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# RECYCLING OF CITRUS INDUSTRY SCRAP INTO NATURAL ADDITIVES FOR FOOD INDUSTRIES

RECICLADO DE LOS SUBPRODUCTOS  
DE LA INDUSTRIA DE CÍTRICOS  
EN ADITIVOS NATURALES PARA  
LA INDUSTRIA ALIMENTARIA

## LAYMAN'S REPORT



LifeCitrus



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# LIFECITRUS PROJECT

## RECYCLING OF CITRUS INDUSTRY SCRAP INTO NATURAL ADDITIVES FOR FOOD INDUSTRIES

### BENEFICIARIES

#### COORDINATOR

Centro Tecnológico Nacional de la Conserva y Alimentación (CTC)

#### PARTNERS

AMC Innova Juice and Drinks, S.L. (AMC)

Fundación Clúster Agroalimentario de la Región de Murcia (AGROFOOD)

Federalimentare Servizi srl (FEDSERV)

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# 1. THE PROJECT

## 1.1 introduction

EU citrus fruits production is concentrated in the Mediterranean region. Spain represent nearly the 60% of the EU-28 total production and Italy about 30%; the remaining 10% is distributed among other Member States, mainly Cyprus, Greece and Portugal. Within the agro-industry, the processing of citrus fruits has different phases from the collection of raw materials to the desired product obtaining. During this process, a significant amount of waste is produced. The nature of this waste is a low-quality fruit and especially parts of the fruits without commercial value (crust) removed during the transformation processes. The management and elimination of this waste, at best, mainly take place by means of direct use in animal feeding. This solution is not the adequate way to manage the huge volume of citrus waste produced, and they are not supported by the advanced scientific and technical approaches. These practices are caused by confused definitions as well as insufficient operative legislation, which only consider these materials as valueless, leftover elements of the productive processes, without taking into account their intrinsic nature and characteristics and their important potential for different novel, valued-adding utilities. Concerning the negative environmental effects, the most significant are:

- in the case of the not suitable soil reincorporation: organic wastes are a great source for plagues and pathologies.
- in the case of being directly destined to animal feeding (without elaboration or control): it has a short effectiveness and a potential danger for the cattle health, being particularly dangerous the FVW pesticide residues that it would be able to contain.

Both, land filling and animal feeding use of the citrus fruit residues, has a negative impact on the environment due to the emanating liquids which can ferment and contaminate soil and aquifers, besides the smelling problems. Also, in all those cases, with negative economic effects due to the costs of incorrect management and remediation of the mentioned



effects. Feasible solutions, from technical, economic and environmental points of views are necessary to improve the competitiveness of the agroindustry businesses and minimize their environmental impact, leading to a sustainable use of resources.

LIFECITRUS directly aims to achieve the objectives settled out in the Roadmap for a Resource-Efficient Europe and the 7th Environment Action Programme, given that the proposed innovative process will maximize the waste recycling, accordingly to the first steps of the UE waste hierarchy (prevention, re-use and recycling), as well as it will limit the landfilling of residues or even their non-appropriate management.

## 2. THE BEGINNING

### 2.1 Addressing the problem

At present, high levels of industrial development lead to the generation of waste, while at the same time leading to the development and implementation of new methods or techniques for taking advantage of said waste. In food production processes, in addition to the desired product, by-products, waste and sub-standard products are generated, each of which can be used for human or animal consumption and industrial application, leading to financial profit.





The citrus sector in Europe is strongly geared toward the fresh product market; however, the production of citrus juice (orange juice especially) has a strong market position due to modern consumption habits as opposed to the consumption of fresh whole fruit. This agro-industry generates a significant amount of waste made up of fruit discarded due to low quality, but especially by the parts of the fruit with no commercial value (skin/peel) that are removed during the transformation process. Management of this waste through direct use in animal feed leads it to be classified as a by-product, but this solution is not compatible with advanced technical and scientific criteria. These by-products are generated in large amounts due to the high industrialization of the processes, with Spain producing over 1.5 million tonnes in 2013/2014 season, representing 57% of industrialized citrus production in the Mediterranean Region (1). In the case of citrus fruits, between 35% and 55% of the fruit processed is a by-product that can be exploited to obtain value-added ingredients that can be applied in different sectors. The project titled "Recycling of by-products from the citrus industry as natural additives for the food industry" known as LIFECITRUS proposes the implementation of an innovative process that the National Technological Centre for Preserves and Food (CTC) has been testing in the laboratory with positive results in recent years. The process is

based on physical operations that lead to the production of a new ingredient for application in the food industry.

