exchange of emails.
20. "LIFE REVA-WASTE – Demonstration of an integral and sustainable system for multi-waste recycling and valorization"
    a. Life platform meeting on Circular Economy
21. "LIFE GREENJOIST - Production of recycled high quality joists from wood waste"
    a. Life platform meeting on Circular Economy
22. "LIFE K-12 - PU Disruptive technology to dramatically improve Energy Efficiency of Household Appliance"
    a. Life platform meeting on Circular Economy
23. LIFE-PLA4COFFEE
    a. On May 2015, SSICA, as a lecturer, participated in a scientific workshop on "Territorial Circular Bioeconomy".
24. LIFE Multibiosol project (LIFE14 ENV/ES/000486) - "Innovative fully biodegradable mulching films & fruit protection bags for sustainable agricultural practices"
    a. On November 2017, SSICA, as a lecturer, has participated in a scientific workshop and Dr. Angela Montanari has presented "Sustainable bio-based coating from tomato processing by-products for food metal packaging – LIFE BIOCOPACPLUS".
    b. Exchange of emails.
    c. Publication of the BiocopacPlus description on Multibiosoil website. http://multibiosol.eu/en/multibiosol-news/networking-with-life-biocopac-plus-164.html.

Since the project has aroused a great interest, far beyond our expectations, there were no problems encountered relative to this action in collecting expressions of interest and establishing network collaborations, also because the theme presented by the project was very timely and the solution proposed has a high degree of innovation.
BiocopacPlus received 76 expressions of interest and implemented a stakeholder database which included 210 contacts. There were 16 projects presentation in external meeting and 110 participants at networking events. BiocopacPlus has been participated at the national networking day Territorial Circular Bioeconomy, in Bologna Campus on May 16th, 2017 on the occasion of the presentation of LIFE call 2014-2020.
The future intention is to create collaborations in particular in the field of BPA free biomaterials for food-contact applications through participation in thematic conferences, due to the release of the new Regulation 213/2018/UE on BPA restriction.

Comparison between indicators of progress and obtained results, expressed in quantitative terms (where possible)
All the indicators of progress of Action E.2 were achieved

Indicators of progress	Obtained results	Attachments
Survey on similar project or interesting results to be exchanged	100%	Annex V
N° of expressions of interest received	76	
Stakeholders database with stakeholders from target groups at EU, national and regional level (at least 200 records)	210 contacts	Annex VI-Stakeholders database
N° project presentations in external meetings (e.g. participation in at least 8 Conferences, exhibitions)	16	
N° of people or organizations briefed at networking events (at least 50) sharing of the reports and meeting at the company with other projects' managers for information exchange activities	220	
N° of partnerships established with external partners (at least 10)	10	
N° Joint papers or project monograph collaboratively edited with different project (at least 2)	1	
Networking report containing recommendations for further the uptake and market penetration.	100%	Annex VII

5.1.11 Action E.3 After Life communication plan

The BIOCOPACPLUS project has been very successful during all its whole duration, in fact many expressions of interest have been received both from the industrial sector, namely from some multinational companies and from the communication sector, namely from some scientific journal and even from many popular newspapers and media. In addition the project has received three awards at regional and national level. Furthermore, the project received expressions of interest from sectors that are different from that of metal packaging, as Plastic packaging, Shipyard, Interior design, Cosmetic

The recent EU regulation (213/2018) on BPA will certainly increase interest in the BiocopacPlus lacquer. In these years, also national authorities, in particular ISS, have followed the progress of the project with attention.
Starting from this success, which was partly unexpected, the technical and communication activity will continue also after Life, as described in detail in Deliverable E.3.1.
The communication strategy features the use of paper tools, such as the Layman report, web and social networks, as well as the participation in workshops, conferences and exhibitions. Visits of the plant also by schoolchildren will be promoted. The participation of SSICA and Chiesa in the Agrimax project will offer further opportunities to disseminate the results of the project at a European level.
At the end of the pack test, which will be carried on by the partners also after Life, a scientific conference will be organised indicatively by the end of June 2019 to present the results to the food industry and competent authorities. At the end of the project, some dissemination

activities have taken place as: national award ceremony for Oscar Green 2017 in Rome on 26th January 2018, participation in Geo&geo TV show on Rai3 on 5th February 2018, a publication of an article on agricultural magazine "Terra e Vita" on 23rd March 2018, a skype-call with a study group of Management Engineering of Unimore on 19th April 2018 and a presentation of the project at Cibus Fair in Parma on 10th May 2018. (Annex VIII)
Indicators of progress and obtained results, expressed in quantitative terms (where possible)
All the indicators have been persecuted obtaining good results.

Indicators of progress	Obtained results	Attachments
N° of expression of interest collected	13	
Updating and continued visibility of the website beyond the duration of the project (5 years)	Planned	Deliverable E.3.1
First draft at the mid-term meeting	All partner undertake to continue the activity	
Final validation at the final meeting	A specific steering committee has been organized in January 2018 to define the commitment of the partners after life	Annex IX – AfterLIFE meeting 16-01-18

5.2 Dissemination actions

5.2.1 Objectives

The main objectives of the dissemination plan has been set out in the project proposal. They could be summarized in the following points:
• To establish a Dissemination Working Group within the PSC, which is focused on strategies for ensuring that the project will evolve to a sustainable business initiative.
• To raise awareness, sensitivity and increase acceptance of bio-lacquers for food-contact applications;
• To identify and produce suitable dissemination products for the needs and goals of the project;
• To organize 2 Workshops, in conjunction with the most important conferences in the field;
• To gain credibility (reputation, visibility) and acceptance from targeted communities and fostering the creation of and international community of potential end-users, developers and commercial partners;
• To develop exploitation plan defining a credible roadmap for use and transfer to establish a sustainable business model for down streaming results beyond the project completion.
It was considered appropriate to not establish a formal dissemination working group (DSW), as provided in D.1.2. , given the continuous relations among partners and the geographical proximity. SSICA has coordinated all diffusion and exploitation activities, interacting with partners on the communication strategy during the internal meetings. SSICA supported by all the partners, was responsible for developing the communication and dissemination plan. Any decision on dissemination derived mainly from SSICA who, once received the consensus' partners, had implemented the action. For the dissemination activities SSICA has been

supported by Dr. Brenni of Salchi, by Dssa. Adravanti of CFT and by Mr. Stefano Chiesa of CHIESA.
In addition to playing the role of coordination of the dissemination, SSICA has worked to ensure that all partners involved are applying the guidelines defined by the Common Provisions. In addition to the realization of informative materials, there was the participation in public events and some project presentations at several conferences. The public awareness and dissemination actions plan was being implemented as it was planned, obtaining good results and many positive feedbacks.
The most important outputs and relative deliverables that have helped and contributed to this success, has been the realization of the project website from the beginning of the project and constantly update during all the project (deliverable D.1.1), the realization of the video, of the brochure (deliverable D.1.3) and notice boards of the project. Finally the Layman's Report (deliverable D.1.5) will be an important tool to help the spread of the final results after Life.
A relevant event has been the inauguration of the pilot plant, on 27 October 2016, an opportunity for research and industries to meet each other and discuss about the results obtained and the possible future applications. Moreover it has been a possibility to receive many positive feedbacks.

