



LIFE Environment and Resource Efficiency

LIFECITRUS

LIFE14 ENV/ES/000326

B3_Summary report of the Region of Murcia demonstration initiatives

30 July 2018.





This report collects information on the B3 action raised in the memory of the project “LIFECITRUS-LIFE14 ENV/ES/000326”.

1. SECTOR AND COMPANIES' INTRODUCTION

With the action B3, the demonstration of a processing line for citrus byproducts was achieved to present an alternative to citrus waste by recycling. We have pursued the objective of disseminate to Murcia citrus farmers, marketers and industries, that the by-products of the citrus industry should not be considered a polluting agroindustrial waste.

Below is information on the citrus sector and the companies that integrate it in the Region of Murcia.

Citrus Agricultural Production

Citrus fruits are acid fruits as their soluble solids are composed of mainly organic acids and sugars, components which contribute to flavor attributes and largely affect taste characteristics and organoleptic quality.

Citrus fruits are fruit with good acceptance due to their flavour, aroma, colour, texture and high nutritional value in human diet. They are mainly a primary source of our daily requirements for vitamin C. This is the reason for incorporation of citrus fruits into the diet of developed countries. Moreover, citrus fruits have a high nutritional value due to their contents in amino acids, minerals, bioflavonoids of high biological value.

Citrus crops are often very intensive systems with high inputs of irrigation water, fertilizers, pesticides and fungicides. In Murcia fresh fruits have an important national market and exports, so there are many hectares cultivated and its production is high

This high production allows fresh commercialization and for industry. However, when there are unfavorable situations in the market, the farmer benefits are not high, not even covering costs. This situation produces, excess productions in field and waste. Another problem is that fruit with not good appearance are difficult of commercialize. In the Region of Murcia, the production of Verna lemon it the thirty percent of the total lemon production. It is due to its excellent resistance conditions for fresh market. However, Verna lemon has a thick and rough skin, size and irregular shape, above all in the first years of production. This is the reasons for high percentages of fruits which can not be comercialized and can become waste. In addition, this variety has a low content of essential oil, which it is dificult its industry processed and can be destined to another market or treated as a waste.

The most common waste management methods for citrus waste are composting, anaerobic digestion, incineration, thermolysis, and gasification. One of the objctive of LIFECITRUS project has been contact farmers to show them that they can access to new industrial market more profitable and environmentally sustainable to produce a new food ingredient.

Citrus Industry (Juices and essential oil)

When the Spanish citrus industry born, had two specific objectives: production of orange juice and preparation of raw materials from bitter orange to produce jam.

Nowdays, citrus industry uses all fruit, although sometimes part of the total process citrus is is completed in specialized industries. In spite of this, this industrial sector has developed machinery able to obtain different products of the raw material. In the process to make citrus juices is posible obtain essential oil. The essential oil is obtained scraping the peel of fruits and washing whit water. After that, with a centrifuga, the esential oil and water are separated.

These volatile oils are used for flavoring ingredients in drinks, ice creams, and other food products. Additionally, substantial quantities of these oils are used in the preparation of toilet soaps, perfumes, cosmetics, and other home care products. Therefore, it is a product with high added value and very demand.

Currently, the citrus juices process consists first of all in the selection and washing of the raw material. After that, the fruits are calibrated and passed to the extractors machine. The extractor produces juice and the essential oil in an aqueous emulsion in a single operation. Next, the juice is filtrated to reduce the and is homogenized to keep the solids in suspension. The watery emulsion is then centrifuged to recover the essential oil.

Finally, the juice is pasteurized with termal treatment and packaged for commercialization. The essential oil for sale to other industries.

Because of processing, large amounts of after-wash waste water; solid residues (mainly peels, membranes, and seeds); and semisolid residue after the extraction of juice, in the form of centrifugation pulp, remain as waste products. It is remarkable that citrus peel alone accounts for almost 50% of the wet fruit mass. This byproduct/waste is rich in sugars, fibers, organic acids, amino acids and proteins, minerals, oils, lipids, and large amounts of flavonoids and vitamins.

Pectin is another product of interest to the industry. Pectir is recover from the bark of citrus fruits. The process to make pectin is complicated and expensive. The previous operations necessary to obtain it include the preparation of the skin (extraction of soluble sugars, bitter glycosides and enzymatic inactivation, with abundant amounts of water) and drying for storage. After that, a treatment to make soluble pectin is aplyed by acid hydrolysis, and successive and tedious operations of precipitation, purification and filtration. Finally, the soluble pectin is dried to have a standardized product.

In Spain, years ago, there was different facilities to dry citrus peel and even as treatments previous to production of pectin. However, this product has not become a fact, in spite of that there are huge quantities of lemon peel that could justified this process. Perhaps it was due to the complexity of the international market for pectic substances.

For this reason and due to current processes are not sustainable, the LIFECITRUS project has contact with citrus process companies to show them the advantages of produce a new food ingredient that can offer solutions to the citrus waste.

Food processing (jam, jellies and other agrofood products)

The industry has adapted procedures and homemade recipes to industrial processes using facilities, technology and other ingredients, to ensure uniform and high-quality finished product. In addition, nowadays, people are aware of relationship between diet and health is very important to have high quality of life. For this reason, new marked with healthier foods called "functional foods" has appeared. The Region of Murcia must adapt to new markets and work to satisfy the consumers demands.

Food processing industry is of enormous significance for Region of Murcia' development because of the vital linkages and synergies it promotes between the two pillars of our economy, industry and agriculture. In 2014 in the Región de Murcia there was 158 agrofood according to ECONET data of Regional Statistics Center of Murcia (CREM). This sector consists of the following subsectors or classes:

- Processing and conservation of potatoes (Clasificación 1031).
- Preparation of fruit and vegetable juices (Clasificación 1032).
- Process and conservation of fruits and vegetables (Clasificación 1039).

The clasificacion1032 has described in the previous parragrafs, so now, we are describing clasificacion1039.

In this sector, the most of industrial processes included common basic operations and the general process to produce canned vegetables can be described as follows: i) the raw material received can be immediately is introduced into the processing line, or stored in refrigerated rooms; ii) before the product be introduced in the line process, it must be washed to eliminate organic or inorganic residues. After that, the product is calibrated and inspected; iii) next, the products are bleached, peeling, disheartened, cutting and the washed to prepare the producto to their final presentation; iv) the preserve can be done by packaging with addition of brine, juice or syrup. After that the product are seterilized or freezing. In addition, in this sector, there are a lot of Companys that make jams, with a differentiated production process, and therefore its description is interesting.

