LIFE Environment and Resource Efficiency

LIFECITRUS

LIFE14 ENV/ES/000326

B2_Report about the process effectiveness and the characterization of obtained ingredients and final products

30 August 2017.

This report collects information on the B1 and B2 actions raised in the memory of the project "LIFECITRUS-LIFE14 ENV/ES/000326".

Note that this report had a previous version in June 2017 that included test developed until April 2017. This new report that also included the tests carried out from May to July.

PREVIOUS TEST. Action B1. Design and implementation of the demonstration plant

With the action B1, 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 different stages of the process initially consisted of the following operations:

- Reception of the raw material: The byproduct will be stored at refrigerated (4 °C) conditions until his processing, not more than 1 day.
- Inspection: Review of the byproduct to discard, and use only in the food process those with good appearance.
- Cut: At this stage, the Urschel (model GK-A) cutter will be used to produce 8x8 mm skin dices of citrus.
- Washed and drained: The objective of this stage is the elimination of essential oils from the skin of citrus fruits and the components that give bitterness. This operation will be carried out in a washing machine and a centrifuge. It consists of two tanks for washing and a tank to drain the water, taking the fund the total water discharge. The system has an automatic wash with agitation by air.
- Cooking and enzymatic inactivation: The product obtained after the wash and centrifugation, is heated to 100°C in a tank with a steam-jacket (FMA) to the enzymatic inactivation (known as boiler). In this step, the pH must be controlled fewer than 4.6. Therefore if necessary, you can use lemon juice concentrate for the regulation of product.
- Particle size reduction to puree: The objective of this equipment is to obtain a citrus puree, available for use as a food ingredient. This stage of the process cannot be carried out on a semi-industrial scale with the current equipment available in the CTC's pilot plant. Therefore, it is necessary to incorporate a device with a "high speed knife cutter machine" with the following technical characteristics:
    - Spoon capacity: 40 L.
    - Full stainless steel construction, in accordance with the requirements of the UE.
    - Equipped with 2 independent motors, control panel, switches, with an electrical control panel.
    - Knife holder for more than 6 knives.
- Deaeration: In this step, the oxygen in the pure product is removed by a vacuum system to prevent oxidation reactions that affect the nutritional and sensory properties of the puree. This equipment consists of a 300 litres tank (HRS) connected to a vacuum pump.

- Processing and packaging. The packaging of the puree in an aseptic system is expected " bag-in -box " (HRS), after a controlled heat treatment " HTST " of 1 minute to 93,3 °C and a cooling to 25 °C before aseptic packing in aseptic bags of 10 litres. It is taken a control of the useful life and if this heat treatment leads to short time conservation or sensory degradation can be used alternatively freezing using a tunnel of cryo-conservation (Linde), after the deaeration stage, being the puree stored frozen at -18 °C.

The line initially considered contemplated the acquisition of a new equipment and its installation in the pilot plant, in order to perform the test in good condition since the objective of this equipment is obtain a puree of citrus available for use as a food ingredient not detected easily in new foods, with a capacity of semi-industrial scale, with reliable construction and easy maintenance.

The justification for the acquisition of the new equipment is due to the fact that in the tests developed at laboratory scale (years before by the CTC) noted that the particle size of the puree of citrus reached made that strange particles were detected in the elaborated jam. The equipment used at this level was a colloid mill, which is intended for the manufacture of emulsions and has no knives, so the particle size reduction not occurred. In this context, the pilot plant of the CTC does not have equipment that allows reducing the size of the particles of the skin of citrus to microns and is necessary to contact with providers of technology to acquire a prototype equipment and assess its effectiveness with a feeding of about the 90% of moisture. It is intended that the selected prototype avoid the clogging of the feeding system and be easily industrially scalable. Once the line was designed, the new equipment was purchased and the LIFECITRUS process started using the equipment in the pilot plant of the CTC.

For the start-up, first, the raw material used in the process was analyzed, in order 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 (hesperidin was taken as a reference parameter due to its known antioxidant properties, with the advantage that it is considered a flavonoid that does not add flavour to citrus fruits). In addition, the organoleptic characterization of bitterness was carried out by the tasting of the product.

It is noteworthy that in the design initially considered (at the end of October 2015) has entered a stage of aseptic packaging, but the equipment has not been able to be tested by technical problems in the pilot plant of the CTC. This drawback is not relevant for the obtaining of the new natural ingredient since there are other types of heat treatment and storage, but it has been necessary to adopt a new measure. As a solution it was decided to try a thermal

treatment by cooking and storage of the new ingredient in refrigeration and freezing using vacuum bag packaging, which have been microbiologically controlled to guarantee the useful life of the new ingredient. However, the possibility of evaluating a sterilization treatment for the new ingredient (with a subsequent stability test to check the effectiveness of the treatment) was also taken into account.

Another decision made by the team at the start-up was the inclusion of a washing stage using a maceration tank and a Decanter centrifuge, due to its greater effectiveness in the extraction of soluble compounds and subsequent separation of liquid phase and solid. The Decanter centrifuge allows obtaining the desired solid product and a liquid rejection by adjusting the conditions of the feed pump flow and the speed of the drum and auger. Therefore, the design of the semi-industrial plant was slightly modified at the end of action B1. In any case, it was decided to leave the semi-industrial design with the stage of aseptic packaging for its high implementation in the food industry. These aspects were reserved for the request of the budget of an industrial plant according to the action C2.

Start-up

Specifically, 5 tests have been developed, using a total of 355.83 Kg of lemon by-product, with the characteristics of Table 1.

Table 1- Raw material characteristics (lemon by-product)

Parameters	Values
Physical-Chemical	
pH	3.45
° Brix	6.9
Acidity (% citric acid)	0.8
Texture (Bostwick)	0
Colour (L, a, b)	Max: L= 73.32; a= -6.37; b= 26.76 Min: L= 73.27; a= -6.40; b= 26.65 Average: L= 73.3; a= -6.39; b= 26.72
Moisture (g/100g)	87.3
Fiber (g/100g)	3.3
Total Fats (g/100g)	0.3
Essential oils (mL/100g)	0.45
Dietary fiber (g/100g)	6.8
Instrumental	
Pesticide residues (mg/Kg)	2-phenylphenol (1.91); Chlorpyrifos- methyl (0.01); Imazalil (3.55); Pyrimethanil (0.94); Pyriproxyfen (0.014); Thiabendazole (1.13)
Hesperidin (mg/Kg)	5340
Microbiological	
Pathogens (/g)	Absence
Mold and yeast (cfu/g)	16000

Results in fresh weight

The tests performed are shown below:

Test reference	1 (21/12/2015)	2 (22/12/2015)	3 (14/01/2016)	4 (29/01/2016)	5 (12/02/2016)
Raw material (Lemon peel-Kg)	80	56.35	60.2	100.64	58.64
Description	Washing machine operation-centrifuge (continuous water entry: 26.25 L/Kg) + thermal treatment + packed in vacuum bags	Washing machine operation-centrifuge (continuous water entry: 50.14 L/Kg) + thermal treatment + packed in vacuum bags	Washing machine operation-centrifuge (5.8 L water/Kg bypr., in 4 batches reusing it- 1.2 L/Kg) + "high speed knife cutter" equipment operation + Decanter centrifuge operation (3 L/Kg – 4 extractions: 12 L/Kg) + packed in vacuum bags	Washing machine operation-centrifuge (initial wash with water change and three washes of 1:3 ratio- 9 L/Kg) + "high speed knife cutter" equipment operation + Decanter centrifuge operation (3 L/Kg – 4 extractions: 12 L/Kg) + thermal treatment	Washing machine operation-centrifuge (initial wash 1 with water change and three washes of 1:3 ratio- 9 L/Kg) + Urschel cutter 8x8 cm operation + Washing machine operation-centrifuge (initial wash 2 with water change and four washes of 1:3 ratio - 12 L/Kg) + "high speed knife cutter" equipment operation + Decanter centrifuge operation (4 L/Kg – 3 extractions: 12 L/Kg) + packed in vacuum bags

Description test 1 (21/12/2015):

- The washing system was tested with continuous water intake for 6 hours and agitation by means of compressed air supply. The water consumption was 26.25 L/Kg of byproduct.
- The thermal cooking treatment was tested (20 min, 100 °C) with the incorporation of evaporation water in the 1:1 ratio.
- The vacuum packer was tested for heat sealing bags of approximately 2-3 Kg in weight.

Conclusion test 1: With this test it was possible to verify that the pH value remained practically the same as the raw material (which does not require an acidification stage) and the product was bitter, so it was decided that the procedure was not adequate and it was necessary to increase the supply of washing water. In addition, the effectiveness of the cooking stage was verified to reduce the microbiological load that the lemon by-product initially has and enzymatic inactivation. The evaporation of the cooking water was not controlled.

On the other hand, it was observed that the concentration of hesperidin in the paste obtained was kept high and the heat sealing of the bags was correct with a hot product.

Description test 2 (22/12/2015):

- The washing system was tested with continuous water input for 12 hours and agitation by supplying compressed air. The water consumption was 50 L/Kg of by-product.
- The heat treatment of cooking was tested (20 min, 100 °C) with the incorporation of evaporation water with 1:1 ratio.
- The vacuum packer was tested for heat sealing bags of approximately 2-3 Kg in weight.

Conclusion test 2: In this test it was found that the increase in the proportion of water used in the wash (up to 50 L/Kg of by-product) did not allow to increase the pH value (so an acidification stage was not necessary) and the product was still bitter, despite the high water consumption. It was determined that the washing with the vegetable washer is not sufficient for the extraction of soluble compounds that could bring bitterness and a washing step may be necessary with a maceration tank and a Decanter centrifuge for the solid-liquid separation. In addition, with this test the effectiveness of the cooking stage was corroborated to reduce the microbiological load that the lemon by-product initially has, but it was not possible to evaporate all the cooking water (to favour the homogeneous cooking of the whole dough). Therefore, it is necessary to evaluate a lower ratio of cooking water to ensure its evaporation. On the other hand, it was observed that the concentration of hesperidin in the paste obtained was kept high and the heat sealing of the bags was correct with a hot product.