5.2.2 Dissemination: overview per activity

Dissemination has been active and we have considered that relevant stakeholders working with related issues were aware of our actions.
The following dissemination tools, products and actions has been planned to spread the project results:
1. Participation in scientific conferences and events. The partners took action to disseminate project-related work through professional conferences, special events, and demonstrations. Each partner will be encouraged to participate in some events each year. In the table 12 the scientific conferences to which the project has participated are listed:

Date	Partner	Conference / event attended	Title of talk /presentation	Location
3-6/11/14	SSICA	Ecomondo	Biocopacplus: una vernice ecosostenibile per l'imballaggio alimentare	Rimini, Italy
11-13/11/14	Salchi Metalcoat	Brau Beviale	BiocopacPlus's stand	Nuremberg, Germany
12/05/15	SSICA	FP7 OliPHA	The project LIFE BIOCOPACPLUS: Sustainable bio-based coating from tomato processing by-products for food metal packaging	Pisa, Italy
22/05/15	SSICA	Ricerche Mediche di Frontiera – Convegno INBB	Il progetto LIFE BIOCOPACPLUS: un rivestimento ecosostenibile per l'imballaggio metallico per alimenti dalle bucce di pomodoro	Rome, Italy
10/06/15	SSICA	Consorzio Italbiotec, Programma Life	Biocopacplus: una vernice ecosostenibile dalle bucce di pomodoro per l'imballaggio alimentare	Milan, Italy
23-25/06/16	SSICA	4th International Conference on Sustainable Solid Waste Management	Cutin isolated from tomato processing by-products: extraction methods and characterization	Limassol, Cyprus
06/10/16	SSICA	Tinplate Conference 2016	Feasibility of a bio-based coating: the Life project BiocopacPlus	London, UK
12-13/10/16	SSICA	Food Village	A stand presenting the Biocopac project	Bruxelles,

		Conference Food 2030	and BiocopacPlus' video at the exhibition	Belgium
02/05/17	SALCHI	METPACK Conference	Biocopac: tomato-based varnishes for the protection of food cans	Essen, Germany
10/05/17	SSICA	Seeds&Chips, Unido International Award 2017	"BiocopacPlus - Sustainable bio-based coating from tomato processing by-products for food metal packaging" and Award Ceremony	Milan, Italy
16/05/17	SSICA	LIFE Territorial Circular Bioeconomy	LIFE BiocopacPlus as a Successful Life Environment Projects on the Waste, Circular Economy and Water Topics in the "biowaste valorization/exploitation" category	Bologna, Italy
23/11/17	SSICA	LIFE Multibiosoil workshop	"Sustainable bio-based coating from tomato processing by-products for food metal packaging – LIFE BIOCOPACPLUS" (Annex X)	Pisa, Italy

Tab.12 List of scientific conferences to which BiocopacPlus project participated

In the table 13 the events for general public to which the project has participated are listed:

Date	Partner	Conference / event attended	Title of talk /presentation	Location
10/05/16	SSICA	Gastronomy Cities Meeting	The project LIFE BIOCOPACPLUS	Parma, Italy
27/08/16	SSICA	Tomaca Fest, "Le istituzioni premiano la ricerca"	Il progetto LIFE «BIOCOPACPLUS», dalle bucce di pomodoro un rivestimento ecosostenibile per l'imballaggio alimentare	Parma, Italy
27/10/16	SSICA, SALCHI, CHIESA, CFT and policy makers	Inauguration of pilot plant	Bioeconomy: a strategic priority for Europe Plant Lay-out BiocopacPlus - CFT Imballaggi metallici: innovazione, vantaggi e sostenibilità Salchi: from a natural product to a high tech bio-based varnish Sustainable chemistry from tomato skins Sustainable chemistry from tomato skins at Azienda Agricola Virginio Chiesa	Canneto sull'Oglio, Italy
06/06/17	CHIESA	Oscar Green 2017	Award Ceremony (Annex X)	Milan, Italy
21/09/17	SALCHI	Good Energy Awards 2017	Award Ceremony (Annex X)	Milan, Italy

Tab.13: List of general public events to which BiocopacPlus project participated

2. Organization of a workshop in conjunction with important international fairs conferences in Food Technology (CibusTec for disseminating the project results to the end-users community. At CibusTec, Cft, in its booth, has organized the presentation of the project.

The pilot plant for cutin extraction from tomato waste has been inaugurated on 27th October 2016. The event has foreseen a workshop and a visit to the plant, in conjunction with the important international fair conference CibusTec. A shuttle service from Parma fair to Canneto sull'Oglio (MN) has been organized by CFT. Target audience was producers of waste by-products, local farmers' public authorities, enterprise associations, farming associations and packaging industries. Invitations has been sent to the principal stakeholders (167) and the participants were 89. The workshop has enabled partners to discuss the latest project results with key stakeholder and in this event the partners of the project have received feedback on future activities. Two kind of invitation for the inauguration has been chosen, considering different proposals and agreeing the final choice with all partners. The committed external graphic assistance has been chosen after an appropriate evaluation of three budgets and related quality of service. **Green project merchandise for awareness raising and outreaching** has been prepared, committing his creation to an external graphic company, chosen after an appropriate evaluation of three budgets. The green project merchandise has been distributed among the participants of inauguration and other stakeholders. It consists in a "**Game of tomato**" realized both in Italian and in English to allow the spread at national and international level. The **shoppers** were printed by a typography that it has guaranteed an optimum quality of service. Its graphic has been realized by the same graphic assistance of green project merchandise. On 3rd May 2017, Salchi Metalcoat has presented the BiocopacPlus project during the international trade fair for metal packaging, Metpack. Unfortunately it was not possible to organize a workshop as planned but Dr. Brenni has participated as a lecturer in Metpack conference with a presentation entitled "Biocopac: tomato-based varnishes for the protection of food cans".

3. Publishing articles, publications, conference papers and abstracts. There were articles about the project printed specialized magazines and articles appeared in various web news and portals. Two **articles** were published in specialized magazines. In particular, on April 2015, an interview about BiocopacPlus was published in "Trattamenti e finiture", an Italian magazine specialized in surface treatments and industrial painting. On May 2015, in the Italian bimonthly magazine on sustainable packaging COM.PACK, an article about the BiocopacPlus projects was published. An **article** was published in the April 2016 issue of the specialized magazine "The Canmaker" which mentions the Life BiocopacPlus project, the title is "Revolution in chemistry. Coating suppliers are focusing on broadening their portfolios of non-BPA-based lacquers. " A **special** was published on BiocopacPlus written by the journalist Daniele Colombo on n. 257 of Mark Up, hereinafter the link to the web newsstand version:
https://pixelbook.tecnichenuove.com/newsstand/markup/viewer/guest/com.tecnichenuove.markup.mk.2017.257/ and to the light version on the site: http : //www.mark-up.it/il-pomodoro-rivoluziona-il-pack-di-metallo/. On February 2016, an article about BiocopacPlus was published on Biologi Italiani. On December 2016, an article has been published in the journal Agrimprese Cia Coldiretti of the month of December, http://www.agrimpresaonline.it/sfogliabile/13-2016low/; Publication of an article in Terra Mantovana, n.9. the article is in the pages. 20-21 of this link http://bit.ly/2i96HRU, an article was published on "Vita in campagna", monthly magazine of agriculture, http://www.vitaincampagna.it/abstract/febbraio-2017/. In January 2017 an article has been published on "Pitture e vernici", a bimonthly magazine for paint formulators, adhesives and sealants, inks and varnishes for printing, related products. An article has been published on Agrinnovation magazine: https://ec.europa.eu/eip/agriculture/sites/agri-eip/files/eip agri agrinnovation magazine 4 2017 en web.pdf. A scientific article entitled "Cutin isolated from tomato processing by-products: extraction methods and characterization." (A.