The jam is a product prepared by cooking whole fruit or vegetables, chopped, crushed, sieved or not. Sugar is added until a semi-fluid or thick product is obtained. The jam has a minimum final quantity of 40% of sugar and a minimum proportion of fruit of 30 %. To make jam, it necessary prepare the fruit and making a pulp or using pulp directly. This pulp is introduced in a marmita and other ingredients, pectin, sugar and citric acid are added in the suitable proportions. The pectin is added mixed with of sugar. The total product is cooking for an enough time to get appropriate product. Finally, the product is filling in appropriate container.

The Region of Murcia have a strong specialization in the sector of the canning of fruit and vegetables industry, but currently its growth is slower than other sectors of the Region. Therefore, we believe that a greater use of resources and new demands of people related to healthy foods could enhance the regional production of this sector.

If we use common raw materials, the fruit and vegetable preserves and, especially, jams, are very popular and have a little added value. So that market innovations could be directed towards them, using natural ingredients instead of pectins or other thickeners according to the current demands of society.

Organic products

On the other hand, more and more consumers want to know what they are eating and want foods to be healthy and produced without harming the environment. For these reasons, the demand for organic products is now growing worldwide.

Consumers consider organic products of higher quality, principally for the lack of chemical products utilized during the production process or conservation phase, largely utilized and employed in conventional farming, allowing a more sustainable and environmentally friendly supply chain (1, 2). In general, it can be said that the quality of the organic product is greater than that of the conventional one, without this supposing to undervalue the benefits of the latter. They are foods that are subject to less risk in their production and are more natural and safer and are less likely to cause allergies, poisoning and other disorders that may arise because of the different substances used for food processing conventional.

Nowadays, about 20 years after adopting Regulation (EC) No. 2092/91 (3), organic farming represents a successful reality in lots of European Union countries and the sector is still growing.

In the year 2014, the total area of organic farming in the Region of Murcia was 57,540 ha (1,381 ha corresponded with the cultivation of citrus). Citrus products labelled as “organic” are those certified as having been produced through clearly defined organic production methods (see glossary). The compliance of the grower with these methods is verified by an independent organization (generally called ‘certification body’) accredited by an authority (e.g. national authority in the producing or importing country).

In 2016, the total area of organic farming certified by the Regulatory Board of Organic Agriculture of the Region of Murcia amounted to 79,043.95 hectares, with more than 31,000 organic agricultural operators.

In this regard, the LIFECITRUS project took into account the need to evaluate the process with organic citrus fruit and develop clean label food products. This organic product can be used as 100% natural ingredient through the collaboration of companies very involved in organic production and marketing.

2. METHODOLOGY

According to previous information, a lot of regional companies and farmers organized work meetings and demonstrative actions were carried out in the pilot plant of LIFECITRUS project.

A total of 94 regional companies have been contacted throughout this action. 41 lemon companies, 57 other citrus and non-citrus fruits and 40 canned foods, jams, jellies and/or other foodstuffs.

Three workshops were developing in the frame of this action. The first workshop, focused on regional lemon juice and oils industries and fresh lemon producers and marketers, was held on the 1st February 2017, with the attendance of 7 companies. The second workshop, focused on other regional citrus and fruit industries, fresh producers and marketers, was held on 7th June 2017, with the attendance of 6 companies and farmers. And the third workshop, focused on jam, jellies, canned vegetables and other agro-food regional industries, was held on 4th October 2017, with the attendance of 9 companies.

On the other hand, in 2017, attempts were made to contact CAERM, but there was no response due to its high workload due to the conversion of organic crops. Finally, and because ASAJA Murcia is close to farmers and organic production, they were contacted, a meeting was organized, and we were able to report to farmers in their General Assembly.

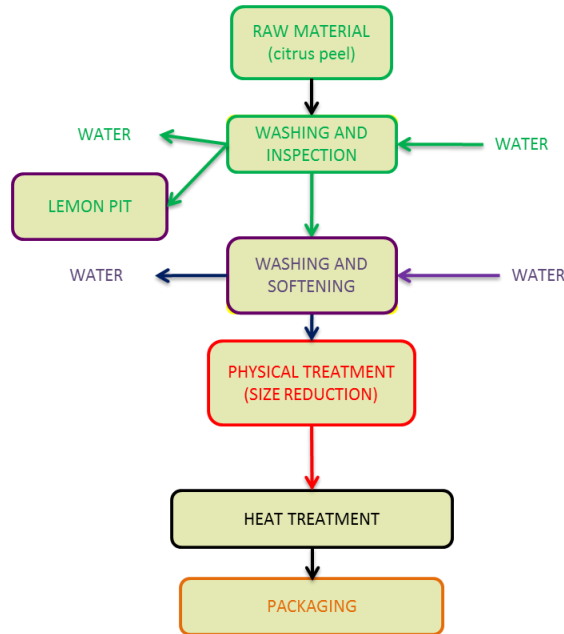
Because of the workshops and other dissemination activities, meetings with technicians from 18 regional companies and farmers have been held to plan demonstration activities in the semi-industrial plant. In fact, 27 tests for 16 of them have been done, while tests with the other two weren't scheduled at the end.

3. TESTING AT THE DEMONSTRATION PLANT

27 tests have been done mainly with citrus processing companies (especially lemon) with CNAE 10.32 and 10.39 and farmers and traders with CNAE 1.23, 1.50 and 46.31 ("Citrus cultivation", "Agricultural production combined with livestock production" and "Wholesale of fruit and vegetables" respectively) to produce the new natural ingredient. Other companies of Manufacture of canned fish (CNAE 1022) tested the new ingredient to make new products too.

In the tests, the objective was obtain a natural ingredient that can be used without modification the organoleptic characteristic of foods available in the market, but which can modify qualitatively and quantitatively its nutritional value. The new ingredient has been obtained as a pure aspect, but also its moisture has been reduced to be used as a powder due to demands of the interested companies. The new ingredient has been properly integrated into processed foods to offer interesting products for consumers and designed by participating companies.