Description test 3 (14/01/2016):

- The washing system was tested with agitation by adding compressed air, as an initial wash with water re-use to reduce the water consumption of previous tests (5.8 L water/Kg by-pr., In 4 batches reusing it: 1.2 L/Kg).
- The operation of the equipment of particle size reduction to puree ("high speed knife cutter"), known as *comitrol*, obtaining a product of size 500 microns was proved. This test was performed after installing the equipment in the pilot plant of the CTC.
- The extraction stage was tested with the Decanter centrifuge, with a 1:3 mixture of the previously obtained puree (to avoid possible obstructions due to the particle size and looking to increase the exposed surface for extractions) and four extractions were made. The working conditions had to be modified to collect the solid fraction. The total water consumption in the 4 extractions was 317 litres of water (a lower value than expected because the performance of the Decanter centrifuge was low, it should have been about 600 litres of water).
- The vacuum packer was tested for heat sealing bags of approximately 2-3 Kg in weight.

Conclusion test 3: This test was intended to reduce water consumption for extraction, but it can be said that it was not enough to obtain a neutral product free of compounds that contribute bitterness. The total water consumption of the test was 387 litres of water to process 60.2 kg of raw material (6.4 L/Kg). If we had a 100% performance in all the equipment, the consumption would be approximately 13 L/Kg. In addition, it can be said that the *comitrol*

worked correctly, but part of the puree remains in the equipment and it has to be careful and check in the inside of the equipment. Finally, it was found that with the Decanter centrifuge the extraction of soluble compounds was increased, but the working conditions of the equipment were not established for an acceptable performance, since it did not adequately separate the solid and liquid phases. An acidification stage was not necessary because the pH value of the mash does not vary much with respect to the raw material.

On the other hand, it was observed that the concentration of hesperidin in the paste obtained was kept high and the heat sealing of the bags was correct with a hot product.

Description test 4 (29/01/2016):

- The washing system was tested with agitation by adding compressed air, as an initial wash with water change and three washes in a 1:3 ratio(3 L water/Kg by-pr., In 3 washes: 9 L/Kg).
- The operation of the equipment of particle size reduction to puree ("knife cutter of high speed"), known as *comitrol*, obtaining a product of size 500 microns was proved.
- The extraction stage was tested with the Decanter centrifuge, with a 1:3 mixture of the previously obtained mash (to avoid possible obstructions due to the particle size and looking to increase the exposed surface for extractions) and four extractions were made. The total water consumption in the 4 extractions was 589.6 litres of water (a lower value than expected because the performance of the Decanter centrifuge was low, it should have been about 966 litres of water if the yield was 100%).
- The heat cooking treatment was tested (20 min, 100°C) with the incorporation of evaporation water in the 1:0.5 ratio.

Conclusion test 4: This test is intended to obtain a neutral product free of compounds that contribute bitterness, but it cannot and the bitterness is enhanced. The total water consumption of the test was 1489.6 litres of water to process 100.64 kg of raw material (14.8 L/kg). If we had 100% performance in all the equipment, the consumption would be approximately 21 L/Kg. In addition, it can be said that the *comitrol* worked correctly and only took the precaution of checking the interior of the equipment and recovering all the puree. It was also found that with the Decanter centrifuge the extraction of soluble compounds is increased, but it was not possible to establish the working conditions of the equipment for acceptable performance, since it did not adequately separate the solid and liquid phases. An acidification step was not necessary because the pH value of the puree does not vary much with respect to the raw material. Another aspect to be highlighted is that, the effectiveness of the cooking stage was corroborated to reduce the microbiological load that the lemon by-product initially has, but the cooking water was not evaporated (to favour the homogenous cooking of the whole dough), which may be due to the lack of agitation in the dough to facilitate evaporation. Therefore, it is necessary to use equipment to work with continuous agitation that favours evaporation.

On the other hand, a considerable reduction in the concentration of hesperidin in the product was observed.

Description test 5 (12/02/2016):

- The washing system was tested with agitation by adding compressed air, as an initial wash with water change and three washings 1:3 ratio (3 L water/Kg bypr., In 3 washings: 9 L/Kg).
- Cutting equipment was tested to favour the contact surface and guarantee the extraction of soluble compounds in a second initial wash. We used Urschel cutter available in the pilot plant of the CTC that allows us to obtain a size of 8x8 cm.
- A second initial wash was tested, with water change and four washings with a ratio 1: 3 (3 L water/Kg bypr., In 4 washes: 12 L / Kg).
- The operation of the equipment of particle size reduction to puree ("high speed knife cutter"), known like *comitrol*, was proved; with the obtaining of a product of size 500 microns.
- The extraction stage was tested with the Decanter centrifuge, with a 1:4 mixture of the previously obtained mash and three extractions were made. The total water consumption in the 3 extractions was 367.4 litres of water (a lower value than expected because the performance of the Decanter centrifuge was low, it should have been about 395 litres of water if the performance was 100%).
- The vacuum packer was tested for heat sealing bags of approximately 2-3 Kg in weight.

Conclusion test 5: This test was intended to obtain a neutral product free of compounds that contribute bitterness, using the water ratio that would make the extraction of all soluble compounds effective. The total water consumption of the test was 1347.2 litres of water to process 58.64 kg of raw material (23 L/Kg), but if we had a 100% yield on all the equipment, the consumption would be approximately 33 L/Kg, which is very high water consumption. In addition, it was found that with the Decanter centrifuge the extraction of soluble compounds is increased, but a micron particle size is not suitable for solid-liquid separation in a Decanter centrifuge. Therefore, it is necessary to optimize this stage.

As a conclusion of the tests carried out in action B1, it can be said that the line designed for the LIFECITRUS process must have:

1. Vegetable washer / vegetable centrifuge

2. Urschel cutter 8x8 cm

3. “High speed knife cutter” equipment

4. Decanter centrifuge

5. Cooking tank with agitation

6. Vacuum packer

This equipment works correctly in the demonstration plant and it is necessary to optimize their working conditions in order to obtain the new food ingredient. Action B2 is aimed at developing the LIFECITRUS process and characterizing the new food ingredient.

OPTIMIZATION TEST. Action B2.Performing a test programme and characterization of the process parameters and products specifications

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 this two phases were developed together.

The optimization of the process was planned with the aim of used water reduced, higher hesperidin contends, 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 1856 kg of citric by-products (lemon, orange and tangerine) in 13 tests was processed. This amount is lower than the real processed amount due slurries, that were not used. 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.

	Test date (of by-products)							Total amount processed
Lemon	25/02/16	22/04/16	11/05/16	21/10/16	13/01/17	10/03/17	06/06/17	1123 Kg
Orange	13/07/16	04/10/16	18/11/16	24/03/17				490 Kg
Clementine	20/01/17	10/04/17						243 Kg

The developed test and the new food produced are described following.

Test lemon 250216

Description:

1) Pitted (manual)

2) First washed:

- 3 washed (ratio 1:3, 10 minutes)
- 9 washed (ratio 1:3, 30 minutes)

The pH was measured with the aim of obtained a neutral final pH of the elaborated ingredient.

Yield: 67.8%

3) Sized reduced using a high speed cutter (0.5 mm cutting head)

Yield: 96.8%

4) Washed using centrifugal Decanter (extraction)

- 3 times extractions (ratio 1:4)

In this process step the equipment parameters (bowl speed, screw speed and feed pump speed) were tuned with the aim of increase the equipment yield.

Yield: 45.4%

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) The use the new ingredient for producing strawberry jam (the pectin (E-440) was replaced by the new elaborated ingredient according with commercial strawberry jam recipe).

Results and discuss:

The analytical characterization of the raw material (lemon by-product) and the new elaborated ingredient are shown in table 2.

Table 2. Characteristics test 250216

Parameters	**Raw material**	**Obtained puree**
Physical-Chemical		
pH	3.45	6.6
° Brix	6.9	1
Acidity (% citric acid)	0.8	0.03
Texture (Bostwick)	0	0
Colour (L, a, b)	Max: L= 73.32; a= -6.37; b= 26.76 Min: L= 73.27; a= -6.40; b= 26.65 Average: L= 73.3; a= -6.39; b= 26.72	Max: L= 64.01; a= -3.02; b= 19.21 Min: L= 63.27; a= -3.10; b= 19.01 Average: L= 63.73; a= -3.07; b= 19.11
Moisture (g/100g)	87.3	90.6
Raw Fibre (g/100g)	3.3	4.9
Fat (g/100g)	0.3	<0.1
Essential oils (mL/100g)	-	<0.1
Dietary Fibre (g/100g)	6.8	6.9
Instrumental		
Pesticides residue (mg/Kg)	2-phenylphenol (1.91); Chlorpyrifos-methyl (0.01); Imazalil (3.55); Pyrimethanil (0.94); Pyriproxyfen (0.014); Thiabendazole (1.13)	Imazalil (0.26); Pyrimethanil (0.011); Thiabendazole (0.065)
Hesperidin (mg/Kg)	5340	228
Microbiological		
Aerobic counts (cfu/g)	-	< 10
Mold and yeast (cfu/g)	16000	< 10

Results in fresh weight

The water consumed of this test was 2.96 m^3 for processing 59 kg of lemon by product (water consumed are the sum of process water (1.96 m^3) and cleaning water (1 m^3)). Summarized, the water consumed were 50 L/Kg by lemon by-product with a yield of 23%.

It can be concluded that a neutral final pH of the lemon pure can be obtained with a high number of washed steps, but with huge water consumed. The soluble solids decreased to 14%,

the dietary fibre remained steady during the process steps and finally, the hesperidin concentration dropped. In the other hand, the cooked step killed the microorganisms of the elaborated puree, but the brightness of the elaborated puree decreased compared with raw material.

The water ratio (1:4) in the centrifugal decanter extraction step obtained an acceptable equipment yield, but it was not enough. New tests have to be developed with the aim to optimize the process parameters.

The used of 84 grams of the new elaborated ingredient per kg were tested in the fabrication of strawberry jams, but the consistency obtained were not acceptable in comparison to a commercial strawberry jams. A new test with 168 grams of the new elaborated ingredient per kg were developed, where improved results. A sensorial analysis of the new formulation was carried out with an acceptable result for texture parameter, but the size of puree was detected by the consumers, so in the following tests the texture has to be optimized.

Relate to the vegetable salad, the use of the new ingredient was for his potential hydrocolloid capacity and as a thickener agent. The syneresis in the vegetable salad not occurred and the product obtained was compact.

Conclusions:

According to lemon test 250216 results, the optimization of washed and extraction steps has not been achieved. It can be concluded that the strawberry jam (65 °Brix) and vegetable salad are potential foods where the new elaborated citric puree can be used for its gelling and flavour free properties. A new cutting head was tested with the aim to demonstrate the size reduction (lower than 0.1 mm) into citric puree and decide if it could be necessary to rent or buy this new cutting head.

<u>Test lemon 220416</u>

Description:

1) Pitted (manual)

2) First washed:

- 5 times washed (ratio 1:3, 60 minutes)

  The pH was measured with the aim of obtained a neutral final pH of the elaborated ingredient.