Cifarelli, I. Cigognini, L. Bolzoni, A. Montanari) has been published by the Unit of Environmental Science and Technology, School of Chemical Engineering, National Technical University of Athens, it is available at this link: http://uest.ntua.gr/cyprus2016/proceedings/pdf/Cifarelli_et_al_Cutin_isolated_from_tomato_processing_by-products.pdf
Dr. Montanari and Dr. Cigognini have worked on an other scientific entitled "Processing, valorization and application of bio-waste derived compounds from potato, tomato, olive and cereals: A review". It has been published on Sustainability Open Access Volume 9, Issue 8, 22 August 2017, Article number 1492 and it is available at this link: http://www.mdpi.com/2071-1050/9/8/1492 (Annex XI).

4. An annotated bibliography of publications on bio-lacquers and extraction of cutin has been updated. The items reviewed in the bibliography include reference to scientific papers, standards and patents. We decided to maintain closed the bibliography.

5. White Papers and Policy briefs will be distributed to relevant policy actors as soon as demo results will be available. Due to the delay in the realization of pack test these briefing papers weren't produced. However, contacts with public authority were periodically updated. In particular with the ISS (istituto superiore di sanità), that was continuously informed of the project development, starting from 2013 during the Biopolpack Congress. In particular, during the conference AGORÀ - INCONTRO NAZIONALE SUL FOOD PACKAGING, 3a edizione, 25 OTTOBRE 2017 Fondazione CARIPLO, Milano, Dr. Montanari discussed the results obtained with Dr. Milana and Dr. Leclercq (Annex XII).

6. Design & diffusion of Communication and Dissemination Products
This task has edited, designed and distributed the following communication tools:

- **Development of a coordinated project image both in terms of look & feel and templates**; as project coordinator SSICA has assured the correct use of **LIFE logo** on documents, visual supports and durable goods, giving instructions about it to all partners during internal meetings. SSICA have realized customized **labels** to send the BiocopacPlus samples, in addition CHIESA have realized customized metal BiocopacPlus labels for the prototype.
  In order to respect a coordinated project image, this is the preview image viewable on search engines and Youtube search (Fig.21).

Fig.21: BiocopacPlus image

- **N.16 Multimedia project presentations** were submitted in conferences, congresses and workshops. . The intent was to participate with multimedia presentations to many conferences, congresses and workshops until the end of the project in order to raise awareness Life + Programme, the project BiocopacPlus and its members.

- **Brochures to be delivered in the dissemination events**; The brochure (A4 two-sided, folded leaflet), has been developed in order to introduce and present the

BiocopacPlus project and to disseminate its main objectives. In particular, it illustrates the project long-term impact on life quality, food safety and health. It has the same hues of the logo, thus respecting the coordinated project image. A **brochure** (Fig.22) has been designed and distributed among stakeholder at national and international level in events to which BiocopacPlus member have participated. The distribution of the brochure took place also via email in conjunction with the sending of questionnaires C.2., the networking letters and the invitation of 27th October 2016, for the inauguration of the pilot plant.

Fig.22: Brochure of the BiocopacPlus project

• **Video**; A video has been released on internet (BiocopacPlus activated its YouTube channel in June 2015. The video is targeted to the general public and describes the research objectives, challenges, tangible results and benefits. The first version of the presentation is online https://www.youtube.com/watch?v=LKnXjywU_Ss, the chosen language is Italian with English subtitles. In figure 23 it is possible to see some frames of the video:

Fig.23: Frames of the BiocopacPlus video

Other videos about bio-lacquer application and bio-lacquer preparation were made by Salchi Metalcoat but they are not public.

• **Posters, roll-ups and flyers promoting the project explaining its rationale and impact**; A **poster** was created. It was presented during the Workshop "International Workshop on Industrial Waste" held February 17, 2016 in Genoa, at the Department of Chemistry and Industrial Chemistry of the University of Genoa. The workshop was organized by the project LIFE12ENV / IT / 000295 LIFE FIBERS, it is a part of the networking activities. A **flyer** (Fig.24) was designed by Salchi, which was distributed at the Brau Beviale fair.

Fig.24: Flyer designed and distributed by Salchi at Brau Beviale fair

• **Media campaign**, tasks in this action are mainly related to press conferences, publication of articles in general and specialized press both at local and regional levels, and communication actions in social networks. BiocopacPlus project has been very active in the dissemination/communication activities. Since the beginning of the project, several press articles have been published and different media appearances have taken place.
Some press releases were published in national journals. On 21/05/2014 it was written about the BiocopacPlus project in Nòva24, an insert of the national newspaper "Il Sole 24 Ore", devoted to issues of research and innovation (http://nova.ilsole24ore.com/esperienze/il-bio-rivestimento-per-le-lattine/). In particular, in the national newspaper "La Stampa", on 09/12/2014 an article was written about the innovative idea of the project BiocopacPlus ("Barattoli con le bucce di pomodoro. Era autarchia ora è sostenibilità"). In the local journal "Dossier Lombardia" an article about the project BIOCOPAC and its follower project was published.("La bio-lacca che viene dal pomodoro"). The project BIOCOPACPlus was presented in the magazine of CFT: http://www.cftgroup.com/news/magazine/ready_june_2014.aspx . On January 2016, the news agency ADNKronos published an article about the BiocopacPlus project. The article was then reported on other websites of national importance such as: www.focus.it, www.meteoweb.eu and www.tiscali.it. On 30 May 2017 an article about BiocopacPlus has been published on New York Times: https://www.nytimes.com/2017/05/30/dining/packaging-materials-food-waste.html. On 7 June 2017 an article about BiocopacPlus has been published on the national journal "Corriere della Sera".A presentation of BiocopacPlus has been broadcasted on a **National Tv channel** as Rai3 and **National radio channel** as Radiorai2. In detail:
- May-June 2016, Rai3,the Italian national broadcaster realized a news report dedicated to SSICA, Coordinator of the BiocopacPlus project, in the television show called "Officina Italia". The news report also included an interview with the project assistant, Ilaria Maria Cigognini, that speaks about BiocopacPlus at 00:03:49. http://www.rai.tv/dl/RaiTV/programmi/media/ContentItem-25ed10fb-1a81-4eba-9e70-ae33799dbcf0-tgr.html?refresh_ce
- 2 April 2017, Radio interview with Dr.ssa Angelica Cifarelli, available at the following link to 00: 53: 28: http: //www.radio2.rai.it/dl/portaleRadio/media/ContentItem-c3d06434-dd2c-4130-9132-3e1bf4c4f010 .html. The interview was broadcast on RadioDue within the "Miracolo Italiano" program.
- 25 November 2017, Stefano Chiesa in "Il Posto Giusto", the program, created in collaboration with the Ministry of Labor, is dedicated to innovation and to the opportunities promoted by the Ministry of Labor and the Regions, with the support of European funds. The broadcast aired on Saturday 25 November and the interview is

available at the following link: http://www.raiplay.it/video/2017/11/Il-posto-giusto-92ce42bf-88df-4ebf-9011-45fe80df7682 .html (Annex XIII).