The aims of this project were to obtain a new ingredient and to verify the use of this new ingredient in food products as a substitute for additives used in the food industry, but also its incorporation to increase the dietary fiber content and obtain new products with a lower caloric content.

## 2.2 Methodology and optimization tests

LIFECITRUS is based on the premise that lemon peel contains a high pectin content, which would allow to value a byproduct generated in high quantity in citrus juice industries. Since it is sought to improve the process, it was considered to obtain a higher yield to the obtained at laboratory scale processing a greater amount of raw material. Also, the minimization of water and energy consumption, indicators not considered in the laboratory test, were valued in this project.

In addition, during the process it was sought to obtain a neutral product with small particle size and high content of dietary fiber, which may be applicable in the elaboration of food products. With this action, the development of a processing line for citrus byproducts was achieved to obtain a semi-finished product on a semi-industrial scale, making use of physical operations.

The picture 1 represents the flow chart of the process of citrus scrap treatment to





obtain high added value natural gelling agents (citrus puree) implemented at CTC Pilot Plant.

For the start-up, first, the raw material used in the process was analysed, to guarantee its use at the food level (which does not contain contaminants or are below the permitted levels) and to be able to determine the compounds of interest that they can be evaluated in the optimization stage. Ensuring the application of the new ingredient at the food level is a priority.

Subsequently, tests were carried out to evaluate the connections and the system for supplying the washing water, in continuous or in batches, as well as the heat treatment to guarantee the food safety of the product. The pH value, °Brix, microbiological contamination and the hesperidin content were taken as reference parameters. In addition, the organoleptic characterization of bitterness was carried out by the tasting of the product.

As a conclusion of these tests carried out, the equipment works correctly in the demonstration plant and the optimization of their working conditions enable to obtain the new food ingredient.



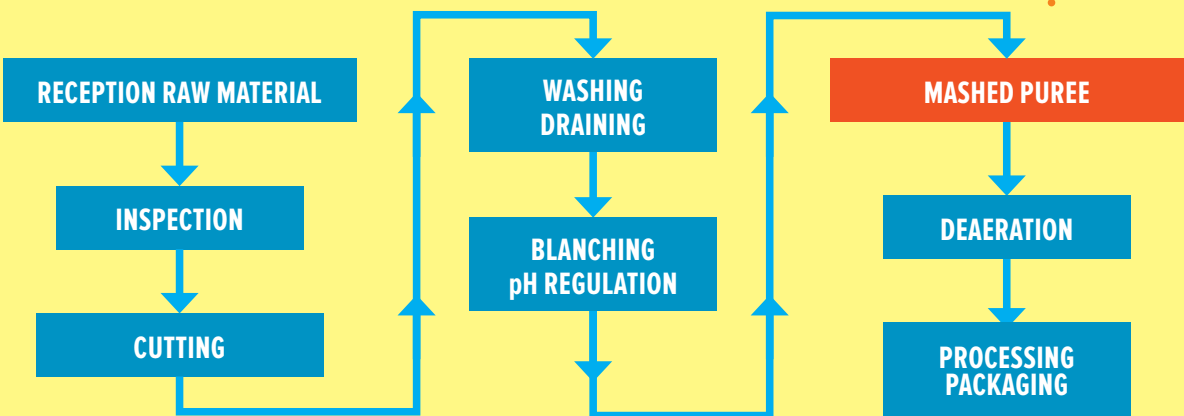
It was performed a test programme and characterization of the process parameters and products specification. This study was planned as two separated phases initially (the first one for the production and packaging of the puree and the second for the use of the ingredient on the foodstuffs fabrication), but these two phases were developed together.