  Yield: 65%

3) Sized reduced using a high speed cutter (0.1 mm).

   Yield: 95%

4) Washed using centrifugal Decanter (extraction)

- 3 times extractions (ratio 1:4)

In this process step the equipment parameters (bowl speed, screw speed and feed pump speed) were tuned with the aim of increase the equipment yield.

Yield: 47%

5) Blanching (enzymatic inactivation)

Yield: 93%

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) The new ingredient was used for producing strawberry jams (the pectin (E-440) were replaced by the new elaborated ingredient according with commercial strawberry jam recipe), cake and tomato soup (the citric puree was used instead of bread as a gellificant).

Results and discuss:

The analytical characterization of the raw material (Mixed of 2 batch lemon by-product) and the new elaborated ingredient are shown in table 3.

Table 3. Characteristics test 220416

Parameters	**Raw material**	**Raw material**	**Obtained puree**
Physical-Chemical			
pH	3.45	3.54	4.4
° Brix	6.9	7.1	0.8
Acidity (% citric acid)	0.8	0.95	0.024
Texture (Bostwick)	0	0	0
Colour (L, a, b)	Max: L= 73.32; a= -6.37; b= 26.76 Min: L= 73.27; a= -6.40; b= 26.65 Average: L= 73.3; a= -6.39; b= 26.72	Max: L= 71.84; a= -5.65; b= 29.25 Min: L= 71.17; a= -5.88; b= 26.04 Average: L= 71.53; a= -5.80; b= 27.62	Max: L= 60.52; a= -1.19; b= 17.54 Min: L= 60.30; a= -1.24; b= 16.71 Average: L= 60.40; a= -1.21; b= 17.17
Moisture (g/100g)	87.	87	90.2
Raw Fibre (g/100g)	3.	2.3	3.6
Fat (g/100g)	0.3%	<0.1	<0.1
Essential oils (mL/100g)	-	0.5	<0.1
Dietary Fibre (g/100g)	6.8	6.7	9.0
Instrumental			
Pesticides residue (mg/Kg)	2-phenylphenol (1.91); Chlorpyrifos- methyl (0.01); Imazalil (3.55); Pyrimethanil (0.94); Pyriproxyfen (0.014); Thiabendazole (1.13)	2-phenylphenol (0.69); Chlorpyrifos (0.01); Imazalil (1.57); Pyrimethanil (0.87); Prochloraz (0.031); Tebufenpyrad (0.036)	Imazalil (0.92); Pyrimethanil (0.064); Prochloraz (0.051); Thiabendazole (0.036)
Hesperidin (mg/Kg)	5340	1235	215
Microbiological			
Aerobic counts (cfu/g)	-	48000	210
Mold and yeast (cfu/g)	16000	3500	< 10

Results in fresh weight

The water consumed of this test was 7.68 m^3 for processing 324.55 kg of lemon by product (water consumed are the sum of process water (6.68 m^3) and cleaning water (1 m^3)). Summarized, the water consumed were 23.66 L/Kg by lemon by-product with a yield of 27.3%.

Gas consumed in the blanching step was 34.7 m^3.

It can be concluded that the reduction of water consumed, allowed the production of lemon puree similar to raw material (lemon by-product) used. Furthermore, the speed of feed pump to centrifugal decanter have to be optimize for the improvement of extraction step yield in the centrifugal decanter

According to microbiology analysis, it was necessary to carry out a shelf life study of the lemon puree storage under refrigeration and freezing conditions, to determinate the use by date for consuming the puree in edible conditions according to food legislation. In the frame of this test the shelf life study was carried out to chilled and frozen lemon puree during 9 months. The microbiology analysis results concluded that the use by date of chilled lemon puree was 3 months and 9 months for frozen lemon puree.

Regarding to produce strawberry jams, 168 grams of lemon puree per kg were used, the result of parameter texture in the jam with lemon puree added (9 Bostwick) was different with the commercial strawberry jam with pectin E-440 (5 Bostwick). Nutritional and sensorial analyses were carried out for strawberry jam with 168 grams of lemon pure per kg and commercial jam. It can be concluded that there were not nutritional different between both, and the lemon puree was not detected by the consumers. There were significant differences in the texture parameter, but with a score upper to acceptable limit.

The use of lemon puree was evaluated into the cake. Four different recipes of cake were cooked: cakes with egg and two different lemon puree concentration and cakes with egg free and two different concentrations of lemon puree. The texture was acceptable in the four recipes of cakes elaborates with a concentration of lemon puree up to 250 grams of puree per kg. Furthermore, it could be concluded that the content of fibre into cakes increased with the addition of lemon puree. The nutritional values of 4 elaborated cakes are shown in table 4.

Table 4. Nutritional analysis of 3 recipes of cakes with egg: without lemon puree (control) and two different concentration of lemon puree.

Parameter	**Value**		
	Control	**10 g lemon puree**	**25g lemon puree**
Total sugars (g/100g)	15.77	15.07	14.38
Moisture (g/100g)	31.2	34.5	37.4
Total fat (g/100g)	17.2	16.7	15.8
Total Carbohydrate (g/100g)	40.1	37.2	35.2
Proteins (g/100g)	6.8	6.5	6.2
Dietary fiber (g/100g)	2.5	3.0	3.3
Calories (kcal/100g)	347	331	314

Results in fresh weight

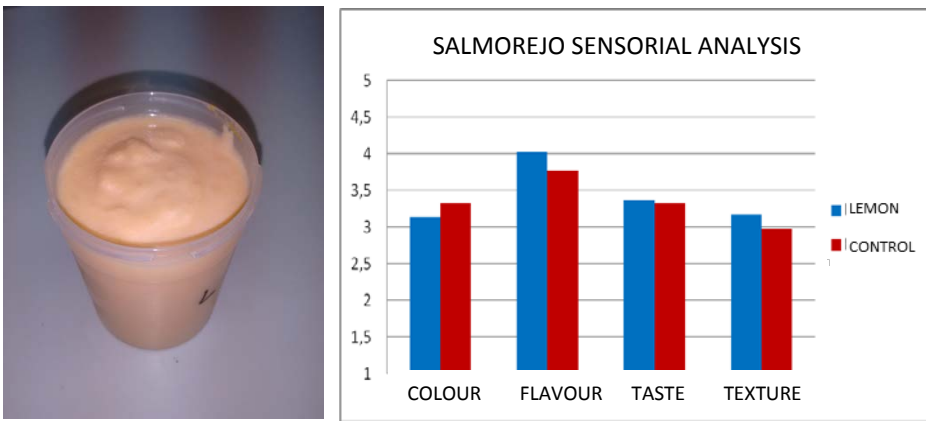
The tomato soup "salmorejo" was the last food where the addition of lemon puree was tested. Two different recipes were produced "control salmorejo", where bread was used as gelling and salmorejo with lemon puree as a gelling instead of bread. It was observed a higher fiber concentration and lower caloric value in the salmorejo with lemon puree compared with salmorejo control. The results of the samples, salmorejo (control and with lemon puree), are shown in table 5.

Table 5. Nutritional analysis of two recipes of "salmorejo"

	"Salmorejo" (Control)	**"Salmorejo" (Lemon puree)**
Calories (Kcal/100g)	137	93
Total fat (g/100g)	10.3	8.7
Total carbohydrate (g/100g)	8.3	1.0
Total sugars (g/100g)	2.23	0.97
Proteins (g/100g)	1.6	0.7
Dietary fiber (g/100g)	2.5	3.8

Results in fresh weight

The picture 1 shows the salmorejo with lemon puree and the score of the sensorial parameters evaluated by a five-point hedonic scale with the numbers used in the statistical assessments.: Means of score are: 1: Dislike very much, 2: Dislike, 3: Neither like, nor dislike, 4: Like, 5: Like very much. For both recipes of salmorejo, control and with lemon puree, the sensorial parameters were above of the acceptable score (3). It can be concluded that the salmorejo with lemon puree raised higher scored than salmorejo control, in all of the sensorial parameters evaluated (colour, flavour, taste and texture).



Picture 1. Salmorejo with lemon puree and Sensorial analysis

Conclusions:

Regarding to the results obtained it can be concluded that: First, the extraction step has not been not yet optimized. Second, the centrifugal decanter has to be fed with a higher size of lemon scraps. Third, the water consumed is still high. Finally, the used of lemon puree in pastry and bakery are a good chance to increase the fibre contend above 3%, so these foods could be label as "fibre source" according to nutritional claims legislation.

Test lemon 110516

Description:

1) Pitted (manual)

2) First washed:

- 1 washed (ratio 1:3, 15 minutes)
- 1 washed (ratio 1:3, 30 minutes)

Yield: 90%

3) Washed using centrifugal Decanter (extraction)

- Extractions with different ratios of lemon scrap/water. In this test the lemon by-products were diced before the extraction step, the difference with the last test was that the lemon scraps were not mashed before centrifugal decanter. Different ratios lemon scraps/water were tested with the aim to optimize the centrifugal decanter yield and tuned the equipment process parameters (bowl speed, screw speed and feed pump speed).

Test	A	B	C
Ratio (byproduct:water)	1:2	1:3	1:4
Extractions number	3	3	4
Yield (%)	68	83	64
pH	3.2	3.4	3.5
° Brix	2.5	1.6	1.6

According to yield parameter the best option was the ratio 1:3. This ratio was applied for the following tests.

4) Sized reduced using a high speed cutter (0.1 mm and 0.5 mm). The objective of this step was to determinate the best particulate size for lemon puree.

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) Validation of the lemon puree in strawberry jams (the lemon puree was used instead of pectins), cakes, vegetable soups (zucchini and vichyssoise), tea biscuits and strawberry jellies.

Results and discuss:

The analytical characterization of raw material (lemon by-products) and two lemon purees elaborated with 0.1 mm cutting head and 0.5 mm cutting head are shown in the table 6.