7. **LIFE+ Notice boards**

N. 4 Notice boards, which bare the Life logo and project name, has been placed since the very beginning of the project. SSICA has developed the notice-boards of the project, that are exposed at the entrance of each partner's institute, in 2 language versions (English and Italian). In particular one of the notice board is placed near the pilot plant, in this way the visitors can be informed about the project during the visit to the CHIESA facilities.

8. **Project Web-site:** SSICA has set up a web-site to meet communication needs with targeted communities in terms of dissemination and knowledge sharing. It acts as a means of communication among citizens, science, research community, and SMEs it will also facilitate meeting between the demand and the offer of related to project results. Website was functioning and was available for wider audience, it will be available for the next five years after the end of the project. The project website (http://www.biocopacplus.eu) has been created in December 2014, it is regularly updated with information and news, the programmer was consulted for an update of the webpage so that it was in line with the European cookie law.

Taking into account its nature, news about the project have been published and the content of the website has been updated as the project evolves.

The domain of the public website is www.biocopacplus.eu. In the header of the public website in the top right were located the Life logo and the different links in order to access to website sections (Fig.25):

- Homepage: Key data and summary of the project
- Project: aim of the project, long term and industrial objectives of the project
- Impact: health, environmental and economic benefits
- Partners: Logo, website and details of the partners
- Sites of interest: headquarters of partners and location of the future pilot plant.
- News: Publications, Press releases and Presentations performed by the partners which can be of public interest.
- Contact: Contact data of Project Coordinator
- Partner's Area: Link to the project management portal (restricted access to partners).

Fig.25: Homepage of the BiocopacPlus web-site

The project **website** has been regularly updated: the number of visits of the website has been monitored through a Google Analytics counter. Number of feedbacks on the project's results in the website have been monitored (number of the visits of website, until 31st December 2017: 5.285). In figure 26 the frame of the counter is reported (Annex XIV).

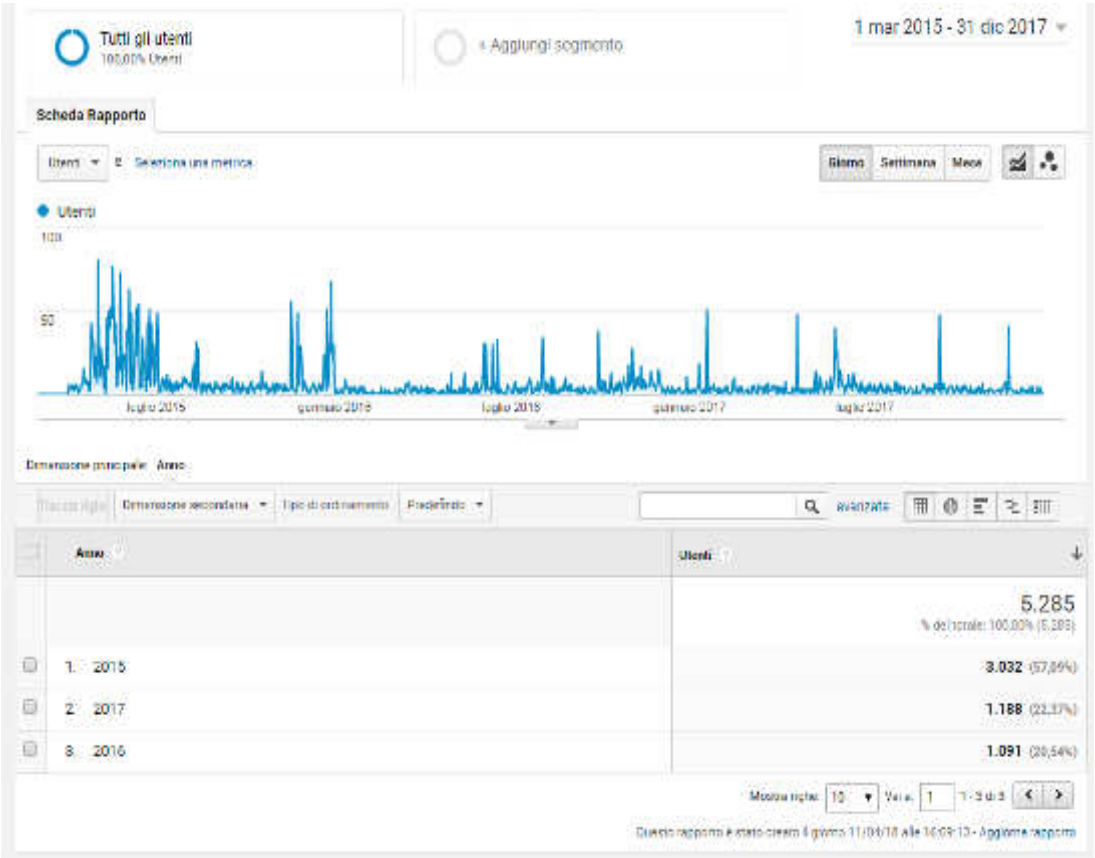


Fig.26: Monitoring of the visits of the BiocopacPlus website

Further, dissemination by means of social media technologies and across social Web 2.0 Communities /groupings (Twitter, Facebook, LinkedIn, Slideshare). The **LIFE logo** is correctly published on website and social networks.
Facebook profile created (https://www.facebook.com/biocopacplus) has been clearly and visibly marked with Life logo. 121 likes, 225 likes to other pages, 118 post, 32 sharing.
A BiocopacPlus **LinkedIn** group (https://www.linkedin.com/grps/BiocopacPlus-6959960/about?) has been set up, aiming to target experts interested in the project. 10 members, 9 threads.
On **Twitter** an account with the username @BiocopacPlus has been set up. 291 tweets 874 following 204 follower.
A **YouTube channel** https://www.youtube.com/channel/UCWDkcZ_Q_hW--RwVciyGcPA was activated in June 2015. Account BiocopacPlus subscribed to 29 Youtube channels. The video has received 997 views, 6 likes, 6 followers.
Meetings **photographs** have been regularly published on the website and social networks.
Links to the **press cuttings** are published on the website and social networks.
A **landing page** with registration form to the inauguration have been created by Cft Spa. The contents of the temporary web-site have been decided after evaluation with all partners;
Realization of an **ad hoc web page** as the winner innovative idea within the UNIDO ITPO Italy's institutional website http://www.unido.it/award2017/biocopacplus/

It has been created a web page dedicated to BiocopacPlus project on www.ssica.it
A **Slideshare** account has been set up. In the last year the views have been concerned the following Countries: Italy, USA, Iran, India and France. 6 presentations have uploaded, they are concerning the follow-up of the inauguration of 26th October 2016. There have been 315 views.