The following chart shows the LIFECITRUS process for produce the new ingredient used in the demonstrations. In each product made with the new ingredient, the procedure will be indicated in the description of test of each company.



COMPANY TEST TO PRODUCE THE NEW INGREDIENT. Cítricos de Murcia (lemon puree)



Cítricos de Murcia is a company dedicated to the production of concentrated juices and citrus derivatives (orange, lemon, ...) and other fruits from the Murcia area and belongs to the Dallant group.

This company provide 50 kg of lemon by-product to evaluate the performance of the LIFECITRUS process equipment in the CTC demonstration plant. Finally, 14.24 Kg of the new ingredient was obtained. Therefore, the performance process was 30%.

This information was very interesting to the company to develop new products. However, other test was carried out to evaluate the performance with quantities closer to industrial scale.

The test was repeated with 450 Kg of lemon by-product. The new test made allowed get a higher performance, of 59%. The table 1 show characteristics of the ingredient obtained.

Table 1. Characteristics of lemon puree

	Lemon puree
pH	3.65
Calories (Kcal/100g)	25
Total fat (g/100g)	0.4
Total carbohydrate (g/100g)	1.2
Total sugars (g/100g)	< 0.05
Proteins (g/100g)	0.6
Dietary fiber (g/100g)	7.1

Sodium chloride (g/100g)	0.03
Hesperidine (mg/Kg)	3138
Moisture (g/100g)	90.4

Results in fresh weight

With these results, the company is interested in developing products such as lemon drinks. However, they must evaluate cost production like consumption of water and energy because their annual production is high, but it may not be enough for an economic viability. In addition, the lemon puree has an atypical flavor and it would be necessary to optimize the processing time.

COMPANIES' TEST. Membrillo Emily (quince jelly)



Membrillo Emily S. company L. I wanted to explore the possibility of developing an organic quince jelly used puree of lemon instead of the pectin. Therefore, a quince jelly with 65 Brix was elaborated with the new ingredient. The quince jelly was accepted by a panel of tasters. In figure 1 you can see the two products (commercial and with the new ingredient) and the results of the sensory analysis. Also, table 2 shows the results of the nutritional analysis.

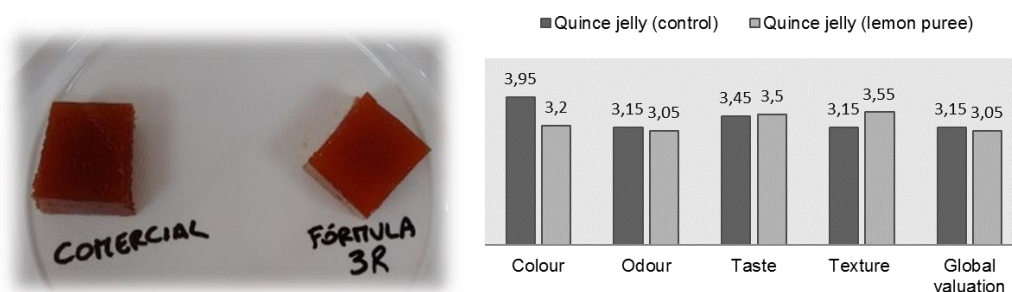


Figure 1.- Commercial quince jelly and new formulation. Sensory analysis results

Table 2.- Nutritional characteristics of quince jelly

	Quince jelly (control)	Quince jelly (lemon puree)
Total sugars (g/100g)	63.4	65.1
Moisture (g/100g)	26.7	24.6
Total fats (g/100g)	0.2	0.1
Total carbohydrates (g/100g)	72.2	74.5
Proteins (g/100g)	0.4	0.3
Dietary fiber (g/100g)	3.7	3.9
Energy value (kcal/100g)	299.4	307.9

Results in fresh weight

Several formulas were developed and differences with respect to color and texture were observed, so the quince jelly with puree of lemon shows differences with respect to currently

comercial quince jelly that company have in the market. The product should have a longer processing time to present an appearance that does not differ from the commercial product.

The company is interested in developing its own new ingredient and using it privately.

COMPANIES' TEST. Coato (almond drink)



COATO is an agricultural cooperative company located in Totana (Murcia), an area with agricultural tradition. In its beginnings it was constituted by producers of pepper of paprika, but nowadays it is one of the most important cooperatives of the sector that has extended its activity to other products (fresh fruits and vegetables, almond, oil, honey, etc.)

The company has tried to develop an almond-based vegetable drink using as thickener the new ingredient (citrus puree) obtained through the LIFECITRUS process. In addition, it was proposed to obtain a product with low caloric content, which can be labeled as organic and as a fiber source product. This product has been designed to use the thickening capacity from citrus byproducts.

Due to the company's demand, the preoces to get a lyophilized product of the citrus puree was evaluated and for this CTCt was holding contac with the company AQP Ingredients, which provided us with a powder product with the characteristics showed on table 3.

Table 3.- Characteristics of lyophilized lemon puree

	Lyophilized lemon puree
pH	3.2
Soluble solids (Brix)	15.0
Acidity (% citric acid)	3.0
Calories (Kcal/100g)	222
Total fat (g/100g)	0.7
Total carbohydrate (g/100g)	7.2
Total sugars (g/100g)	0.07
Proteins (g/100g)	5.6
Dietary fiber (g/100g)	82.3
Sodium chloride (g/100g)	0.27
Moisture (g/100g)	0.6

Results in fresh weight

To achieve the objective, 8 tests with the fresh and lyophilized natural ingredient was carried out. In the last test, a product with commercial valued and with the nutritional characteristics showed on table 4.

Table 4.- Nutritional characteristics of almond drink

	Almond drink
Total sugars (g/100g)	0.8
Moisture (g/100g)	89.4
Total fats (g/100g)	2.5
Total carbohydrates (g/100g)	3.5
Proteins (g/100g)	1.0
Dietary fiber (g/100g)	3.3
Calories (kcal/100g)	47
Sodium chloride (g/100g)	0.12
Hesperidine (mg/Kg)	83

Results in fresh weight

The company was in evaluating the results and has to plan a previous investment or establish contracts with other companies to develop the product and market it. But now, the company not going to produce it because the new ingredient is not in the market.