The optimization of the process was planned with the aim of used water reduced, higher hesperidin contents, lower bitter taste and the microbiology safety. Furthermore, the elaborated ingredient was used for producing foods. The nutritional and sensorial analysis were carried out to validate the use of the elaborated ingredient in foods.

A total amount of about 2.000 kg of citrus by-products (lemon, orange and tangerine) in 13 tests was processed. And a total of 27 new foods were produced, in the frame of 13 different food categories: jam, vegetable salad, cake, vegetable soup, tea biscuits, jelly, paparajotes, orange cookies, tomato soup, hamburger, almond beverage, quince jelly and light jelly.

In the project were necessary to optimize the steps of the LIFECITRUS process (washed, extraction, cut and enzymatic inactivation). The yield of the LIFECITRUS process was between 45-67%, this value depends of the raw material (lemon, orange or tangerine by-products), and the higher value was achieved with lemon by-products and the lower with tangerine by-products. The consumed water was

**Picture 1.**  
**Flow chart of**  
**citrus puree**



reduced from 40 to 15 L of consumed water per kg of citrus by-products. Once obtained the mash, it opens a wide range of possibilities to any company of the sector that is in the search of the development of increasingly natural foods. The picture below shows the development LIFECITRUS process.

About of the validation of the new ingredient in the food industry, LIFECITRUS's staff formulated different foods and it can be concluded that the residual citric flavour of the lemon puree was not appreciated when this puree was used as an ingredient in all the tested food. On the other hand, when the orange and tangerine purees were used as an ingredient in foods the taste and the colour of the tested products were negatively affected by the acidity of orange and tangerine purees. The lemon byproduct was the most potential byproduct for its nutritional, sensory, gelling and hydrocolloid properties compared with orange and tangerine byproducts.

In order to disseminate the innovative process and the use of the new ingredient to citrus juices and oil industries, fresh producers and marketers, and jams, jellies and canned foods companies, the partners have been in contact with 200 companies and relevant associations and have organized 7 workshops at

regional, national and international level. 7 workshops at regional, national and international level.

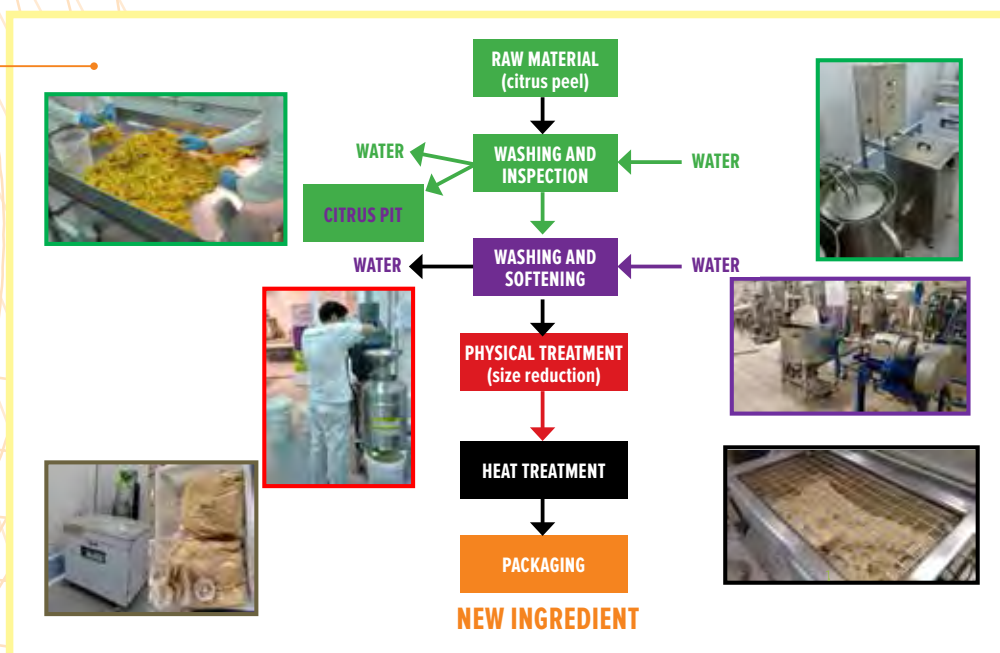
Finally, companies in the sector have been able to test the demonstration plant to obtain the new ingredient or evaluate its application in new foods.