Table6. Characteristics test 110516

Parameters	Raw Material	Lemon puree 0.1 mm	Lemon puree 0.5 mm
Physical-Chemical			
pH	3.54	3.87	3.87
° Brix	7.1	1.7	1.7
Acidity (% citric acid)	0.95	0.14	0.11
Texture (Bostwick)	0	0	0
Colour (L, a, b)	Max: L= 71.84; a= -5.65; b= 29.25 Min: L= 71.17; a= -5.88; b= 26.04 Average: L= 71.53; a= -5.80; b= 27.62	Max: L= 69.93; a= -2.23; b= 25.76 Min: L= 68.25; a= -2.78; b= 23.63 Average: L= 68.85; a= -2.45; b= 25.04	Max: L= 67.48; a= -2.21; b= 24.61 Min: L= 67.18; a= -2.36; b= 24.28 Average: L= 67.35; a= -2.27; b= 24.41
Moisture (g/100g)	87	87.9	88.9
Raw Fibre (g/100g)	2.3	7.1	6.3
Fat (g/100g)	<0.1	0.1	0.1
Essential oils (mL/100g)	0.5	<0.1	<0.1
Dietary Fibre (g/100g)	6.7	9.9	9.8
Instrumental			
Pesticides residue (mg/Kg)	2-phenylphenol (0.69); Chlorpyrifos (0.01); Imazalil (1.57); Pyrimethanil (0.87); Prochloraz (0.031); Tebufenpyrad (0.036)	2-phenylphenol (0.18); Chlorpyrifos (0.01); Hexythiazox (0.034); Imazalil (1.78); Pyrimethanil (0.77); Prochloraz (0.053); Fenpyroximate (0.011)	2-phenylphenol (0.24); Chlorpyrifos (0.011); Hexythiazox (0.038); Imazalil (1.78); Pyrimethanil (0.88); Prochloraz (0.055)
Hesperidin (mg/Kg)	1235	1967	1835
Microbiological			
Aerobic counts (cfu/g)	48000	3100	9600
Mold and yeast (cfu/g)	3500	300	140

Results in fresh weight

The water consumed of this test was 3.92 m^3 for processing 221.54 kg of lemon by product (water consumed are the sum of process water (2.92 m^3) and cleaning water (1 m^3)). Summarized, the water consumed were 17.7 L/Kg by lemon by-product with a yield of 39.4%.

Gas consumed in the blanching step was 98 m^3 with an electricity consumed of 45 kWh.

It can be concluded that the reduced of consuming water allowed to obtain a lemon puree with a pH similar to pH of raw material. Furthermore, the dicer of the lemon scraps (lemon by-products) before the extraction step in the centrifugal decanter allowed obtaining a higher concentration of hesperidin in the lemon puree.

The shelf life study was carried out to chilled and frozen lemon puree during 9 months. The microbiology analysis results concluded that the use by date of chilled lemon puree was 3 months and 9 months for frozen lemon puree.

A strawberry jam with pectins (control) and two strawberry jams with 168 grams of lemon puree (0.1 mm and 0.5 mm) per kg were produced. There was not significant nutritional different between the two jams with lemon puree added. In the case of sensory analysis, the particles sized of the 0.5 mm lemon puree were detected by consumers. The fibre concentration was higher in the two jams with lemon purees (table 7).

Table 7. Nutritional analysis of strawberry jams

	Strawberry jam (Control)	Strawberry jam (Lemon puree 0.1 mm)	Strawberry jam (Lemon puree 0.5 mm)
Calories (Kcal/100g)	242	256	258
Total fat (g/100g)	0.2	0.2	0.2
Total carbohydrate (g/100g)	59.1	62.4	62.7
Total sugars (g/100g)	59.01	61.70	61.89
Proteins (g/100g)	0.6	0.6	0.5
Dietary fiber (g/100g)	0.7	1.3	1.5

Results in fresh weight

The two lemon purees were tested in cakes. The acceptable texture and high dietary fibre concentration of these cakes allowed concluding that the two lemon purees are a good ingredient in bakery products.

The two lemon purees were added in vegetable soups (zucchini and vichyssoise) for their potential gelling properties. In these products a lemon puree was used instead potatoes and the texture obtained was acceptable. There were not significant differences between vegetables soups with potatoes and lemon purees.

Finally, the 0.5 mm lemon puree was validated in the elaboration of tea biscuits and strawberry jam. In the case of the production of tea biscuits the mix of lemon puree and butter result a mouldable paste with high fibre content. The use of the lemon puree in strawberry jellies allowed to eliminate the use of pectins in this product with a lower sugar contends than jams. The texture measured into strawberry jelly with the lemon puree (4 Bostwick) was similar to a commercial strawberry jam with pectins (3.5 Bostwick). The table 8 shows the nutritional characteristics of both jams, (with pectins and with lemon puree); all of them are similar except the higher concentration of fibre in the strawberry jam with lemon puree.

Table 8. Nutritional characteristics of strawberry jams

	Strawberry jelly (Control)	Strawberry jelly (Lemon puree)
Calories (Kcal/100g)	197	221
Total fat (g/100g)	0.1	0.2
Total carbohydrate (g/100g)	47.3	52.4
Total sugars (g/100g)	44.56	50.13
Proteins (g/100g)	0.5	0.6
Dietary fiber (g/100g)	2.6	3.4

Results in fresh weight

Conclusions:

Summarizing the results of this test: First, the process parameters of the centrifugal decanter in the extraction step had been optimized. It is required to dicer the lemon by-products before feed the centrifugal decanter. Second, the consumed water has been reduced. Third, the gelling property of the lemon puree instead of the use of pectins has been validated in jams and jellies. Finally, the lemon puree is a potential ingredient as a fibre source and hydrocolloid agent in the elaboration of bakery and pastry foods (cakes, tea biscuits…) and vegetable soups.

Test orange 130716

Description:

1) Pitted (manual) and size reduced in the dicer machinery (8x8 cm)

2) First washed:

- 2 washed (ratio 1:3, 10 minutes)

Yield: 95%

3) Washed using centrifugal Decanter (extraction)

- 3 extractions (ratio 1:3)

Yield: 69.5%

4) Sized reduction in the high seep cutter (0.5 mm)

Yield: 98%

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) Validation of the orange puree in cakes and vichyssoise.

Results and discuss:

The characteristic of the raw material and orange puree elaborated are shown in the table 9.

Table 9. Characteristics test 130716

Parameters	**Raw material**	**Orange puree**
Physical-Chemical		
pH	3.18	3.49
° Brix	14	3.8
Acidity (% citric acid)	0.9	0.21
Texture (Bostwick)	0	0
Colour (L, a, b)	Max: L= 74.61; a= -5.02; b= 64.24 Min: L= 74.61; a= -5.02; b= 64.24 Average: L= 74.61; a= -5.02; b= 64.24	Max: L= 66.57; a= -2.89; b= 45.79 Min: L= 66.53; a= -2.93; b= 45.29 Average: L= 66.55; a= -2.91; b= 45.54
Moisture (g/100g)	78.4	90.9
Raw Fibre (g/100g)	3.3	3.6
Fat (g/100g)	<0.1	0.2
Essential oils (mL/100g)	1.3	<0.1
Dietary Fibre (g/100g)	7.3	7.2
Instrumental		
Pesticides residue (mg/Kg)	2-phenylphenol (1.34); Chlorpyrifos (0.052); Chlorpyrifos- methyl (0.013); Imazalil (2.5); Pyrimethanil (0.43); Thiabendazole (0.51)	2-phenylphenol (0.12); Chlorpyrifos (0.034); Chlorpyrifos- methyl (0.016); Imazalil (0.39); Pyrimethanil (0.34); Thiabendazole (0.093)
Hesperidin (mg/Kg)	-	-
Microbiological		
Aerobic counts (cfu/g)	150000	-
Mold and yeast (cfu/g)	2200	< 10

Results in fresh weight

The water consumed of this test was 2.15 m^3 for processing 115 kg of orange by product (water consumed are the sum of process water (1.65 m^3) and cleaning water (0.5 m^3)). Summarized, the water consumed were 18.7 L/Kg by orange by-product with a yield of 61.2%.

Gas consumed in the blanching step was 36 m^3 with an electricity consumed of 50 kWh.

It this test the consumed water was reduced, in spite of the soluble solids decreased up to 73%, but the orange puree had a strong orange coloration. The picture 2 shows the lemon and orange puree.

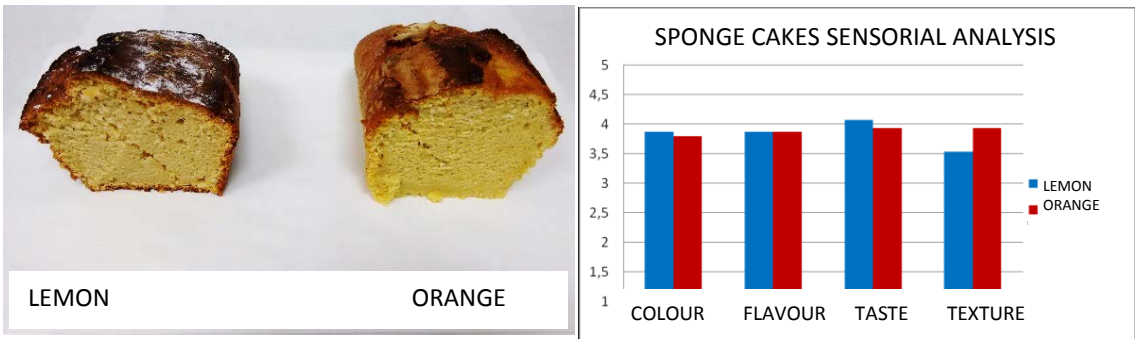
Picture 2. Lemon and orange purees

The acidity value of orange puree was lower than raw material (orange by-product). The aim of the washed was to decrease the acidity of final puree to eliminate the citric taste.

The low value of pH is acceptable in the orange puree, but not the loss of brightness compared with the raw material.

Regarding to microbiology analysis, it was necessary to carry out a shelf life study of the orange puree storage under refrigeration and freezing conditions, to determinate the use by date for consuming the puree in edible conditions according to food legislation. In the frame of this test the shelf life study was carried out to chilled and frozen orange puree during 12 months. The microbiology analysis results concluded that the use by date of chilled orange puree was 3 months and 12 months for frozen orange puree.

The orange puree was tested in cakes; the addition of 250 grams of orange puree per kg coloured the cake (picture 3) and the fibre value was lower than 3%, so this cake did not claim as a source of fibre. A sensorial analysis was carried out with the aim to compare the cake with the lemon puree added and the cake with the orange puree added. The picture 3 shows the result of sensorial parameters evaluated (colour, flavour, taste and texture), a similar scored reached both samples except in the texture parameter, where the score of the cake with orange puree (3.93) was slightly higher than the score of cake with lemon puree (3.53).



Picture 3. Sponge cake (lemon and orange) and Sensorial analysis

A vichyssoise with a low fibre value resulted, when the orange puree was added to this vegetable soup (table 10), this fibre value could be increased with the addition of more than the 150 grams of orange puree added, but in this case the colour obtained could be not acceptable. It can be concluded that the vegetable soup “vichyssoise" was not a potential food where the orange puree could be added.