COMPANY TEST TO PRODUCE THE NEW INGREDIENT. Fruit Tech Natural (lemon/orange)



Fruit Tech Natural (FTN) company selects and processes the best citrus to produce juice (is just juice squeezed from fruit), concentrate (is the result of removing the natural water in the juice through evaporation. This process is aimed at lowering storage and transportation costs) or other products as wonf, cells, oils, etc.

This company contributed by-product of the lemon and orange transformation to carry out two tests in this action, since it was looking for a new ingredient that would expand its market lines. This company has enough production to implement the LIFECITRUS process but needs to evaluate yields and characteristics of the previously obtained product.

The first trial was carried out with 180 Kg of lemon by-product and with 400 Kg of orange by-product. The raw material of lemon by-product was frozen for storage before transport to the demonstration plant. The table 5 shows the nutritional characterization of the raw material received to run the LIFECITRUS process.

Table 5.-Nutritional characteristics of citrus raw material

	Lemon byproduct	Orange byproduct
pH	3.28	3.44
Soluble solids (Brix)	8	12
Acidity (% citric acid)	1.2	-
Calories (Kcal/100g)	41	40
Total fat (g/100g)	0.3	0.4
Total carbohydrate (g/100g)	4.0	3.6
Total sugars (g/100g)	0.2	0.7
Proteins (g/100g)	1.1	1.0
Dietary fiber (g/100g)	8.7	9.2
Sodium chloride (g/100g)	0.06	0.014

Hesperidine (mg/Kg)	1235	-
Moisture (g/100g)	85.3	85.3
Plaguicidas (mg/Kg)	chlorpyrifos (0.01); chlorpyrifos-methyl (0.038); fludioxonil (0.011); imazalyl (0.12); metalaxyl (0.028); pyrimetaniil (0.039); pyriproxyfen (0.068)	chlorpyrifos (0.012); imazalyl (0.81); pyrimetaniil (0.44); pyriproxyfen (0.013); thiabendazole (0.09)

Results in fresh weight

The yields obtained for both raw materials were 47% for lemon and 60% for orange. The lower yield in the lemon was due to the appearance of slurries after defrosting of the raw material, something that indicated the breaking of bonds and a greater solubility in the extraction process. The table 6 shows the nutritional characteristics of the two new ingredients obtained.

Table 6.- Nutritional Characteristics of citrus puree

	Lemon puree	Orange puree
pH	3.5	3.61
Soluble solids (Brix)	1.4	-
Acidity (% citric acid)	0.19	-
Calories (Kcal/100g)	32	17
Total fat (g/100g)	0.3	0.3
Total carbohydrate (g/100g)	2.8	< 0.1
Total sugars (g/100g)	< 0.05	< 0.05
Proteins (g/100g)	0.8	0.6
Dietary fiber (g/100g)	7.3	6.0
Sodium chloride (g/100g)	0.04	< 0.01
Hesperidine (mg/Kg)	1571	-
Moisture (g/100g)	88.3	92.9
Plaguicidas (mg/Kg)	Pyrimetaniil (0.014) Pyriproxyfen (0.038)	chlorpyrifos (0.014); imazalyl (0.099); pyrimetaniil (0.13);

Results in fresh weight

According to the results shows in the table 6, the company is interested in developing a process for extracting the new ingredient, but the obtained yield and the high-water consumption do not support its implementation without a study in its own facilities with their industrial equipments.

COMPANY TEST TO PRODUCE THE NEW INGREDIENT. Mocitos (apple)



Marín Montejano group is specialized in the production and sale of canned fruits, vegetables, legumes, juices, nectars, milk-based drinks + fruit, gazpacho, jams, preserves, fruit purees and wine packaging. It has various locations from where it sells products with the brand MOCITOS.

This company had a byproduct of apple processing to evaluate the performance of the LIFECITRUS process equipment in other raw material different from citrus.

Two tests, of 116 and 200 Kg, were carried out using an apple by-product. This by-product was mainly peels and seeds, the table 7 shows the nutritional characteristics of apple by-product. It was determined that a previous washing step is not necessary, and the extractions of the feed are reduced by the greater solubility of its compounds and lower acidity. The LIFECITRUS process has been developed, but without initial washings and only two extractions with the ratio product/water of 1: 3 and 1: 2.

The second test was carried out because in the first trial one a very dark product was obtained. In the second trial were evaluated different thermal treatments (in vacuum) with the objective to achieve a reduction in the coloration of the final product.

Finally, 110 and 190 kg of a new ingredient from apple by-products were obtained with the nutritional characteristics shows in the table 7. The process yield, above 90%, was higher than obtained for citrus by-products. This data is very interesting for its economic viability.

Table 7.- Nutritional characteristics of raw material and apple puree

	Apple byproduct	Apple puree 1	Apple puree 2
pH	3.83	4.64	4.97
Colour (CieLab)	-	-	L= 45.25, a= 4.34, b= 23.08
Calories (Kcal/100g)	93	37	38
Total fat (g/100g)	1.7	1.6	1.7
Total carbohydrate (g/100g)	11.4	0.7	0.6
Total sugars (g/100g)	10.8	0.6	0.6
Proteins (g/100g)	1.6	1.0	1.0
Dietary fiber (g/100g)	13.0	8.0	8.0
Sodium chloride (g/100g)	0.03	0.04	0.05
Moisture (g/100g)	71.8	88.5	88.5
Plaguicidas (mg/kg)	Boscalid (0.063); cypermethrin (0.017); cyprodinil (0.046); chlorpyrifos-methyl (0.057); deltamethrin (0.039); difenoconazole (0.052); fludioxonil (0.016); phosmet (0.018); lambda-cyhalothrin (0.088); pyraclostrobin (0.027); tebuconazole (0.04); tetraconazole (0.06); thiacloprid (0.015)	< LQ	< LQ

Results in fresh weight

On the other hand, the evaluation of the coloration of the final product was unsatisfactory in both cases. The product obtained was dark coloured due to the oxidation of the high amount of sugars of the apple by-products. The figure 2 shows the raw material (apple by-product) and the new product obtained after LIFECITRUS process.



Figure 2.- Raw material of apple by-product and product obtained

The conclusion of these trials is that the company is interested in developing new products by valuing its apple by-product, but they must evaluate the implementation costs.