9. The **Layman's report** has been prepared at the end of project and it is available on the project website. D.1.5 task which is centred in the elaboration of the Layman's report was started in August 2017 making an exhaustive study of the previous and similar reports from other LIFE projects. After evaluate more than 10 documents, a structure was decided including an introduction to the project entitled "project scope & objectives", problem and background information, how the BiocopacPlus consortium tackled the problem, results obtained, successful validation of new bio-lacquer, and project impact: environmental & socio-economic benefits. The Layman's report is available in two languages: Italian and English. In this way we allow a worldwide distribution of it enforcing the local distribution to the general public. A translation job from Italian to English has been done during the last month of the project as well as the layout by experimented designers in order to attract the interested readers. It has been published as flipping book in the project's web pages and as well be available on paper. This report is 10 pages long and presents the project, its objectives, its actions and its impact and actual results to a general public. It is addressed to a large public of trade, industrial and institutional stakeholders, interested citizens, environmental organizations, waste treatment operators. The report has been edited with a simple and not technical language featured by an iconographic support, in order to be accessible to the general public. After final approval by all partners, the digital version of the Layman's report has been delivered to all partners, in order to be used and distributed in exhibitions and conferences where the partners will participate;

10. Outreaching effort

- SSICA and SALCHI participated in workshop on "Innovative and Sustainable Food Packaging & Manufacturing Technologies" in the EU Pavilion at the EXPO Milano. The workshop provided successful FP7-funded projects within the field of innovative and sustainable food packaging a unique opportunity to present their results and discuss applications with relevant stakeholders at the heart of the EXPO Milan "Feeding the Planet, Energy for Life". Although this is a presentation dedicated to the FP7, it was also presented BiocopacPlus, as a development of the project FP7 BIOCOPAC.
- To monitor the possible socio-economic impact of the project actions on the local economy and population, SSICA participated in two local meetings: Economie circolari e sviluppo d'impresa e del territorio, Milano, 19/03/15; Emilia-Romagna Innovazione e Territorio, Parma, 17/05/15.
- On the occasion of "Food Village 2030" Conference on 12-13 October 2016 in Brussels. D. ssa Montanari and D. ssa Cigognini have had the opportunity to make known the continuation of the project with Life + BiocopacPlus.
- There was a brochure distribution of BiocopacPlus at the BioLinX Circular Bioeconomy Workshop on 21 November 2017 at Palazzo Besana in Milan. The project (with reference to the LIFE financial program) was also presented in the presentation "Bio-lacquer and lycopene from tomato peels: Agrimax an integrated cascade process" by Dr. ssa Serena Chierici.
- Dr. Angela Montanari has talked about BiocopacPlus among students of ITS Tech&Food, "MAfood Agribusiness & Food Industry Management" Master (Unipr) and Packaging Master (Unipr).

- Visit to the pilot plant by the French High School "Campus de pouillé", Angers and "I.I.S. Bonsignori" High School, Remedello (BS) (Annex XV).

5.3 Evaluation of Project Implementation

During the project, frequent meetings were scheduled to discuss the project scope, the project requirements to be implemented during the different phases, the technical advance, and the monitoring of indicators. This methodology was useful to integrate the knowledge and visions of the different partners and to solve the problems incurred in the crucial moments of the project, as the definition and assembling of the prototype. The methodology followed was helpful in order to obtain the results explained in the following table (Tab.15) for each action and task and to create dissemination activities.
However, it is important to note that the expenditures for all actions are generally consistent with those reported in the original proposal, with the exception of the costs of building the structure, higher than expected, due to the need to adapt the building to the provisions required during the granting of authorization.
The milestones in the project was achieved in time, considering the approved amendment. The pilot plant has been assembled and tested.

Action	Task	Foreseen in the revised proposal	Achieved	Evaluation
A1	Detailed study covering the main EU countries producing tomato and the related waste; presentation of the data in table and different kind of graphs in relation to each country, the different geographical area and the different kind of enterprises.	Yes. Descriptive statistics have been reported both for tomato production and tomato by-products production. The chemical composition and the actual uses were examined.	Yes	The data collected were very useful in the dissemination activity
A1	A scientific publication about the data collected	Yes	Partially	We decided to do a publication on a special issue of a technological journal, dedicated to tomato on the issue ComPack. The paper *Comparative study on different protocols to isolate 10,16-dihydroxy acid and its oligomers from tomato waste* *A.Cifarelli, I. Cigognini, L. Bolzoni, A. Montanari* has been submitted to Journal of food science and technology (JFST) and it is has been accepted
B1	Definition of the key-drivers of the extraction pilot plant and of the technologies	The key drivers of the pilot plant have been evaluated and confirmed. All the basic requirements of Pilot Plant	Yes	Good collaboration between SSICA and CFT. In close collaboration they have identified the experimental

	suitable to realize the extraction procedure	components have been defined, in particular the kind of peels separation, the concentration of soda solution, the combination time-temperature, the conditions of separation liquid/solid, the pH and the type of inorganic acid, the yield. An elevated number of trials has carried out		conditions the most possible similar to the industrial conditions, by turning for help even to technologies of other plant sectors, as oenology. The results are detailed in the Deliverable B.1.1
B1	Request of the necessary authorisations for the new plant from Chiesa	The administrative procedure for the building part and the necessary environmental authorizations have been presented and registered	Yes	For this part Chiesa has given an assignment to Cremaschini Studio. The procedure Impresa in un giorno was used, presented to the Municipality of Canneto sull'Oglio.
B2	Preparation of the flow diagram of the pilot plant process	The main components of the pilot plant have been chosen; the flow diagram has been prepared. The separation method of peels has been identified	Yes	All the components of the plant was identified by CFT
B2	Assembling and start-up of the prototype plant for cutin separation and extraction at semi-industrial level.	The pilot plant has been assembled with the utilities and the start up has been completed. The layout of the pilot plant and of the utilities have been prepared	Yes	The transfer of the parameters identified in laboratory has been completed. The activity has taken place in close collaboration between CFT, Chiesa and SSICA, with the presence of all partners on the plant every day.
B3	Realization of several tests in order to control the composition of the cutin and to evaluate the influence of different process parameters	Several trials were carried out in laboratory and on SSICA pilot plant in order to overcome the delay in the assembling of the plant and to identify the right range for the different parameters	Yes	The results were reported in the Deliverable B3.1. This work has been very important to reduce the number of trials on the pilot plant and the effect of the delay on the other actions
B3	Realization of several tests in order to control the composition of the cutin and to evaluate the influence of different process parameters	Several trials were carried out on the pilot plant to identify the right range for the different parameters and the correct functioning of the different equipment (time, temperature, yield, stability	Yes	The results were reported in the Deliverable B3.1.1. This work has been very important to definitely establish the process conditions
B3	Optimization of the environmental properties of the process	Some trials have been performed to reduce the environmental impact of the extraction process	Yes	The results were reported in the Deliverable B3.2. In particular a very high biogas potential was measured on the exhausted peels in comparison with peels as are.
B3	Inauguration of the prototype	The pilot plant has been inaugurated on 27 October 2016; in conjunction with the event, a work shop was organized on metal packaging	Yes	The event has been successful; more than 100 people have participated, including regional and local athourities; it was an

		and green chemistry		interesting opportunity to discuss and take stock on the food metal packaging
B4	Polymerization and characterization of the cutin	Several trials have been performed on raw and traded cutin to find a bioresin with good properties	Yes	Salchi has set-up a method to synthetized the bioresin. A bioresin, code 20600, has been produced at laboratory and pilot plant scale. Pisa was very useful in order to analyze the cutin obtained in the extraction process
B4	Formulation of coatings using cutin-based products	Several trials have been performed on the bioresin to find some lacquer formulations with good properties	Yes	Salchi has formulated n°4 types of coating solvent-based in lab with good properties of adherence and chemical resistance (codes 7249012 VI 1001 BIOCOPAC ORO, 7249013 VI 1002 S.S. BIOCOPAC ORO, 7484001 SM 2000 BIOCOPAC BEIGE, 7249010 VI 1000 BIOCOPAC ORO). Lacquers 7249010 and 7249013 were also produced at pilot semi-industrial scale
B4	Use of solvent from renewable resources for lacquer formulation	The solubility characteristics of several solvents from renewable sources have been verified. Structures with free hydroxyl groups and with characteristics that can favour compatibility with very acidic polymers, such as the 20600 bio-resin, are favourites for this purpose.	Yes	Product based on renewable source glycerine to replace those of oil origin was selected
B4	Formulation of side-stripe cutin-based products	After several test a cutin-based lacquers suitable for the application on longitudinal side seam has been developed, code 7249013	Yes	This result is very important, in fact in this way a can totally cutin based can be produced
B5	Production and application of lacquers, production and filling of cans at pilot plant	About 200 cans in tinplate and 50 cans in Al were produced and filled on Salchi and SSICA pilot plant	Yes	The realization of this part of work was very important in order to obtain preliminary information on the behaviour of the cans to be confirmed in the industrial pack test (18 months). The cans have been filled with legumes and tomato passata
B5	Production of the lacquers at industrial level; application on metallic materials	About 50kg of lacquer BIOCOPAC n°7249010 has been produced and applied on 100 sheets of tinplate and TFS on industrial line	Yes	The application has been performed in standard conditions with good results
B5	Electrochemical	The corrosion resistance of the	Yes	The results obtained in the