### 3. WHAT WE ACHIEVED: RESULTS

#### 3.1 Technical feasibility

The nutritional characteristics of the citrus purees elaborated (lemon, orange and tangerine) allowed to label these ingredients as a low-calorie product. The nutritional facts of the samples show a low value in fats, carbohydrates, proteins and energy parameters. The tangerine puree showed the higher value in the energy parameter due to the higher value in fibre and carbohydrates compared to lemon and orange purees. The 3 citrus purees elaborated in the frame of LIFECITRUS project are a potential product for use in food as a source of fibre. The elaborated lemon puree showed a lower brightness (higher L value) than the raw material, the b Value of Cielab Chroma, showed that the lemon puree was more green than the lemon by-products. Similar results were

Picture 2.  
LIFECITRUS process  
flowchart.



found for the orange by-products. Finally, for the tangerine by-products a higher value of brightness in the elaborated puree and more red colour than the raw material, were obtained. The whiteness of the elaborated lemon puree makes this ingredient more applicable in foods than the orange and tangerine purees. The main conclusion was that the lemon by-product was the most potential by-product for its nutritional, sensory, gelling and hydrocolloid properties compared with orange and tangerine by-products. The LIFECITRUS process for obtaining natural food ingredients from discarded parts of citrus fruits is environmentally sustainable. The new products obtained have been used as an ingredient for food development, highlighting its application in a strawberry jam where it has been possible to verify the gelling capacity of citrus byproducts versus pectin.



This project also investigated the use of the new ingredient in the preparation of cream of vegetable soups, Paparajotes (typical product of the Region of Murcia), cakes and in meat products such as hamburgers also because the citrus puree can replace the additives and be incorporated into foods to increase the dietary fiber content and obtain new products with a lower caloric content.

In the cream of courgette, an adequate texture was observed in both cases since the addition of dietary fiber can improve the texture characteristics of foods depending on their ability to retain water and form gel, as well as their texturing and thickening effects. The nutritional analysis presents significant differences in all measured parameters between the control (with potato) and the new product evaluated with citrus puree, with a significance level of  $p=0.05$ . On the other hand, the sensory analysis indicated that consumers preferred the odour and taste of the cream of courgette soup with potato, but they preferred the consistency of the cream of courgette with the citrus puree, with a confidence level of 95%. When making the "Paparajotes", it was decided to include the new lemon puree ingredient to replace the lemon zest and part of the flour in the traditional pastry recipe. In nutritional terms, no differences were observed in the content of fat and dietary fiber, though the remaining analyzed parameters were different.

**Strawberry jam.**  
**LIFECITRUS**  
**food**  
**development**



**"Paparajotes".**  
**LIFECITRUS**  
**food**  
**development**

For the sensory parameters evaluated, the odour and taste attributes showed significant difference due to consumers preferred the odour and taste of the Paparajote sample with lemon puree, with a confidence level of 95%. When making the cakes, proper dough consistency was maintained even after incorporating