COMPANY TEST TO PRODUCE THE NEW INGREDIENT. Toñifruit (lemon)



The company Toñifruit sells the best selection of organic fruits and vegetables in the most common formats: bulk, embedded, girsac, mesh, flowpack, film, etc.

This company sent 450 Kg of lemons to extract the juice and obtain the lemon peel as a by-product. Since the juice yield was 45%, initially 300 Kg of lemon by-product was available to evaluate the performance of the LIFECITRUS process equipment in the CTC demonstration plant. After the LIFECITRUS process, 166 Kg of the new ingredient was obtained. Therefore, the yield was 55%. The table 8 shows the nutritional characteristics of the product obtained.

Table 8. Nutritional characteristics of lemon puree

	Lemon puree
pH	4.19
Calories (Kcal/100g)	29
Total fat (g/100g)	0.5
Total carbohydrate (g/100g)	0.1
Total sugars (g/100g)	< 0.05
Proteins (g/100g)	0.9
Dietary fiber (g/100g)	10.3
Sodium chloride (g/100g)	0.03
Hesperidine (mg/Kg)	2385
Moisture (g/100g)	87.7

Results in fresh weight

With the trials results, the company contacted with the CTC and later decided to repeat the test with another batch of lemons with a total weight of 343 Kg. On this occasion the usable discards were obtained again after extracting the juice and its weight was approximately 200 Kg. The

Table 9 shows the nutritional characteristics of the processed by-product as well as of the obtained mash.

This test showed better results because it was decided to reduce the extraction stages and increase the solid/ water ratio and the contact time. Finally, the yield was 78%.

Table 9.- Nutritional characteristics of lemon byproduct and lemon puree

	Lemon byproduct	Lemon puree
pH	3.09	3.91
Soluble solids (Brix)	8.2	2.2
Acidity (% citric acid)	1.9	0.2
Calories (Kcal/100g)	35	22
Total fat (g/100g)	0.2	0.1
Total carbohydrate (g/100g)	4.9	1.3
Total sugars (g/100g)	2.7	1.1
Proteins (g/100g)	0.9	0.4
Dietary fiber (g/100g)	5.1	7.2
Sodium chloride (g/100g)	0.01	0.03
Moisture (g/100g)	88.5	90.8
Hesperidine (mg/Kg)	667	995

Results in fresh weight

After evaluating these results, the company could be interested in having more data because the line of work is interesting, but its activity is the marketing of fresh citrus.

COMPANY TEST TO PRODUCE THE NEW INGREDIENT. Hortimur (orange)



Hortimur company has a wide range of products from citrus. It is a company dedicated to the production and commercialized of frozen cups, rinds, strips and slices of citrus.

This company wanted to evaluate the process of obtaining the new ingredient from orange peel. 200 Kg of orange peel was used and a yield of 57% was obtained using the optimized LIFECITRUS process. The table 10 shows the characteristics of the new ingredient. In figure 3 you can see the technician in the demonstration plant.

Table 10. Nutritional characteristics of orange puree

	Orange puree
pH	3.77
Soluble solids (Brix)	4
Calories (Kcal/100g)	24
Total fat (g/100g)	0.2
Total carbohydrate (g/100g)	1.0
Total sugars (g/100g)	< 0.05
Proteins (g/100g)	0.9
Dietary fiber (g/100g)	7.5
Sodium chloride (g/100g)	0.03

Hesperidine (mg/Kg)	23137
Moisture (g/100g)	90.0

Results in fresh weight



Figure 3.- Demonstration test with the company Hortimur in January 2018

The feedback received from Hortimur is that it will evaluate its production to know the profitability of implementing the process, but it prefers to be able to sell its by-product to another more profitable application due the high content of hesperidine.

COMPANIES' TEST. Manuel García Campoy (citrus jam)



Manuel García Campoy S.L. it is included in an organization of producers of both fresh fruit and canned fruit and vegetable under the MILAFRUIT trademark.

In a first contact, technicians of the company could be contacted to evaluate discards of their fresh production with the objective of elaborating a citrus pulp and then using it in the elaboration of jams.

The demonstration trials consisted of producing a tangerine pulp and making use of this tangerine puree for the development a product with the aim to add value to its discards.

The tangerine pulp was obtained after the cooking of peel with water. A jelly was formulated with 50% tangerine pulp and 15% of the new ingredient (tangerine puree) looking for a product with 54 Brix and typical sensorial parameters. The table 11 shows the nutritional characteristics of tangerine jelly.

Table 11.- Nutritional characteristics of citrus jelly

	Citrus jam (pH: 3.11)
Total sugars (g/100g)	43.8
Moisture (g/100g)	44.8
Total fats (g/100g)	0.2
Total carbohydrates (g/100g)	51.7
Proteins (g/100g)	0.4
Dietary fiber (g/100g)	2.6
Calories (kcal/100g)	215
Sodium chloride (g/100g)	0.17
Quality	Nice visual appearance, taste, smell and texture (Bostwick 3 cm)

Results in fresh weight

Manuel García Campoy would have to open a market line, so he has to evaluate its economic viability. Another drawback is that the company is not interested of obtaining the LIFECITRUS process and therefore it should look for a supplier of citrus puree, which is unfeasible, while there are suppliers of pectin.

COMPANIES' TEST. GranBiBio (strawberry jam)



GranBibio Supermercados Ecológicos is a company specializing in organic farming that today offers a diversified range of organic products. The business aim, they want to share with their clients, is the information of where the food comes from and what its route is until it reaches the homes. For this reason, contact with this company was considered interesting for the project.

The LIFECITRUS project allowed to Toñifruit company to obtain the new ingredient from organic raw material, from organic lemons specifically, and this puree was used to demonstrate the application in the development of ecological jellies of 45 Brix, with 60% fruit and 16% of the new ingredient. All the ingredients used in the formulation were ecological and an ecological strawberry jam was developed with the nutritional characteristics show in the table 12.

Table 12.- Nutritional characteristics of organic strawberry jam

	Organic strawberry jam (pH: 3.08)
Total sugars (g/100g)	46.5
Moisture (g/100g)	48.0
Total fats (g/100g)	0.2
Total carbohydrates (g/100g)	48.4
Proteins (g/100g)	0.6
Dietary fiber (g/100g)	2.5
Calories (kcal/100g)	203
Sodium chloride (g/100g)	0.015
Quality	Nice visual appearance, taste, smell and texture (Bostwick 4 cm)

Results in fresh weight

The company showed interest in the results achieved and could disseminate the LIFECITRUS process among its customers to boost the consumption of organic food without any trace of additives.