	measurements	lacquered metallic materials has been studied by means of impedance spectroscopy in different model solutions		electrochemical measurements were positive
B5	Production and filling of 0.5 kg cans and of standard cans	N°3000 0.5kg cans were produced on industrial line and filled with tomato and beans products; standard cans were filled in the same conditions with the same products	Yes	The pack test has been organized at 3 storage temperatures; results at 6 months for tomato and 3 months for beans
B5	Evaluation of the hygienic and sensorial properties of the new lacquers	The migration test has been carried out in compliance with European legislation; the sensorial analysis has been performed according to UNIEN 10192/2000	Yes	The results obtained were below the legal limit; no modification of flavour and taste has been found
B5	Analysis and results of the pack-test carried out both, at pilot and industrial lines	At prestablished times 3 cans /lot /storage T were open and examined.	Yes	All the cans showed good behaviour of the cutin lacquer as reported in the Deliverable B5.2. Some problems are discussed in the text below the table
B6	Inventory analysis	Input and output of 3 different scenarios concerning the final use of tomato by-products have been identified	Yes	The work was carried out in collaboration with Chiesa and Salchi
B6	Environmental evaluation of the valorization of tomato by-products	LCA study has been performed for the assessment of the environmental impact of the extraction process of cutin	Yes	The study has been performed in collaboration with Chiesa and CFT
B6	Evaluation of the environmental impact of the new eco-cans in comparison with standard one	LCA study has been performed, considering the phases of production of the lacquers and of the cans	Yes	The study has been completed; new cans allow to save natural resources and reduce the carbon footprint, as reported I Deliverable B6.2
C1	Identification of environmental indicators by means of questionnaires	The indicators have been found and the questionnaires have been sent	Yes	The work was carried out in collaboration with Chiesa and Salchi
C1	Monitoring of the environmental indicators	The environmental indicators identified at the beginning of the project have been monitored through the entire project	Yes	The results of the monitoring were described and reported in the specific deliverable
C2	Preparation and distribution of the questionnaires; data analysis	The questionnaire for 2 groups of stakeholders have been prepared, distributed and collected	Yes	The answers of the first group was very good; not satisfying the answer of the second group of GDOs
D1	Preparation of the Communication plan	The dissemination plan has been prepared and updated	Yes	The details are reported in the Deliverables D1.2 and D1.4
D1	Preparation of dissemination tools, brochure, notice board,	All the materials foreseen have been prepared and distributed	yes	The materials are in annexes

	leaflet			
D1	Participation at fairs, conferences, seminars, publications	A lot of conferences, interviews and papers have been presented, even TV programmers	Yes	The materials are in annexes
D1	Layman report	Layman report of 10 pages has been prepared in English and Italian	Yes	The report is in annex and 20 copies have been printed
E2	Identification of networking criteria	Yes, a methodology has been defined for the identification of the life projects for networking	Yes	Similar projects have been selected at national and international level
E2	Networking with others projects	9 life projects have been contacted and shared web sites and information	Yes, ongoing	The networking is going very well; we participated at workshops
E2	BPA topic	A project on the topic of BPA has been selected and contacted	Yes	The project is very important, because it is coordinated by the Istituto Superiore di Sanità
E1	Scientific and administrative management	Several meeting have been organized. SSICA supported the partners in the preparation of time-sheets and in the financial reports	Yes	The collaboration between the partners and the participation in the different phases of the project were very good
E1	Organization of a final work-shop	A final work-shop to present the final results has been organized in SSICA	No	The work-shop wasn't organized due to different reasons; a workshop has been organized in occasion of the inauguration of the pilot plant; the results have been presented at several conferences by the partners, and they have been published through several national and local TV channels. A workshop on the results of the pack test will be organized by 2019
E1	Project Steering Committee (PSC)	The PSC has been established	Yes	Each partner has nominated a representative, who participated in the meetings, discussed the results and planned the research activity
E3	After life communication plan	The plan has been prepared, taken also into consideration the new Horizon project Agrimax	Yes	The report is in annex

Tab.4: Description of the actions tasks and results achieved

The most visible results obtained during the project were the following (annex XIV):

- pilot plant in a new building
- tinplate cans, TFS can ends and aluminium cans, lacquered with the cutin based lacquer produced on industrial line
- cans filled with tomato, legumes and meat products

5.3.1 Problems encountered

In addition to the difficulties in realizing the plant, which caused the delay that led to the request of amendment, other problems arose during the project. These problems have been partly identified and are being solved, and partly will be dealt with after the end of the project, also as part of the scope of the new Horizon BBI Agrimax project. They are briefly described below:

- as shown in deliverable B.5.2, a preliminary pack test was carried out to perform the test for a storage time that would be long enough to obtain information on the behaviour of cans for at least 18 months at room temperature. Since an industrial application of the lacquer was impossible within the time fixed in the proposal, the following procedure was chosen: the tinplate sheets were lacquered manually in the laboratory, leaving the welded area; they were later processed into cans on an industrial line. However, in this way it was not possible to apply the side stripe protecting the longitudinal weld as it normally happens. Cans were therefore filled in the SSICA pilot plant with tomato passata and pulses, and were stored at 3 temperatures, namely 20, 37 and 50°C. At set times (see Deliverable B.5.2) cans were checked for vacuum and lacquer corrosion. However, it was not possible to use metal concentration in the product, especially iron, to assess the shelf life as it normally happens because the lack of the stripe caused strong corrosion of the longitudinal weld with loss of vacuum and high metal concentrations. However, it was possible to obtain reliable information on the behaviour of the lacquer in terms of adherence and corrosion resistance based on a visual examination and comparing it to the reference cans without side stripe.
- the previous problem, i.e. the absence of the side stripe, was solved during the second industrial pack test since also a side stripe cutin-based lacquer was developed and applied to cans on an industrial line. In the second pack test, however, some defects of the lacquer gave rise to low corrosion resistance. To overcome this problem, a new lot of cans is being manufactured. These cans will be filled with tomato passata and will be used for a new pack test. After Life, this part of the activity will be entirely supported by partners.
- The plant has a production capacity of 100kg/h and can work continuously. So far, batch tests have been carried out because the final step, i.e. the extraction of cutin from the centrifuge, is still manual. This depends on the physical state of cutin that is a very thick and sticky paste. To solve this problem, different strategies have been adopted:
  - a semi-industrial washing machine was purchased to wash the centrifuge plates in a closed system, thus saving time and improving work conditions;
  - the new Agrimax projects provides for an acidification tank of 1000 l, instead of the current 300, so that downtime can be reduced;
- No interesting results were obtained with regard to water based systems.The recent acquisition of new know-how (including water-based products) and business by Salchi Metalcoat can open up new possibilities for the development of this type of lacquer.
- Panel test: The panel test was not carried out because of the difficult hygienic-sanitary to realize a taste test in a retailers; it was then decided to replace the panel test by presentations of the project results and of the pack test. The adopted strategy has been very useful; in fact the retailers demonstrated high interest in the opportunity of commercialize the new eco-cans.
- Final work-shop: even if foreseen in the proposal, the work-shop wasn't organized due to different reasons; the pack test is not completed; a workshop has been organized in occasion of the inauguration of the pilot plant; the results of the project have been presented at several conferences by the partners, and they have been published through several national and local TV channels. A workshop on the results of the pack test will be organized by 2019.
- In the proposal n°2 joint papers with other project were foreseen. We produced only one paper, even if the networking with other project was very intense.