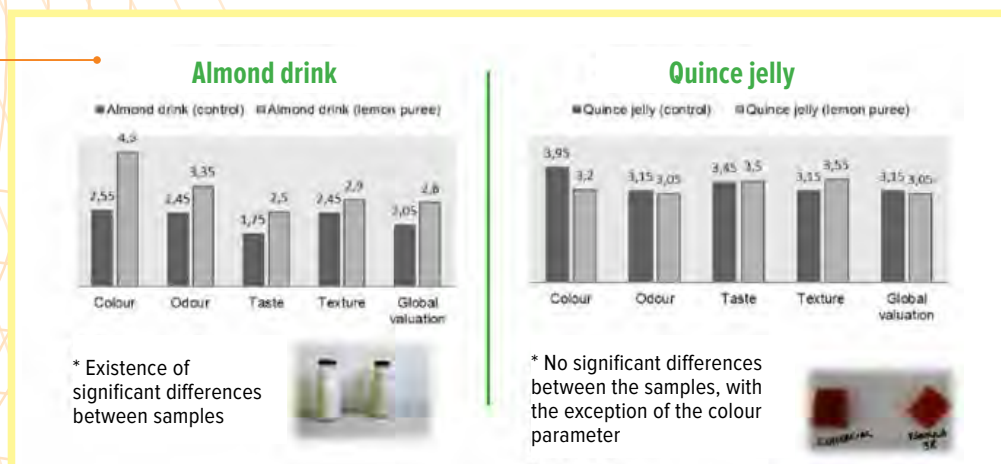


the new ingredient. The nutritional analysis of the two samples can confirm that there are significant differences, with a significance level of  $p=0.05$ . In addition, the fat content is reduced by incorporating the citrus puree, but the fat content remains above 7 g/100g so "no fat" or "low fat" statements cannot be advertised, in accordance with the current regulations (nutritional claims). However, it can be determined that the addition of the puree ingredient allows an increase in the dietary fiber content of the cake while at the same time reducing the energy value of the product, but the sensory analysis does not improve with the citrus puree. Nonetheless, these results may be of interest to improve the effects on health and achieve an average daily consumption of dietary fiber close to the adequate intake of 38 g for men and 25 g for women. Lastly, the beef hamburgers with a 10% of the citrus puree ingredient did not show significant differences ( $p < 0.05$ ) in the fat and sugar parameters compared with their control, but there were differences in the remaining parameters. In the sensory parameters evaluated both samples of hamburger show no significant difference in terms of colour and taste, with a confidence level of 95%, however, there is a significant difference in terms of the preference for the odour and consistency, and consumers preferred the odour and consistency of the hamburger with lemon puree. Another of studies has been the validation of the new ingredient in the production of innovative products like

an almond drink and a quince jelly (Picture 3), that they can have on their labeling a nutrition and health claims according to the current legislation and focused on the final consumer for its beneficial effects (also can be classified as "Clean labels") and their acceptability from consumers. These products have been designed by the thickening and gelling capacity of citrus byproducts. The results obtained have shown that 2% and 10% of the new ingredient, in the formulation of each of the products produced is proper to develop products like commercial food and accepted by a panel of consumers. The use of a new natural ingredient from the recovery of citrus by-products allows healthier food products with better nutritional values (more fruit and less sugar and fats, without allergens or preservatives, natural, ecological, with lower amounts of salt and artificial flavours...) to be produced. In conclusions, exceptional properties and composition of the innovative ingredient can substitute additives (pectins, thickeners, ...) in the production of new foods with the consequent achievements:

- improvement of the integral utilization of the citrus fruits;
- total or partial substitution of the chemical additives used in the manufacturing of fruit jams;
- obtaining more natural products, improving the added value and the nutritional and functional properties of the elaborated food;
- offering to the consumer a distinctive product with excellent sales perspectives.

**Picture 3.**  
Almond drink and  
quince jelly results.



### 3.2 Economic feasibility

According to the results obtained, the by-products of the citrus processing industry can be valued within the industry itself through a technically feasible process. The location of the recovery plant can be a fundamental factor. Companies with a high production of citrus by-products are the potential beneficiaries of the LIFECITRUS process.

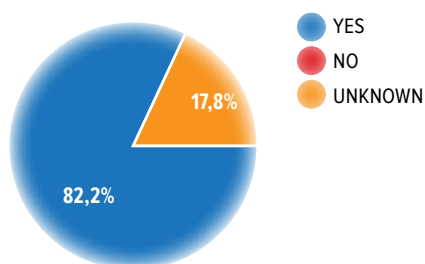
On the other hand, from the market research it can be observed that the potential consuming companies of the puree product show a lack of knowledge about other currently marketed natural ingredients, which could be substitutes for pectin. This fact guarantees the success of the placing on the market of an ingredient as the proposed pure once disclosed its characteristics and properties (Picture 4). The price of commercial powdered pectin has been determinant to obtain a positive result as a net profit.