COMPANY TEST TO PRODUCE THE NEW INGREDIENT AND ITS USE. Juan Alarcón Gonzalez (lemon-strawberry jam)

D. Juan Alarcón is a farmer from La Huerta de Murcia who showed interest in the LIFECITRUS project when informed of the existence of this. It has cultivation fields of all types of citrus (but especially lemons) that it sells and wanted to know about possibilities of revaluation of its discards. He was present at the workshop organized for citrus companies and farmers in 2017 at the CTC facilities and at the end he wanted to participate in the demonstrations.

This farmer sent 300 Kg of lemon peel so that it could be processed in the demonstration plant. After obtaining the new ingredient he wanted to evaluate it in the development of a strawberry jam with 60% fruit and about 45 Brix.

After the LIFECITRUS process, 213 Kg of the new ingredient was obtained. Therefore, the performance was more than 70% because the raw material fed to the LIFECITRUS process had not industrial treatment for juice extraction and had been stored in freezing until its use.

Table 13 shows the characteristics of the raw material and the product obtained and in figure 4 the farmer's lemon field.

Table 13.- Characteristics of lemon byproduct and lemon puree

	Lemon byproduct	Lemon puree
pH	3.35	3.91
Soluble solids (Brix)	7	4
Essential oil (mL/L)	0.3	0.3
Calories (Kcal/100g)	40	19
Total fat (g/100g)	0.1	0.1
Total carbohydrate (g/100g)	5.4	0.5
Total sugars (g/100g)	3.5	0.5
Proteins (g/100g)	1.1	0.5
Dietary fiber (g/100g)	6.4	7.1
Sodium chloride (g/100g)	0.02	0.015
Moisture (g/100g)	86.4	91.6
Hesperidine (mg/Kg)	1376	769

Results in fresh weight



Figure 4.- Lemon trees field of farmer D. Juan Alarcón

With these results, the farmer wanted to make a jam replacing the pectin with its lemon puree as an innovative ingredient. Table 14 shows the nutritional analysis of the same

Table 14.- Nutritional characteristics of organic strawberry jam

	Strawberry jam (pH: 3.43)
Total sugars (g/100g)	44.1
Moisture (g/100g)	51.1
Total fats (g/100g)	0.1
Total carbohydrates (g/100g)	44.4
Proteins (g/100g)	0.6
Dietary fiber (g/100g)	3.4
Calories (kcal/100g)	188
Sodium chloride (g/100g)	< 0.0125
Quality	Nice visual appearance, taste, smell and texture (Bostwick 4.5 cm)

Results in fresh weight

Once the demonstrations with the farmer were finished, it was possible to verify that for farmers are important to know that when discards lemon of their production have important use, so they can achieve a non-abusive price. The aspect of the fruits is very important for fresh marketing, but other market lines can provide benefits and the bark of citrus fruits can open new lines within a sustainable economy.

COMPANIES' TEST. Eurocaviar (esferas cítricas)



Eurocaviar company, S.A. produce products of high quality caviar substitutes for more than 30 years, but it also stands out for its specialization in food spherification with products on the

market such as "Pearls" of organic algae, balsamic vinegar, etc. that they have achieved thanks to a permanent investigation, looking for the raw material in their origin and creating products that differentiate from others by a high quality. This last aspect has made that this company is interested in the new ingredient obtained, but in appearance of dust. Company technicians participated in the workshop organized for food companies and showed their interest in the ingredient to develop citrus spheres

The demonstrative action consisted in the formulation of spheres with 3% of the new lyophilized ingredient (which can be called yellowish citrus fiber) in substitution of other additives used by the company to obtain food spheres that have an adequate texture, colour and taste. Citrus spheres containing lemon juice were developed and could be useful as an accompaniment to high-value gastronomic dishes. In figure 5 you can see the resulting product and in table 15 the results of nutritional analysis are shown.



Figure 5.- Citrus spheres developed in the LIFECITRUS project

Table 15.- Characteristics of citrus spheres

	Citrus spheres
pH	2.66
Soluble solids (Brix)	3.5
Acidity (% citric acid)	1.75
Calories (Kcal/100g)	11
Total fat (g/100g)	0.1
Total carbohydrate (g/100g)	1.4
Total sugars (g/100g)	0.4
Proteins (g/100g)	0.2
Dietary fiber (g/100g)	1.9
Sodium chloride (g/100g)	0.15
Moisture (g/100g)	95.7
Hesperidine (mg/Kg)	26

Results in fresh weight

This company has obtained very satisfactory results when applying the "citric fiber" of the LIFECITRUS process. It has been able to reduce quantities of other additives to achieve spheres with adequate characteristics to include a new product in the food market, but since this innovative ingredient does not yet exist, it will work with its current suppliers.

COMPANIES´ TEST. Hero España (strawberry jam)



Hero España company has been developing its industrial activity since 1922, being currently a reference in the food industry. Its business strength shows that it has been able to adapt to changes and market needs. It has gone from being a company of preserves and traditional food to an advanced nutrition company, oriented to innovation applying criteria of sustainability in all its productive processes.

In addition, it is a company that tries to incorporate environmental criteria and continuous improvement in its activities, so it is committed to the training of its workers and its involvement in innovative initiatives for the food sector. This aspect has been able that technicians of the company had participated in the last edition of the LIFECITRUS course entitled "DESIGN OF PROCESSES OF MANUFACTURE AND VALORIZATION OF BYPRODUCTS IN THE FOOD INDUSTRY" and had contributed their knowledge to be able to demonstrate the use of the new food ingredient in a jam of strawberry, which could be similar to one commercialized by the company.

In the demonstration plant, a 50 Brix marmalade was made using the new ingredient with a 25% proportion in the formulation and without pectin. Table 16 shows the results of your nutritional analysis.