Table 10. Nutritional analysis of vichyssoise with orange puree

	Vichyssoise (Orange puree)
Calories (Kcal/100g)	82
Total fat (g/100g)	7
Total carbohydrate (g/100g)	2.4
Total sugars (g/100g)	2.12
Proteins (g/100g)	0.9
Dietary fiber (g/100g)	2.9

Results in fresh weight

Conclusions:

The development process for producing orange puree was validated, but the application of this orange puree is restricted to foods where the orange colour can be accepted by the consumers.

Test orange 041016

Description:

1) Pitted (manual) and size reduced in the dicer machinery (8x8 cm)

2) First washed:

- 2 washed (ratio 1:3, 10 minutes)

Yield: 74.5%

3) Washed using centrifugal Decanter (extraction)

- 3 extractions (ratio 1:3)

Yield: 76.6%

4) Sized reduction in the high seep cutter (0.5 mm)

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) Validation of the orange puree in tea biscuits and strawberry jelly.

Results and discuss:

The characteristic of the raw material and orange puree elaborated are shown in the table 11.

Table 11. Characteristics test 041016

Parameters	Raw material	Orange puree
Physical-Chemical		
pH	3.18	3.81
° Brix	14	3.5
Acidity (% citric acid)	0.9	0.29
Texture (Bostwick)	0	0
Colour (L, a, b)	Max: L= 74.61; a= -5.02; b= 64.24 Min: L= 74.61; a= -5.02; b= 64.24 Average: L= 74.61; a= -5.02; b= 64.24	Max: L= 66.68; a= -1.82; b= 42.29 Min: L= 66.41; a= -2.11; b= 41.35 Average: L= 66.52; a= -1.93; b= 41.82
Moisture (g/100g)	78.4	89.5
Raw Fibre (g/100g)	3.3	3.7
Fat (g/100g)	<0.1	0.2
Essential oils (mL/100g)	1.3	<0.1
Dietary Fibre (g/100g)	7.3	8.4
Instrumental		
Pesticides residue (mg/Kg)	2-phenylphenol (1.34); Chlorpyrifos (0.052); Chlorpyrifos- methyl (0.013); Imazalil (2.5); Pyrimethanil (0.43); Thiabendazole (0.51)	2-phenylphenol (0.21); Chlorpyrifos (0.026); Etofenprox (0.017); Imazalil (0.68); Pyrimethanil (0.42); Propiconazole (0.011); Thiabendazole (0.2)
Hesperidin (mg/Kg)	-	5774
Microbiological		
Aerobic counts (cfu/g)	150000	< 10
Mold and yeast (cfu/g)	2200	< 10

Results in fresh weight

The water consumed of this test was 2.9 m^3 for processing 144.83 kg of orange by product (water consumed are the sum of process water (1.7 m^3) and cleaning water (1.2 m^3)). Summarized, the water consumed were 20 L/Kg by orange by-product with a yield of 50%.

Gas consumed in the blanching step was 33 m^3 with an electricity consumed of 42 kWh.

In this test the soluble solids decreased up to 75% with a high value of hesperidin, this fact validated the optimization of washed and extraction process steps.

As in the last tests, a shelf life study of the orange puree storage under refrigeration and freezing conditions were carried out to determinate the use by date for consuming the puree in edible conditions according to food legislation. In the frame of this test the shelf life study was carried out to chilled and frozen orange puree during 9 months. The microbiology analysis results concluded that the use by date of the chilled orange puree was 6 months and 9 months for frozen orange puree.

In addition, in this test a heat treatment was applied to the packaged orange puree with the aim to achieve the room temperature stability. Microbiology tests of different samples of pasteurised orange puree were carried out according to regulation AFNOR NV- 08-408. Results are shown in table 12. The results of Stability Tests showed that samples were stable at room temperature.

Table 12. Microbiology stability test of pasteurised orange puree 041016

PARAMETERS	
Sensory parameters of sample at 37 °C	No change
Sensory parameters of control sample	No change
Control packaging state of sample at 37 °C	No change
Control packaging state of control sample	No change
pH of control sample	3.90
pH of sample at 37 °C	3.84
Total count (max. 100) at 37 °C	<100

The orange puree was tested in the elaboration of tea biscuits. The picture 4 shows the orange coloured of the biscuits and table 13 shows a high value of fibre (3.1g/100g), so this product can be labelled as a source of fibre.

Picture 4. Tea biscuits with orange puree

Table 13. Nutritional characteristics of tea biscuits with orange puree

	Tea biscuits (Orange puree)
Calories (Kcal/100g)	478
Total fat (g/100g)	22.5
Total carbohydrate (g/100g)	62.4
Total sugars (g/100g)	25.54
Proteins (g/100g)	5.0
Dietary fiber (g/100g)	3.1

Results in fresh weight

Finally, two strawberry jellies, with a 50% of sugar concentration, were elaborated with 6 g/kg of pectins (control) and with the addition of 150 grams of orange puree per kg. The nutritional values show that there were not significant differences between both jellies. In the other hand, there was a significant difference regarding to texture, jelly with pectins had higher consistency (4 Bostwick) than jelly with orange puree (6 Bostwick).

Conclusions:

In the frame of the results of this test, it can be concluded: First, the replicability of the development process for orange puree has been validated. Second, the heat treatment of citric puree is an available preserve technique for room temperature storage of the citric puree. And finally, the LIFECITRUS process can reduce the soluble solids, up to 75%, in the orange by-products, using water as a solvent solution.

Test lemon 211016

Description:

1) Pitted (manual)

2) First washed:

- 2 washed (ratio 1:3, 10 minutes)

Yield: 89%

3) Washed using centrifugal Decanter (extraction)

- 3 extractions (ratio 1:3)

Yield: 80.82%

4) Sized reduction in the high seep cutter (0.5 mm)

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) Validation of the orange puree in “paparajotes” and vegetables filled for bakery.

Results and discuss:

The characteristic of the raw material and lemon puree elaborated are shown in the table 14.

Table 14. Characteristics test 211016

Parameters	**Raw material**	**Lemon puree**
Physical-Chemical		
pH	3.54	3.82
° Brix	7.1	1.1
Acidity (% citric acid)	0.95	0.14
Texture (Bostwick)	0	0
Colour (L, a, b)	Max: L= 71.84; a= -5.65; b= 29.25 Min: L= 71.17; a= -5.88; b= 26.04 Average: L= 71.53; a= -5.80; b= 27.62	Max: L= 67.20; a= -2.14; b= 25.77 Min: L= 66.79; a= -2.33; b= 25.18 Average: L= 67.02; a= -2.28; b= 25.43
Moisture (g/100g)	87	90.1
Raw Fibre (g/100g)	2.3	6.2
Fat (g/100g)	<0.1	0.2
Essential oils (mL/100g)	0.5	<0.1
Dietary Fibre (g/100g)	6.7	8.3
Instrumental		

Pesticides residue (mg/Kg)	2-phenylphenol (0.69); Chlorpyrifos (0.01); Imazalil (1.57); Pyrimethanil (0.87); Prochloraz (0.031); Tebufenpyrad (0.036)	2-phenylphenol (0.11); Imazalil (0.92); Pyrimethanil (0.41)
Hesperidin (mg/Kg)	1235	1758
Microbiological		
Aerobic counts (cfu/g)	48000	< 10
Mold and yeast (cfu/g)	3500	< 10

Results in fresh weight

The water consumed of this test was 3.8 m^3 for processing 117 kg of orange by product (water consumed are the sum of process water (1.5 m^3) and cleaning water (2.3 m^3)). Summarized, the water consumed were 32.5 L/Kg by orange by-product with a yield of 62.4%.

Gas consumed in the blanching step was 33 m^3 with an electricity consumed of 45 kWh.

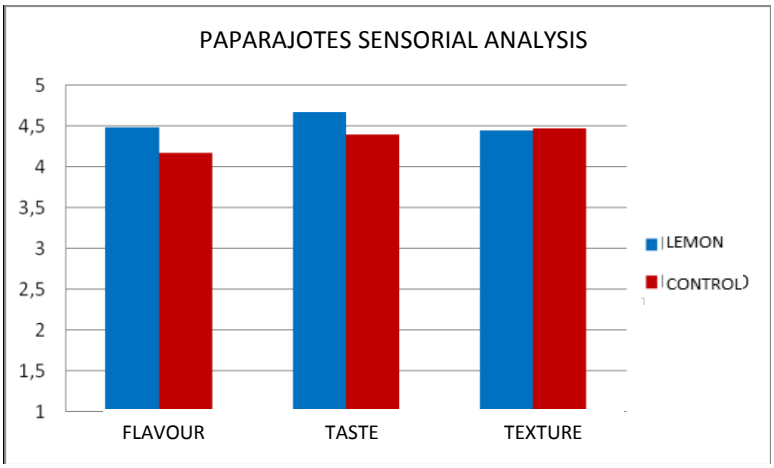
In this test the soluble solids decreased up to 85% with a high value of hesperidin, this fact validated the optimization of washed and extraction process steps.

In addition, in this test a heat treatment was applied to the packaged lemon puree with the aim to achieve the room temperature stability. Microbiology tests of different samples of pasteurised lemon puree were carried out according to regulation AFNOR NV- 08-408. Results are shown in table 15. The results of Stability Tests showed that samples were stable at room temperature.

Table 15. Microbiology stability test of pasteurised lemon puree 211016

PARAMETERS	
Sensory parameters of sample at 37 °C	No change
Sensory parameters of control sample	No change
Control packaging state of sample at 37 °C	No change
Control packaging state of control sample	No change
pH of control sample	3.87
pH of sample at 37 °C	3.85
Total count (max. 100) at 37 °C	<100

The lemon puree elaborated in this test was tested in the production of “paparajotes”, a regional dessert from Region of Murcia, with the following ingredients: Eggs, flour, olive oil, sugar, salt and flakes of lemon peel. In the developed product a portion of flour and flakes of lemon peel were changed by lemon puree, after all ingredients were mixed. This mixture was used as a cover of lemon leaves. Finally, the lemon leaves covered with the mixture were fried (picture 5).The new “paparajotes” and traditional paparajotes were nutritional and sensorial analysed. There were not significant nutritional differences between traditional paparajotes and paparajotes with lemon puree. The figure 5 shows the significant differences in the sensorial parameters, flavour and taste, obtaining the highest score the paparajotes with lemon puree added. No significant differences were detected by the consumers related to texture parameter.



Picture 5. Paparajotes and Sensorial analysis

Finally, a bakery product filled with a mixture of vegetables with lemon puree was tested (picture 6). A commercial base for bakery products was filled with a mixture of vegetables and 100 grams of lemon puree per kg of vegetables, after that the bakery product was cooked in the oven during 10 minutes. And other bakery product filled with vegetables without lemon puree was cooked and used as a control of the bakery product.