### 3.3 Socio-economic study

At the start of the LIFECITRUS project, about 50 fresh citrus fruit trading companies were registered in the Region of Murcia and approximately 15 citrus processing companies. All of them are potential generators of the byproduct to be used in the LIFECITRUS project. After this project, a greater number of target companies of the LIFECITRUS process has been determined and more than 200 companies know the LIFECITRUS project. The socio-economic impact study carried out in Murcia revealed in its survey that the LIFECITRUS project is adapted to the needs of food companies and presents the possibility of hiring new technicians (64% of respondents) from nearby areas as it would be favored the local economy with new investments, but above all an interest of the population to devote efforts in the valorization of byproducts, giving training to the technicians of the companies and without the need to apply large costs.



**Do you think that the LIFECITRUS project is adapted to the current needs of food companies?**



**Picture 4.**  
**LIFECITRUS**  
**feasibility**

### 3.4 Training courses for technicians

Three editions of the LIFECITRUS course have been held with the participation of more than 30 people from 16 different companies and students from 7 training centers with training to perform tasks in the food industry. The course was structured in a theoretical part and a practical part developed in the demonstration plant of CTC with the following contents: Environmental legislation; characteristics and potential of citrus residues; concepts about the technology used in the process; utility of the ingredient obtained in the manufacture of new foods.

**Picture 5.**  
**Do you think that the LIFECITRUS project is adapted to the current needs of food companies?**



## 4. LIFECITRUS COMMUNICATION

### 4.1 General dissemination via press & media

The project was widely disseminated during national and international events where the latest developments have been cited. The overall results of the project which also included the presentation of the innovative process and the product specifications obtained were showed during bilateral meetings with different companies and research centers for the transfer of technology. Also the visibility in national Press, social networks and TV was promoted. More than 450 people visiting the demonstration plant in 63 organized visits: 138 technicians of agri-food companies, 14 journalists, 300 students and 23 technicians of public bodies. Throughout the project, six press releases have been prepared and LIFECITRUS project has had a total of 36 appearances in the media that could have been registered (including 8 appearances in TV reports, YouTube videos, Facebook and digital newspapers, and 6 radio appearances). The full list of scientific and technical publications released by LIFECITRUS team is available at [www.lifecitrus.es](http://www.lifecitrus.es)

- A special dissemination action was the collaboration in the organization of the conference 8<sup>th</sup> FOOD TECHNOLOGY INTERNATIONAL SYMPOSIUM and Murcia Food Brokerage Event 2017. 9-10 May 2017.



- Participation in the SeCyT'17 event organized by the Seneca Foundation of the Region of Murcia and held in the Malecón Garden from November 10 to 12, 2017. On this occasion, the LIFECITRUS project partners organized a demonstration workshop to bring the actions of our project closer to the population through the informative video.
- Project technicians have participated in different forums of interest, highlighting the participation in conferences of other European projects, food fairs (such as CIBUS 2018) and congresses related to food and beverages (such as the 9<sup>th</sup> International Chemistry Congress, ANQUE 2018).



- Initial presentation, on December 11, 2015. The digital newspaper Murcieconomía publishes "How to turn citrus residues into natural additives".
- On February 9, 2016, the article "De corteza a aditivo natural" is published in the section My Land of the newspaper La Verdad de Murcia.
- On February 11, 2016, a report on the LIFECITRUS project for the Diario del Campo program of the 7RM television channel is recorded in the CTC, which is finally broadcast on March 3, 2016.
- The coordinator of the project, PhD. García, visits the Curiosity Program (7 Television Region of Murcia) on April 17, 2018.



- On November 9, 2016 the first guided visits of journalists to the demonstration plant was organized.
- On January 17, 2017, the second day of open doors to the media in the demonstration plant. The Director of the Institute of Development of the Region of Murcia (INFO), Mr. Joaquín Gómez, and the President of the CTC, Mr. José García, were able to attend the media and highlight the work carried out by the LIFECITRUS project for the development of the agri-food sector.





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