5.4 Analysis of long-term benefits

1. Environmental benefits

a. Direct/quantitative environmental benefits:

The use of the eco-friendly lacquer obtained from processing tomato waste will help to reduce the carbon footprint and to achieve greater resource efficiency by substituting oil-based lacquers and increasing the use of secondary raw materials.

The results of the LCA study have shown a clear environmental benefit; the study was carried out using the real conditions of the pilot plant, The benefit of the cutin-based lacquer lies mainly in the saving of natural resources, in the recovery of part of the skins, as well as in the lower consumption of fossil fuel and lower emissions of CO_2eq. Considering the prototype the study showed that, for a single can, it can decrease CO_2eq by 730 mg for 3 pieces cans and by 18 mg for 2 pieces cans. Moreover the damages impact reveal that the cutin-based can is less impacting in terms of Human health and Ecosystem preservation; the effect on the resources isn't evident due to pilot process.

The savings of CO_2 will surely improve and increase, with the industrialization of the extraction method, where the process will be optimized and made more efficient. We repeated the LCA study adopting predictable conditions of a future industrial plant. In our assumption for a single can, it can decrease CO_2eq by 840 mg for 3 pieces cans and by 42 mg for 2 pieces cans. In this case the cutin can is less impacting also on the resources consumption.

In addition the use of a bio-lacquer replacing synthetic lacquer reduces the risk of environmental pollution in the recovery phase of the steel and thus promotes the recycling of metal containers, making provision to overcome the already high recovery percentages, average 70-80% at EU level.

Finally the project demonstrated that the production of biogas is more elevated with the exhausted peels, after the extraction of cutin, in comparison with tomato peels as they are: the value was practically duplicated, from 43 dm^3/kg of v.s. to 100 dm^3/kg of v.s This results represents an important improvement of the environmental impact.

Transport is certainly contributing to environmental improvement which is significantly lower than the supply situation of traditional chemical substances

b. Relevance for environmentally significant issues or policy areas

The BIOCOPACPLUS project promotes a double valorization of tomato by-products, as the tomato peels can be used as a starting material for a natural and eco-friendly bio-lacquer and as a source of energy for biogas production. In this way the BIOCOPACPLUS Project will completely comply with the Waste Directive, (2008/98/EC), and with the principles of Circular Economy Systems (Communication from the Commission to the European Parliament, 398 July 2014), recently update on December 2015 by The Circular Economy Package, recently completed, January 2017, by the Relazione sull'attuazione del Piano d'Azione per l'Economia circolare. The project is besides aligned with a new policy agenda adopted by the European Union with the goal that all plastic packaging in the EU market will be recyclable or reusable by 2030. Further, the agenda targets single-use plastics, with the goal of reducing or eliminating them. "The strategy, the commission says, is part of the transition toward a more circular economy".

The European Platform of Stakeholders for the circular economy was also created. The project achievements go in the direction foreseen also by the renewed European Sustainable Development Strategy (EU SDS), which identifies Sustainable Consumption and Production

(SCP) as one of the key challenges to be addressed in the context of the EU's long-standing commitment to meet the challenges of sustainable development.
The BIOCOPACPLUS project is a current and concrete answer to the problem of BPA. In January 2017, ECHA, the regulatory authority for the implementation of EU chemicals legislation and which aims to protect human health and the environment, has added BPA to the SVHC (substances of very high concern) candidate list because it was considered to be toxic for reproduction. The data collected in the sociologic analysis (Action C2) cinfirmed the importance of this point.
Moreover it was recently published the COMMISSION REGULATION (EU) 2018/213 *of 12 February 2018 UE Regulation* on the use of bisphenol A in varnishes and coatings intended to come into contact with food and amending Regulation (EU) No 10/2011 as regards the use of that substance in plastic food contact.
This regulation fixed a new migration limit for BPA of 0.05 mg/kg, definitely lower than the previous limit of 0.6 mg/kg.
Moreover the demonstration of the feasibility of a lacquer from renewable resources could support legislation action on the Food contact material in banning specific dangerous molecules.

2. Long-term benefits and sustainability

a. Long-term/qualitative environmental benefits

The extraction process of cutin from tomato peels represents a sustainable technology for different reasons: the tomato peels, which actually are used for animal feed or as substrate for fertilizers, with this new extraction process are used both as a starting material for a natural and eco-friendly bio-based lacquer and for the production of biogas, realizing in this way a double valorization of a waste. The extraction process is a process almost circular with reduced losses to a minimum, since the solutions are or re-entered in the process either send to biogas.
Moreover, as already discussed, the bio-based lacquer obtained from the cutin extraction represents a possible solution to the problem of BPA-based lacquer and an alternative to the traditional oil-based lacquers, at a time when sensitivity on bio-materials is very high amongst institutions, consumers and large retailers.

b. Long-term/qualitative economic benefits

The long-term economic benefits of this new technology will be wide. For the tomato industry the main economic benefits will be represented by the peels disposal, which will never be a cost, but it will become with this technology a possible earnings. The results of the project, included the demonstrated greater digestibility to biogas, have possibilities of application and dissemination at the world level, since each year in the world more than 1 mln ton of solid tomato residues (peels and seeds) are produced.
The tomato industry in particular and the food industry in general would also have the advantage of using a green can for their products. Furthermore, considering that the prototype uses simple and consolidated technologies, organic solvents are not used and the total cost is relatively low, it is reasonable to think that it can be easily replicated also by a tomato processing company to have a locally sourced product. Also the green chemistry industry will benefit from the new technology; the plant has been indeed built with a capacity/size that can be easily implemented at an industrial scale and it is flexible enough to be used for other vegetable waste too.
As regarding the bio-lacquers development, there will be great potentiality in the economic market at European level and at international level. For example already now it isn't possible

to introduce BPA lacquer in France, since January 2015; since next September 2018, based on the new regulation, it is also banned at EU level for materials and articles specifically intended to come into contact with infant formula, follow-on formula, processed cereal-based food, baby food, food for special medical purposes developed to satisfy the nutritional requirements of infants and young children or milk-based drinks and similar products specifically intended for young children, as referred to in Regulation (EU) No 609/2013. The new bio-lacquer will find a market in all Europe, in the USA and even in Asian. In fact the global metal packaging market is expected to grow by 4.5% annually to a total value of $132.1 billion in 2021. Strong growth of end-use industries in developing countries including India, China, and Brazil is foreseen further anticipated to propel the market growth over the projected period. The North American region accounted for around 34.4% of the total market share in terms of value, followed by the European and Asia-Pacific regions.
Finally it should be underlined that the final cost of this new bio-lacquer will be comparable with those of oil-based lacquers, about 7.0 euros/kg in comparison with 4.0 Euros/kg. The consumer will pay about the same price but for a safer product, considering that with 1kg of lacquer about 5200 cans are lacquered, the incidence of the cost of the new lacquer would be 0.0006 Euros per can, practically negligible.