Picture 6. Bakery product filled with vegetables

After cooking the control bakery product showed water losses (syneresis), while the bakery product filled with vegetables and lemon puree showed a good texture. This is due the hydrocolloid properties of the lemon puree which absorb the water from vegetables during the cooked.

Table 16. Nutritional characteristics of bakery product filled with vegetables and lemon puree.

	Bakery product filled with a mixture of vegetables (Lemon puree)
Calories (Kcal/100g)	242
Total fat (g/100g)	10.4
Total carbohydrate (g/100g)	29.9
Total sugars (g/100g)	4.57
Proteins (g/100g)	5.9
Dietary fiber (g/100g)	2.5

Results in fresh weight

Conclusions:

In this test the replicability of the development process for obtaining the lemon puree was achieved.

Test orange 181116

Description:

1) Pitted (manual) and size reduced in the dicer machinery (8x8 cm)

2) First washed:

- 2 washed (ratio 1:3, 15 minutes)

Yield: 90.2%

3) Washed using centrifugal Decanter (extraction)

- 3 extractions (ratio 1:3)

Yield: 81.4%

4) Sized reduction in the high seep cutter (0.5 mm)

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) Validation of the orange puree in orange pastry.

Results and discuss:

The characteristic of the raw material and orange puree elaborated are shown in the table 17.

Table 17. Characteristics test 181116

Parameters	Raw materiall	Orange puree
Physical-Chemical		
pH	3.18	3.69
° Brix	14	3.5
Acidity (% citric acid)	0.9	0.286
Texture (Bostwick)	0	0
Colour (L, a, b)	Max: L= 74.61; a= -5.02; b= 64.24 Min: L= 74.61; a= -5.02; b= 64.24 Average: L= 74.61; a= -5.02; b= 64.24	Max: L= 65.78; a= -0.59; b= 40.27 Min: L= 64.80; a= -1.07; b= 39.23 Average: L= 65.30; a= -0.88; b= 39.67
Moisture (g/100g)	78.4	89.6
Raw Fibre (g/100g)	3.3	3.7
Fat (g/100g)	<0.1	0.2
Essential oils (mL/100g)	1.3	<0.1
Dietary Fibre (g/100g)	7.3	8.2
Instrumental		
Pesticides residue (mg/Kg)	2-phenylphenol (1.34); Chlorpyrifos (0.052); Chlorpyrifos- methyl (0.013); Imazalil (2.5); Pyrimethanil (0.43); Thiabendazole (0.51)	2-phenylphenol (0.13); Imazalil (0.48); Pyrimethanil (0.24); Thiabendazole (0.16)
Hesperidin (mg/Kg)	-	4818
Microbiological		
Aerobic counts (cfu/g)	150000	< 10
Mold and yeast (cfu/g)	2200	< 10

Results in fresh weight

The water consumed of this test was 4 m^3 for processing 123 kg of orange by product (water consumed are the sum of process water (1.5 m^3) and cleaning water (2.5 m^3)). Summarized, the water consumed were 32.5 L/Kg by lemon by-product with a yield of 63%.

Gas consumed in the blanching step was 36 m^3 with an electricity consumed of 45 kWh.

In this test the soluble solids decreased up to 75% with a high value of hesperidin, this fact validated the optimization of washed and extraction process steps.

In addition, in this test a heat treatment was applied to the packaged lemon puree with the aim to achieve the room temperature stability. Microbiology tests of different samples of pasteurised orange puree were carried out according to regulation AFNOR NV- 08-408. Results are shown in table 18. The results of Stability Tests show that samples were stable at room temperature.

Table 18. Microbiology stability test of pasteurised orange puree 181116

PARAMETERS	
Sensory parameters of sample at 37 °C	No change
Sensory parameters of control sample	No change
Control packaging state of sample at 37 °C	No change
Control packaging state of control sample	No change
pH of control sample	3.71
pH of sample at 37 °C	3.66
Total count (max. 100) at 37 °C	<100

The orange puree elaborated in this test was tested in the production of orange pastry (a regional Christmas pastry from the Region of Murcia, picture 7)). 200 grams of orange puree per kg were added to orange pastry and traditional orange pastry without the orange puree,

were cooked as a control sample. In this case the colour of the orange puree increased the coloration of the orange pastry compared with control orange pastry, and were highly scored by the consumers.

Picture 7. Orange pastry with orange puree

The table 19 shows the nutritional values of control orange pastry and orange pastry with orange puree. It can be observed that the orange pastry with orange puree show higher fibre value and lower energy value than control orange pastry.

Table 19. Nutritional characteristics of orange pastry

	Orange pastry (control)	**Orange pastry (Orange puree)**
Calories (Kcal/100g)	426	395
Total fat (g/100g)	17.2	16
Total carbohydrate (g/100g)	61.5	56.2
Total sugars (g/100g)	25.63	23.03
Proteins (g/100g)	5.9	5.4
Dietary fiber (g/100g)	0.9	2.1

Results in fresh weight

Conclusions:

With the development of this test it can be concluded: First the yield of the development LIFECITRUS process increased up to 60%. Second, the consumed water increased due the water used for cleaning the equipment. Finally, the orange pastry was a potential food for the application of orange puree for its high fibre content and sensorial properties.

As a result of this test a new cutting head for high speed cutting machinery was bought in December of 2016. The following tests were carried out with the new cutting head with the aim to obtain a particulates size below 0.1 mm in the citric puree elaborated.

Test lemon 130117

Description:

1) Pitted (manual)

2) First washed:

- 2 washed (ratio 1:3, 10 minutes)

Yield: 78.6%

3) Washed using centrifugal Decanter (extraction)

- 2 extractions (ratio 1:3)

Yield: 84.06%

4) Sized reduction in the high seep cutter (0.1 mm)

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) Validation of the lemon puree in hamburgers.

Results and discuss:

The characteristic of the raw material and elaborated lemon puree are shown in the table 20.

Table 20. Characteristics test 130117

Parameters	**Raw Material**	**Lemon puree**
Physical-Chemical		
pH	3.53	3.8
° Brix	4.9	2.4
Acidity (% citric acid)	1.14	0.16
Texture (Bostwick)	0	0
Colour (L, a, b)	Max: L= 77.03; a= -5.56; b= 25.90 Min: L= 72.81; a= -5.79; b= 20.61 Average: L= 75.28; a= -5.70; b= 22.66	Max: L= 67.93; a= -3.38; b= 19.78 Min: L= 67.65; a= -3.46; b= 19.43 Average: L= 67.75; a= -3.43; b= 19.65
Moisture (g/100g)	87.6	92
Raw Fibre (g/100g)	3.1	3.5
Fat (g/100g)	0.2	0.2
Essential oils (mL/100g)	0.3	<0.1
Dietary Fibre (g/100g)	6.8	5.7
Instrumental		
Pesticides residue (mg/Kg)	2-phenylphenol (1.23); Chlorpyrifos-methyl (0.016); Fludioxonil (0.44); Imazalil (1.07); Metalaxyl (0.012); Pyrimethanil (0.40); Pyriproxyfen (0.01); Thiabendazole (0.16)	2-phenylphenol (0.50); FLUDIOXONIL (0.44); Imazalil (0.76); Pyrimethanil (0.22); Thiabendazole (0.2)
Hesperidin (mg/Kg)	6434	2242
Microbiological		
Aerobic counts (cfu/g)	>	< 10
Mold and yeast (cfu/g)	>	< 10

Results in fresh weight

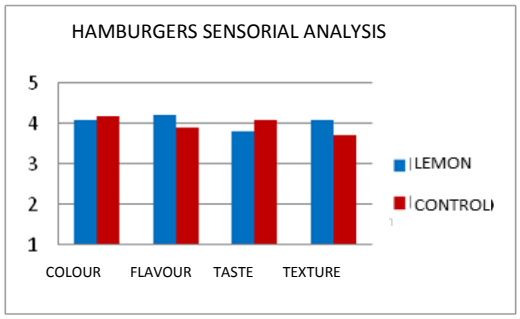
The water consumed of this test was 1.6 m^3 for processing 129.6 kg of lemon by product (water consumed are the sum of process water (1.1 m^3) and cleaning water (0.5 m^3)). Summarized, the water consumed were 12.3 L/Kg by lemon by-product with a yield of 67.1%.

Gas consumed in the blanching step was 35 m^3 with an electricity consumed of 13 kWh. The low electricity consumed was due to this test were carried out in continuous way not in batches.

The objective of this test was to reduce the consumed water in the process, but the soluble solids decreased up to 50% with 2 extractions in the centrifugal decanter. The elaborated lemon puree had a higher moisture and lower fibre than the lemon puree obtained in the last tests.

As in the last tests, a shelf life study of the lemon puree storage under refrigeration and freezing conditions were carried out to determinate the use by date for consuming the puree in edible conditions according to food legislation. In the frame of this test the shelf life study was carried out to chilled and frozen lemon puree during 6 months. The microbiology analysis results concluded that the use by date of the chilled lemon puree was 3 months and 6 months for frozen lemon puree.

The lemon puree was tested in hamburgers with the addition of 100 grams the lemon puree per kg, the control hamburgers were elaborated without lemon puree. The control hamburgers and the hamburgers with lemon puree were nutritional and sensorial analysed after grilled (picture 8 and table 21).



Picture 8. Hamburgers and Sensorial analysis

The consumers scored the hamburgers with lemon puree better than the control samples in the flavour and texture parameters and slightly lower in the taste parameter.

Table 21. Nutritional characteristics of control hamburgers and hamburgers with lemon puree

	Hamburgers (control)	**Hamburgers (Lemon puree)**
Calories (Kcal/100g)	184	182
Total fat (g/100g)	10.4	10.4
Total carbohydrate (g/100g)	0.1	2.1
Total sugars (g/100g)	< 0.05	< 0.05
Proteins (g/100g)	22.4	19.5
Dietary fiber (g/100g)	< 0.1	0.9

Results in fresh weight

The table 21 shows the higher value of fibre in the hamburgers with lemon puree versus control samples.

Conclusions:

The objective of this test of reduced consumed water, with 2 extractions in the centrifugal decanter, was not achieved. The elaborated puree has a bitter taste and coloured. In the other hand, it was validated the use of lemon puree in meat products. It can be concluded that the citric puree could be applied in the canned food, jams and jellies, bakery and pastry, vegetables soups and meat products.