Table 16.- Nutritional characteristics of strawberry jam

	Strawberry jam (pH: 3.26)
Total sugars (g/100g)	52.7
Moisture (g/100g)	48.0
Total fats (g/100g)	0.2
Total carbohydrates (g/100g)	54.0
Proteins (g/100g)	0.5
Dietary fiber (g/100g)	4.7
Calories (kcal/100g)	229
Sodium chloride (g/100g)	0.017
Colour (CieLab)	L= 21.05, a= 8.65, b= 5.15
Quality	Different visual appearance, taste, smell and texture versus commercial

Results in fresh weight

The company was able to verify that the addition of the new ingredient in a proportion of 25% within the formulation is adequate for a characteristic texture, but a loose texture and a colour with less luminosity is observed. The taste is different because the new ingredient has brought atypical flavors.

With these comments, the company, specialized in jams development and its commercialization, would not change its current formula with a new ingredient whose standardization did not validate the non-presence of atypical flavors.

COMPANY TEST TO PRODUCE THE NEW INGREDIENT AND ITS USE. Frutas de Librilla (lemon-blackberry jam)



Frutas de Librilla is a company that sells citrus fruits from its fields, which is committed to quality from the field to the final production, giving the customer a natural and reliable product.

The progress of the project has been of interest to this company and for that reason 200 Kg of organic lemon rinds were available to show them the possibilities of obtaining the new ingredient and its application in a marketable product, such as a marmalade.

550 kg of organic lemons were taken and their peels were obtained. The peeling performance of the fruits was 36.5%, so that 200.75 Kg of lemon by-product was processed in the demonstration plant.

Finally, 157 Kg of the new ingredient was obtained and the yield was close to 80%. This data once again corroborated that, the use of unprocessed raw material in mechanical equipment of the industry of obtaining juices and essential oils achieves a greater yield of the new ingredient in the LIFECITRUS process. Table 17 shows the characteristics of the product obtained.

Table 17.- Characteristics of organic lemon puree

	Lemon puree
pH	3.98
Calories (Kcal/100g)	16
Total fat (g/100g)	0.1
Total carbohydrate (g/100g)	0.2
Total sugars (g/100g)	0.2
Proteins (g/100g)	0.3
Dietary fiber (g/100g)	6.3
Sodium chloride (g/100g)	0.018
Moisture (g/100g)	93.0
Hesperidine (mg/Kg)	844
Limonine (mg/Kg)	51.8
Pesticides (mg/Kg)	< LQ

Results in fresh weight

With these results, the company wanted to know its application in the elaboration of a jam of blackberry (40 Brix and 60% of fruit) replacing the pectin with a puree of ecological lemon in 18%. Table 18 shows the nutritional analysis.

Table 18.- Nutritional characteristics of organic blackberry jam

	Blackberry jam (pH: 3.67)
Total sugars (g/100g)	36.9
Moisture (g/100g)	54.1
Total fats (g/100g)	0.6
Total carbohydrates (g/100g)	37.2
Proteins (g/100g)	1.3
Dietary fiber (g/100g)	6.1
Calories (kcal/100g)	172
Sodium chloride (g/100g)	< 0.0125
Quality	Nice visual appearance, taste, smell and texture (Bostwick 1 cm)

Results in fresh weight

The result of this demonstration action was that the company supports the initiative of the LIFECITRUS project and it seems interesting to be able to market its citrus fruit for new markets of processing companies. Company does not propose the implementation of the process in its facilities.

COMPANIES' TEST. Milco SAT (peach jam)



Milco SAT. it is included in an organization of producers of both fresh fruit and horticultural preserves. Once the application of the new ingredient was valued through another company of the organization, Manuel García Campoy (where it was intended to take advantage of citrus discards), they decided to continue evaluating the application of the new ingredient through Milco SAT to give value to one of its main products, the peach.

The demonstrative action consisted of formulating a peach jam with the use of the new ingredient obtained from lemon by-products, in order that the company can offer greater applications to its raw materials and improve its market.

With these results, the company wanted to know its application in the preparation of a jam of low caloric content and high percentage of fruit, 40 Brix and 60% of fruit respectively in the formulation. The demonstration consisted of making a marmalade with pectin and another replacing part of the pectin with an organic lemon puree. Table 19 shows the percentage of ingredients used in the two formulas and in table 20 the nutritional analysis and physico-chemical parameters of interest of the two marmalades compared.

Table 19. Formulation of peach jams

Ingredients	Peach jam (control)	Peach jam (new ingredient)
Fruit (%)	60	60
Sugar (%)	35	34
Pectin (%)	0.6	0.4
New ingredient (%)	0	10
Citric acid (%)	0.2	0.2

Table 20.- Nutritional characteristics of peach jam

	Peach jam (control) (pH: 3.88)	Peach jam (new ingredient) (pH: 3.86)
Total sugars (g/100g)	36.5	38.9
Moisture (g/100g)	59.4	56.6
Total fats (g/100g)	0.1	0.2
Total carbohydrates (g/100g)	36.8	40.2
Proteins (g/100g)	0.5	0.6
Dietary fiber (g/100g)	2.9	2.1
Calories (kcal/100g)	156	169
Sodium chloride (g/100g)	0.02	0.02
Colour (CieLab)	L= 38.62, a=1.13, b= 3.29	L= 32.62, a=0.47, b=4.18
Quality	Nice visual appearance, taste and smell Low texture (Bostwick 6 cm)	Nice visual appearance, taste and smell Low texture (Bostwick 7 cm)

Results in fresh weight

The results of the analysis indicated that this type of fruit and the use of the new ingredient does not help to obtain an adequate jam texture and the final colour of the product is low light. Therefore, the company's response is to support the LIFECITRUS project, but the application has not been highly satisfactory in order to promote sustainability progress in the company

The new ingredient is very interesting to continue testing with other raw materials and achieve the development of innovative products and improve production and sales.

4. CONCLUSION

Finally, in Action B3, with 27 demonstration actions, 2596 Kg of citrus by-products have been processed and 9 food products have been prepared for different companies and the following conclusions have been obtained:

1. The new ingredient requires high water consumption and its implementation is not viable when the production of by-products or quantities of discards is not enough.
2. Some companies prefer to make modifications to the LIFECITRUS process to obtain an ingredient with characteristics that may be of its application. The evaluation of water consumption and the quality of the raw material (byproduct or discard) is a dependent factor. In some cases, it has been evaluated that a "low processed" ingredient has more interesting characteristics, but the work needed to obtain "low processed" raw material would increase the costs because there is no known industrial machinery to get it quickly.