c. Long-term/qualitative social benefits

The production of a natural lacquer will significantly contribute to the safeguarding of both the health of workers and people health. The absence of organic solvent during the extraction process will improve the working environment and it will increase the safety of workers, also reducing the production of oil-based lacquers, containing dangerous substances. In addition the new bio-lacquer will contribute to increase the safety of food product, producing a natural lacquer with less risk of migration of dangerous substances, monomers and oligomers. The project will contribute to increasing the consumer's feeling towards the issues related to packaging waste.
The realization of the prototype has given rise to at least 2 new professional profiles, therefore its industrial scale-up may lead to the creation of new jobs.
An important aspect to underline is that the construction of the plant on a farm showed the interesting possibility of differentiating activities in line with regional and national policies.

d. Continuation of the project actions by the beneficiary or by other stakeholders.

The BIOCOPACPLUS project is not concluded. The beneficiaries, SSICA in particular, will continue following the pack test up to 24 months. Salchi will continue working on the bio-resin polymerization and on the lacquer formulation to obtain a cleaner and more standardised product. Also thanks to the collaboration with CFT, in the Agrimax project Chiesa will implement the dimensioning of some plant components to obtain a continuous process. At the same time the plant will be completed with other pieces of equipment to increase its flexibility, to process bran as well and especially to extract lycopene from exhausted skins after cutin extraction. SSICA will study in laboratory the possibility of extracting cutin from other vegetables, such as melons, water melons and potatoes, using the same process.
Finally, the possibility will be considered to build a new plant on the premises of a tomato processing company following the interest shown and the request made by a large retailer. Negotiations are in progress.

3. *Replicability, demonstration, transferability, cooperation: potential for technical and commercial application (transferability reproducibility, economic feasibility, limiting factors) including cost-effectiveness compared to other solutions, benefits for*

stakeholders, drivers and obstacles for transfer, if relevant: market conditions, pressure from the public, potential degree of geographical dispersion, specific target group information, high project visibility (eye-catchers), possibility in same and other sectors on local and EU level, etc.

The BIOCOPACPLUS project found much interest from the scientific community, SMEs and multinational companies, as well as from large retail. Every time the project was presented at workshops and conferences, the audience has always shown great interest and asked interesting questions about possible applications of the new product and about the time to market.

The interest in repeatability and transferability refers both to the prototype extraction process and to the product obtained. The extraction process is based on simple and well-known technologies; it doesn't use organic solvent; no environmental permission are required; performance and yield are relatively high at a relatively low cost. So it is easy to be replicated even in a tomato industry to obtain a locally source product.

Since the cutin is not present only in the tomato peels, the research could be extended also to other vegetables, such as watermelons and potatoes, using the same process. In this way the pilot plant realized will become a flexible and versatile prototype (a bio-refinery) able to treat different wastes in different period of the year. Furthermore, it can be industrialised easily since its capacity is about 10-20% that of an industrial plant. As the new Agrimax project demonstrates, the process is also flexible enough to be supplemented by other technologies, such as the use of exhausted skins for lycopene extraction, with higher yields compared to the plain skins.

Cutin was used in the project as a basic resin for the formulation of lacquer to be applied to metal packaging for food. However, as requested by many, it may have many other applications. As a lacquer for metal packaging for non-food products, general lines or aerosols, or as a component of lacquers for non-stick frying pans. Some company have contacted us even to know eventually other application's field of cutin different from lacquer, in care of person and cosmetic, in interior design, building sector.

4. Best Practice lessons

The first best practice measure of the cutin extraction process is the reduction of waste, both solid and liquid, produced by this process, where practically the solid waste, the exhausted tomato peels after the thermal treatment, are directly send to biogas while the liquid solution are in recirculation for a determinate number of times, until it is possible to recycle, then they are finally send to biogas. In this way any waste produced by this process feed the biogas and there are no waste to discard. Besides, since in this extraction process aqueous solutions are used, the pollutants are reduced to a minimum. Finally actually the energy for the thermal treatment is gas oil, but there is already the possibility to use eventually even as energy source pellet or biogas. (The chosen boiler and installed on the prototype can be switched to this other energy sources.) In future it will be possible to think even to other alternative sources for the thermal treatment, such as for example microwave. The process has been developed and could be implemented taken into counts the Best Available Technique for the production of Speciality inorganic Chemical (BREF 08.20007) and for Organic fine Chemicals (BREF 08.20006)

5. *Innovation and demonstration value*

The "innovative" character of the project results from the application of a process for the extraction of the cutin and for the development of a bio-resin cutin-based, that has not been applied before or elsewhere and that offers potential environmental advantages compared to

current best practice. The degree of innovation also derives from the use of industrial tomato by-products as raw materials.
The technological innovation consists of the scale-up of the cutin extraction process, developed and patented from the beneficiaries at laboratory level in a previous project, funded under FP7 program, maintaining the same characteristics of efficiency and effectiveness. A specific work has been performed to transfer several process parameters to pilot plant. The design, realization and start up of the prototype is the milestone, the greater innovation of the project. There is currently no similar industrial plant. With the implementation of the prototype we are actually demonstrating, at TRL 6, the ability to valorize the tomato processing by-products as a raw material with high added value, throughout the year, which currently represent an environmental problem and a cost. The high yields of the extraction process also allow providing for a minimum increase of costs for the consumer in front of a safer paint.
The innovation is also related to the product; with the cutin extracted it will be possible to produce an innovative BPA free lacquer for green metal containers, of which no other examples exist on the market or in literature, unlike the bioplastics sector that is constantly evolving. The technological innovation also covers the scale-up of the production of the resin from the raw cutin, specifically developed for this natural polymer.
The project has combined in an innovative way different competences that have contributed to achieving the final result. The innovative character of the project concerns also the business and economic models developed by the project. The production of a metal can protected with a natural varnish for the food packaging has wide degree and rate of expansion, on the one hand for the high sensitivity and attention of the consumer on the other because the legislation on food contact materials becomes more and more restrictive.

6. Long term indicators of the project success.

The tangible and concrete result of the project was the production at industrial level of the new eco-lacquer. The cutin-based lacquer produced shows chemical and physical properties comparable with the standard one, even after sterilization in water and in steam and in contact with different type of foods. Global and specific migration comply with the European and National legislation. The lacquer was applied at industrial line without any modification of the line parameters; the cans were produced and filled industrially; all that proves the economic viability for the proposed technology.
Summarizing the long-term indicators of success will be:

- Improvement of yield
- Standardisation of extracted cutin
- Reduction of cost difference between the new lacquer and the traditional one;
- Realization of at least 1 industrial plant
- Use of eco-cans for green product lines
- Reduction of the environmental impact of the process through an optimized use of resources, water and energy
- Standard shelf-life for different kind of foodstuffs.

In conclusion if the lacquer produced will be competitive with other standard lacquers for properties, performance, cost and environmental sustainability, the new product will be a successful results of all this research study.