A small quantity of the lemon puree was lyophilized because some companies showed interest to dehydrated lemon fibre.

Test tangerine 200117

Description:

1) Raw material selection and Pitted (manual)

2) First washed:

- 2 washed (ratio 1:3, 10 minutes)

Yield: 61%

3) Washed using centrifugal Decanter (extraction)

- 2 extractions (ratio 1:3)

Yield: 66%

4) Sized reduction in the high seep cutter (0.1 mm)

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

Results and discuss:

The characteristic of the raw material and elaborated tangerine puree are shown in the table 22.

Table22. Characteristics test 200117

Parameters	Raw material	Tangerine puree
Physical-Chemical		
pH	3.37	3.8
° Brix	11.2	2.6
Acidity (% citric acid)	0.91	0.17
Texture (Bostwick)	0	0
Colour (L, a, b)	Max: L= 68.68; a= 3.21; b= 60.38 Min: L= 68.81; a= 1.49; b= 57.15 Average: L= 68.28; a= 2.22; b= 59.29	Max: L= 65.47; a= 3.33; b= 57.05 Min: L= 65.36; a= 3.08; b= 56.75 Average: L= 65.41; a= 3.18; b= 56.94
Moisture (g/100g)	84.4	90.4
Raw Fibre (g/100g)	3.6	2.7
Fat (g/100g)	0.3	0.4
Essential oils (mL/100g)	0.27	0.36
Dietary Fibre (g/100g)	6.5	6.3
Instrumental		
Pesticides residue (mg/Kg)	Chlorpyrifos (0.015); Chlorpyrifos-methyl (0.011); Imazalil (1.83); Lambda-cyhalothrin (0.011); Pyrimethanil (0.023); Pyriproxyfen (0.016)	Chlorpyrifos (0.038); Chlorpyrifos-methyl (0.013); Imazalil (1.20); Lambda-cyhalothrin (0.011); Pyrimethanil (0.14); Pyriproxyfen (0.016); Fenpyroximate (0.011); Pyraclostrobin (0.022)
Hesperidin (mg/Kg)	9839	6287
Microbiological		
Aerobic counts (cfu/g)	560	< 10
Mold and yeast (cfu/g)	-	< 10

Results in fresh weight

The water consumed of this test was 2.5 m^3 for processing 120.5 kg of tangerine by product (water consumed are the sum of process water (1.5 m^3) and cleaning water (1 m^3)). Summarized, the water consumed were 20.7 L/Kg by tangerine by-product with a yield of 54.2%.

Gas consumed in the blanching step was 41.4 m^3 with an electricity consumed of 12 kWh. The low electricity consumed was due to this test were carried out in continuous way not in batches.

The objective of this test was to validate the development LIFECITRUS process into citric by-products with a high value of soluble solid. The ° Brix dropped from 11 in the raw material to 2.6 in the elaborated tangerine puree, so the soluble solids reduced up to 75%.This puree showed a bitter taste and high coloration. For this reasons the tangerine puree was not tested in foods.

As in the last tests, a shelf life study of the tangerine puree storage under refrigeration and freezing conditions were carried out to determinate the use by date for consuming the puree in edible conditions according to food legislation. In the frame of this test the shelf life study was carried out to chilled and frozen tangerine puree during 6 months. The microbiology analysis results concluded that the use by date of the chilled tangerine puree was 3 months and 6 months for frozen tangerine puree.

Conclusions:

It was concluded that the tangerine by-products need more than 2 extractions with the centrifugal decanter to reduce the bitter taste and the coloration in the tangerine puree elaborated.

Test lemon 100317

Description:

1) Raw material selection and Pitted (manual)

2) First washed:

- 2 washed (ratio 1:3, 10 minutes)

Yield: 78.44%

3) Washed using centrifugal Decanter (extraction)

- 3 extractions (ratio 1:3). In this step the consumed water was reused in the second and third extraction, after the elimination of the soluble solids by centrifugation in an Alfa-Laval centrifugal machinery.

Yield: 68.23%

4) Sized reduction in the high seep cutter (0.1 mm)

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) Validation of the lemon puree in almond beverage, tea biscuits, quince jelly and low calorie jelly.

Results and discuss:

The characteristic of the raw material and elaborated lemon puree are shown in the table 23.

Table 23. Characteristics test 100317

Parameters	**Raw material**	**Lemon puree**
Physical-Chemical		
pH	3.53	3.53
° Brix	5	2.3
Acidity (% citric acid)	1.2	0.3
Texture (Bostwick)	0	0
Colour (L, a, b)	Max: L= 77.03; a= -5.56; b= 25.90 Min: L= 72.81; a= -5.79; b= 20.61 Average : L= 75.28; a= -5.70; b= 22.66	Max: L= 69.56; a= -3.75; b= 23.10 Min: L= 69.05; a= -3.95; b= 22.44 Average : L= 69.29; a= -3.86; b= 22.71
Moisture (g/100g)	87.6	90.8
Raw Fibre (g/100g)	3.1	4
Fat (g/100g)	0.2	0.2
Essential oils (mL/100g)	0.3	<0.1
Dietary Fibre (g/100g)	6.8	7.3

Instrumental		
Pesticides residue (mg/Kg)	2-phenylphenol (1.23); Chlorpyrifos-methyl (0.016); Fludioxonil(0.44); Imazalil (1.07); Metalaxyl(0.012); Pyrimethanil(0.40); Pyriproxyfen (0.01); Thiabendazole (0.16)	2-phenylphenol (0.21); Chlorpyrifos (0.13); Fludioxonil(0.11); Imazalil (0.56); Pyrimethanil(0.16); Propiconazole(0.18); Thiabendazole (0.12)
Hesperidin (mg/Kg)	6434	2838
Microbiological		
Aerobic counts (cfu/g)	>	< 10
Mold and yeast (cfu/g)	>	< 10
Energy (Kcal/100g)	-	35

Results in fresh weight

The water consumed of this test was 5.6 m^3 for processing 150.7 kg of lemon by product (water consumed are the sum of process water (1.55 m^3) and cleaning water (4.01 m^3)). Summarized, the water consumed were 32.7 L/Kg by lemon by-product with a yield of 61%.

Gas consumed in the blanching step was 52 m^3 with an electricity consumed of 71 kWh.

The values of consuming water and electricity increased if they were compared with the last tests, due to the incorporation of the Alfa-Laval machinery in the extraction step, with the aim of reused the consumed water in this step. Furthermore, the cleaning of this equipment increases the value of consumed cleaning water.

The table 23 shows a high value of hesperidin, but the soluble solids were reduced up to 50%, so it can be concluded that the washed and extraction steps were efficient. The pH value remained steady compared with the lemon puree elaborated in the last tests.

As in the last tests, a shelf life study of the lemon puree storage under refrigeration and freezing conditions were carried out to determinate the use by date for consuming the puree in edible conditions according to food legislation. In the frame of this test the shelf life study was carried out to chilled and frozen lemon puree during 4 months. The microbiology analysis results concluded that the use by date of the chilled lemon puree was 4 months and 4 months for frozen lemon puree.

The lemon puree elaborated in this test was tested in the production of almond beverage where 30 grams of lemon puree were added (picture 9), with the aim to validate the hydrocolloid properties of the lemon puree. The elaborated almond beverage was compared by the consumers with a commercial almond beverage. In all of the sensorial parameters evaluated (colour, flavour, texture and taste) the almond beverage with lemon puree obtained a score above the acceptable limit and they were similar to commercial almond beverages.

Picture 9. Almond beverage with lemon puree

The table 24 shows the nutritional characteristics of the commercial almond beverage and the almond beverage with 3% lemon puree added. It can be concluded that there were not significant differences in the nutritional values between samples.

Table 24. Nutritional characteristics of almond beverages.

	Almond beverage (commercial)	**Almond beverage (Lemon puree)**
Calories (Kcal/100g)	32	32
Total fat (g/100g)	2.1	3.2
Total carbohydrate (g/100g)	3.3	0.3
Total sugars (g/100g)	< 0.3	< 0.3
Proteins (g/100g)	1	1
Viscosity (cP)	35	20

Results in fresh weight

According to the sensorial and nutritional results, the used of lemon puree for elaborating almond beverages is acceptable. In this product it was validated that the slightly bitter taste of the lemon puree resulted in the improvement of flavour and taste of the beverage and highly appreciated by the consumers.

Other food, where the lemon puree was tested, was in the tea biscuits. A control samples and tea biscuits with lemon puree added were produced and nutritional and sensorial analysed. The table 25 shows the nutritional values of samples, the lower value in energy and higher value of the fibre of the tea biscuit compared to control samples, validated the uses of lemon puree for producing tea biscuits. The score obtained for both samples were similar and above of the acceptable score limit.

Table 25. Nutritional characteristics of the tea biscuits

	Tea biscuits (Control)	**Tea biscuits (Lemon puree)**
Calories (Kcal/100g)	473	453
Total fat (g/100g)	20.1	19.6
Total carbohydrate (g/100g)	65	67.4
Total sugars (g/100g)	19.64	25.3
Proteins (g/100g)	6.6	6.3
Dietary fiber (g/100g)	3.0	3.2

Results in fresh weight

A quince jelly was produced with 100 grams of lemon puree per kg; this sample was compared with a control quince jelly elaborated with pectins as a gelling agent instead of lemon puree. A lemon juice was added to the samples for adjusting the pH up to 3.3 with the aim to increase the gelling action of the lemon puree and pectins. A sensorial analysis of the samples concluded that there were not significant differences between samples in all of the parameters evaluated (colour, flavour, taste and texture), with a high acceptability of the samples by the consumers.

Finally, a low caloric apricot jelly with 175 grams of lemon puree per kg and a low calorie apricot jelly with pectins were elaborated (picture 10). In these samples sweeteners were added (sucralose, stevia and sorbitol) instead of sugar. The texture of both samples (with pectins and lemon puree) produced were similar and acceptable (4 Bostwick).

Picture 10. Low calorie apricot jellies.

The table 26 shows the nutritional values of low calorie apricot jelly with lemon puree added; highlight the low sugars value, 10%, and the low caloric value, 73 kcal/100g.

Table 26. Low caloric apricot jelly with lemon puree

	Low caloric apricot jelly (Lemon puree)
Calories (Kcal/100g)	73
Total fat (g/100g)	0.2
Total carbohydrate (g/100g)	16.8
Total sugars (g/100g)	6.7
Proteins (g/100g)	0.5
Dietary fiber (g/100g)	0.9

Results in fresh weight

Conclusions:

The replicability of the implemented LIFECITRUS process was validated according to the results obtained in this test. Finally, the consumed water was 10 L/Kg (without cleaning water) with a yield of 61%.