3. The new ingredient needs standardization for a commercial application. The citrus varieties and, the transformation into factories or primary discards in the fruit and vegetable plants, show differences in the characteristics and behavior of the new ingredient. Potential use companies prefer to wait for the ingredient to be in the market for purchase and not establish contacts for there to be a production.

4. Companies participating in the demonstrations prefer to evaluate the new ingredient privately.

In summary, the innovative ingredient is interesting for companies in the Region of Murcia, but it is not yet in the market and there is no demand that benefits its implementation. The collaborative citrus processing company (with high production) could evaluate its implementation, but must rethink costs and the use of available machinery to put the new ingredient on the market. It has been shown that the new natural ingredient can be a substitute for other chemical additives, with which agri-food companies would achieve a sustainable production image in line with community directives and consumer demand.

In addition, partners of the project have maintained contact with the company AQP Ingredients and the CEBAS-CSIC. The project has been disseminated to others companies, such as Alifrut (marketing of preserves-Molina de Segura), Buggypower (products for the food industry-Lorquí), Gregorio Martinez Fortun (trade in food products-Cartagena), 3A Antioxidants (Manufacture of synergistic mixtures of preservatives and natural and synthetic antioxidants-Murcia), Hidrogea (waters-Cartagena), Hidrotec (waters-Cartagena), Regenera Levante (waters-Murcia), MOYCA (fresh product-Totana), J. García Carrión (fruit juices-Jumilla) and JBT (machinery companies food-Ceutí). Finally, technicians from the University of Murcia, Technical University of Cartagena and Catholic University San Antonio know the project.

The dissemination of the LIFECITRUS project has been high to facilitate its replicability in the Region of Murcia, but there is still no positive feedback.

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Annex I

LEMON	OTHER CITRUS AND FRUITS	FOOD
CITRICOS DE MURCIA	CITRICOS DE MURCIA	ALCURNIA ALIMENTACIÓN
CITROMIL	CITROMIL	MARIN GIMÉNEZ
RIVERBEND	RIVERBEND	MOCITOS
TOÑIFRUIT	TOÑIFRUIT	MANUEL GARCÍA CAMPOY
MOCITOS	MOCITOS	HIDA ALIMENTACIÓN
DERIVADOS CÍTRICOS	DERIVADOS CÍTRICOS	ALIMINTER
FRUTAS APEMAR	FRUTAS APEMAR	GOLDEN FOODS
MIGUEL PARRA E HIJOS	MIGUEL PARRA E HIJOS	HERO
MUNDOSOL FRUTAS	MUNDOSOL FRUTAS	MENSAJERO ALIMENTACIÓN
ZUMO FRESH LEVANTE	ZUMO FRESH LEVANTE	FILIBERTO MARTINEZ
PANARRO FOODS	PANARRO FOODS	COFRUSA
BERMEJO AGENTES (BAOR PRODUCTS)	JUVER	COFRUTOS
ORIGINAL B2B	COFRUSA	PROBICASA
LEMON CONCENTRATE	MANUEL GARCÍA CAMPOY	ABELLAN BIOFOODS
ANTONIO LOPEZ PUCHE	COATO	MEMBRILLO EMILY
CÍTRICOS CUELLO	BERMEJO AGENTES (BAOR PRODUCTS)	PANARRO FOODS
FRUIT TECH NATURAL	ORIGINAL B2B	LA VEGA DE PLIEGO
FRUGARVA	LEMON CONCENTRATE	COATO
SAT CAMPOTEJAR	ANTONIO LOPEZ PUCHE	LA NIÑA DEL SUR
ARTELIMÓN	CÍTRICOS CUELLO	CREMOFRUIT
FRUTAS ANTOÑETE	FRUIT TECH NATURAL	LA VEGA DEL MAR MENOR
CÍTRICOS DEL SURESTE	FRUGARVA	LA CEHEGINERA
HORTAMIRA	SAT CAMPOTEJAR	HELIFRUSA
LA VEGA DE CIEZA	FRUTAS ANTOÑETE	DOSCADESA 2000, SL
GARCÍA ARANDA	CÍTRICOS DEL SURESTE	MEDITERRÁNEA DE ENSALADAS
SCORPYUS FRUITS	HORTAMIRA	POSTRES REINA
BLAMUCA	LA VEGA DE CIEZA	PASTELERÍA GIMAR
EL LIMONAR DE SANTOMERA	GARCÍA ARANDA	CONSERVAS MARTINEZ
CITRICOS LA PAZ	SCORPYUS FRUITS	JOAQUIN FERNANDEZ E HIJOS
FRUTAS MARGOZ	BLAMUCA	PEDRO GUILLEN
TANA	EL LIMONAR DE SANTOMERA	ALMOND
LA PERLA DE MURCIA	CITRICOS LA PAZ	LOBROT, S. COOP
HORTIMUR	FRUTAS MARGOZ	PROSUR
FRUTAS BUENDÍA	TANA	FAROLIVA
RABAFRUIT	LA PERLA DE MURCIA	EUROCAVIAR
JUAN ALARCÓN GONZÁLEZ	HORTIMUR	RUNAKAY PLUS
ANTONIO MARTÍNEZ LAX	FRUTAS BUENDÍA	FRANCISCA ALEMÁN
LA CEHEGINERA	RABAFRUIT	CAPRICHOS DEL PALADAR
EL HUERTANICO	AGRO CARRASCOY, S.L	GRANBIBIO
FRUTAS DE LIBRILLA S.L.	ECO MURCIA, S.L	JOSÉ RODRIGUEZ PASTOR
FRUTAS NATURALES SA	ARAXSIBON, S.L	
	ANGIBERSAN, S.L	
	HERABENZA, S.L	
	LOS MAJOS BIO, S.L	
	PRODUCTOS MEDITERRANEOS BELCHI SALAS	
	ALHAMA OYC, S.L	
	CAMEXA INVERSION, S.L.	
	DA LUNA PLANTACIONES ECOLOGICAS, S.L.U.	
	LA CEHEGINERA	
	NANACHE	
	NATURAL FRUIT LEVANTE	
	JUAN ALARCÓN GONZÁLEZ	
	ANTONIO MARTÍNEZ LAX	
	MILCO FRUIT SAT	
	EL HUERTANICO	
	FRUTAS DE LIBRILLA S.L.	
	FRUTAS NATURALES SA	