Test orange 240317

Description:

1) Pitted (manual) and size reduced in the dicer machinery (8x8 cm)

2) First washed:

- 2 washed (ratio 1:3, 10 minutes)

Yield: 78.4%

3) Washed using centrifugal Decanter (extraction)

- 3 extractions (ratio 1:3)

Yield: 71.3%

4) Sized reduction in the high seep cutter (0.1 mm)

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) Validation of the orange puree in low calorie jelly.

Results and discuss:

The characteristic of the raw material and orange puree elaborated are shown in the table 27.

Table 27. Characteristics test 240317

Parameters	**Raw material**	**Orange puree**
Physical-Chemical		
pH	3.18	3.67
° Brix	14	2.2
Acidity (% citric acid)	0.9	0.25
Texture (Bostwick)	0	0
Colour (L, a, b)	Max: L= 74.61; a= -5.02; b= 64.24 Min: L= 74.61; a= -5.02; b= 64.24 Average: L= 74.61; a= -5.02; b= 64.24	Max: L= 65.45; a= -1.44; b= 42.35 Min: L= 64.74; a= -1.72; b= 41.66 Average: L= 65.16; a= -1.60; b= 42.11
Moisture (g/100g)	78.4	89.5
Raw Fibre (g/100g)	3.3	3.7
Fat (g/100g)	<0.1	0.2
Essential oils (mL/100g)	1.3	<0.1
Dietary Fibre (g/100g)	7.3	8
Instrumental		
Pesticides residue (mg/Kg)	2-phenylphenol (1.34); Chlorpyrifos (0.052); Chlorpyrifos- methyl (0.013); Imazalil (2.5); Pyrimethanil (0.43); Thiabendazole (0.51)	2-phenylphenol (0.13); Chlorpyrifos (0.021); Imazalil (0.92); Pyrimethanil (0.35)
Hesperidin (mg/Kg)	-	5642
Microbiological		
Aerobic counts (cfu/g)	150000	< 10
Mold and yeast (cfu/g)	2200	< 10
Energy (Kcal/100g)	-	44

Results in fresh weight

The water consumed of this test was 3.9 m^3 for processing 107.4 kg of orange by product (water consumed are the sum of process water (1.4 m^3) and cleaning water (2.5 m^3)). Summarized, the water consumed were 36 L/Kg by orange by-product with a yield of 54%.

Gas consumed in the blanching step was 47.2 m^3 with an electricity consumed of 34 kWh.

The high value of consuming water was due to that the process was carried out in batches.

The table 27 showed a high value of hesperidin, and the soluble solids were reduced up to 85%, so it can be concluded that the washed and extraction steps were efficient. The elaborated orange puree showed a highly orange colour, similar to the last orange by-products tests.

A low caloric apricot jelly with 175 grams of the elaborated orange puree added was nutritionally analysed as well as the texture (Bostwick). The texture value (5.5 Bostwick) of the low caloric apricot jelly with orange puree was lower than the texture value (4.0 Bostwick) of the low caloric apricot jelly with lemon puree, developed in the test 100317. The table 28 shows the nutritional values of low caloric apricot jelly with orange puree, these values were similar to the values of the low caloric apricot jelly with lemon puree, developed in the test 100317.

Table 28. Nutritional characteristics of the low caloric apricot jelly with orange puree.

	Low caloric apricot jelly (Orange puree)
Calories (Kcal/100g)	82
Total fat (g/100g)	0.3
Total carbohydrate (g/100g)	18.8
Total sugars (g/100g)	7.2
Proteins (g/100g)	0.5
Dietary fiber (g/100g)	0.8

Results in fresh weight

Conclusions:

The replicability of the implemented LIFECITRUS process was validated according to the results obtained in this test. Finally, the consumed water was 13 L/Kg (without cleaning water) with a yield of 54%.

The use of the 17.5 % orange puree in low caloric apricot jelly resulted in a soft texture of the jelly, in further tests the addition of thickeners, as calcium, have to be used.

Test tangerine 100417

Description:

1) Raw material selection and Pitted (manual)

2) First washed:

- 2 washed (ratio 1:3, 10 minutes)

Yield: 61%

3) Washed using centrifugal Decanter (extraction)

- 3 extractions (ratio 1:3)

Yield: 55.3%

4) Sized reduction in the high seep cutter (0.1 mm)

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

7) Validation of the tangerine puree in low calorie jelly.

Results and discuss:

The characteristic of the raw material and elaborated tangerine puree are shown in the table 29.

Table 29. Characteristics test 100417

Parameters	**Raw material**	**Tangerine puree**
Physical-Chemical		
pH	3.37	4.06
° Brix	11.2	5.3
Acidity (% citric acid)	0.91	0.19
Texture (Bostwick)	0	0
Colour (L, a, b)	Max: L= 68.68; a= 3.21; b= 60.38 Min: L= 68.81; a= 1.49; b= 57.15 Average: L= 68.28; a= 2.22; b= 59.29	Max: L= 64.06; a= 5.00; b= 45.69 Min: L= 63.78; a= 4.81; b= 45.50 Average: L= 63.95; a= 4.89; b= 45.62
Moisture (g/100g)	84.4	87.9
Raw Fibre (g/100g)	3.6	5.0
Fat (g/100g)	0.3	0.2
Essential oils (mL/100g)	0.27	0.4
Dietary Fibre (g/100g)	6.5	7.2
Instrumental		
Pesticides residue (mg/Kg)	Chlorpyrifos (0.015); Chlorpyrifos-methyl (0.011); Imazalil (1.83); Lambda-CIHALOTRINA (0.011); Pyrimethanil (0.023); Pyriproxyfen (0.016);	Chlorpyrifos (0.051); Chlorpyrifos-methyl (0.027); Etofenprox (0.017); Imazalil (1.67); Pyriproxyfen (0.013); Propiconazole (0.099); Pyraclostrobin (0.026)
Hesperidin (mg/Kg)	9839	6469
Microbiological		
Aerobic counts (cfu/g)	-	< 10
Mold and yeast (cfu/g)	-	< 10
Energy (Kcal/100g)	-	33

Results in fresh weight

The water consumed of this test was 2.8 m^3 for processing 122.6 kg of tangerine by product (water consumed are the sum of process water (1.4 m^3) and cleaning water (1.4 m^3)). Summarized, the water consumed were 22.8 L/Kg by tangerine by-product with a yield of 45.8%.

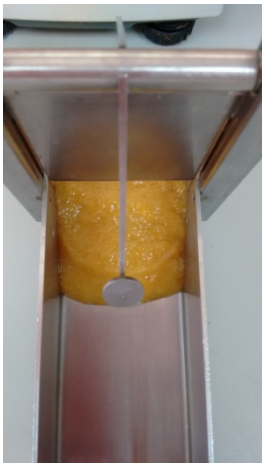
Gas consumed in the blanching step was 43.2 m^3 with an electricity consumed of 24 kWh.

The values of consuming water and electricity were similar with the last tests. The value of consuming water could be reduced with a continuous operation of the process, instead of batches.

The table 29 shows a high value of hesperidin, but the soluble solids were reduced up to 51%, so it can be concluded that the washed and extraction steps were efficient. The pH value remained steady compared with the lemon puree elaborated in the last tests.

As in the last tests, a shelf life study of the tangerine puree storage under refrigeration and freezing conditions were carried out to determinate the use by date for consuming the puree in edible conditions according to food legislation. In the frame of this test the shelf life study was carried out to chilled and frozen tangerine puree during 3 months. The microbiology analysis results concluded that the use by date of the chilled tangerine puree was 3 months and 3 months for frozen lemon puree.

A low caloric apricot jelly with 175 grams of the elaborated tangerine puree added (picture 11) was nutritionally analysed as well as the texture (Bostwick). The texture value (3.5 Bostwick) of the low caloric apricot jelly with tangerine puree was higher than the texture value (4.0 Bostwick) of the low caloric apricot jelly with lemon puree, developed in the test 100317 and the texture value (5.5 Bostwick) of the low caloric apricot jelly with orange puree, developed in the test 240317.



Picture 11. Bostwick analysis of the low caloric apricot jelly with tangerine puree.

The table 30 shows the nutritional values of low caloric apricot jelly with tangerine puree, these values were similar to the values of the low caloric apricot jelly with lemon and orange puree, developed in the test 100317 and test 240317, respectively.

Table 30. Nutritional characteristics of low caloric apricot jelly with tangerine puree

	Low caloric apricot jelly (Clementine puree)
Calories (Kcal/100g)	78
Total fat (g/100g)	0.2
Total carbohydrate (g/100g)	18.2
Total sugars (g/100g)	12.1
Proteins (g/100g)	0.6
Dietary fiber (g/100g)	0.7

Results in fresh weight

Conclusions:

The replicability of the implemented LIFECITRUS process was validated according to the results obtained in this test. Finally, the consumed water was 11.4 L/Kg (without cleaning water) with a yield of 45.8%.

It can be concluded that the use of tangerine puree is a good ingredient for producing low caloric apricot jellies, due to the gelling property of the tangerine puree and the high value of hesperidin, a healthy substance.

Test lemon 060617

Description:

1) Pitted (manual)

2) First washed:

- 2 washed (ratio 1:3, 10 minutes)

Yield: 73.4%

3) Washed using centrifugal Decanter (extraction)

- 3 extractions (ratio 1:3).

Yield: 91%

4) Sized reduction in the high seep cutter (0.1 mm)

5) Blanching (enzymatic inactivation)

6) Packaged in vacuum plastics bags, chilled and frozen storage.

Results and discuss:

The water consumed of this test was 2.1 m^3 for processing 120.8 kg of lemon by product (water consumed are the sum of process water (1.2 m^3) and cleaning water (0.9 m^3)). Summarized, the water consumed were 17.4 L/Kg by lemon by-product with a yield of 67%.

Gas consumed in the blanching step was 31 m^3 with an electricity consumed of 18 kWh. The low consumed water was due to a continuous processed during the extraction step.

The lemon puree elaborated in this test was used in the B3, B4 y B5 actions of LIFECITRUS project. The lemon by-product was selected for developing actions B3, B4 and B5 for its potential gelling and hydrocolloid properties and high fibre value, instead of orange and tangerine by-products.

Conclusions:

The replicability of the implemented LIFECITRUS process was validated according to the results obtained in this test. Finally, the consumed water was 10 L/Kg (without cleaning water) with a yield of 67%. According with the improvement of yield and the reduced of consuming water validated that a continuous process is better than a batches process.

The elaborated lemon puree of this test was liofilizated.

The table 31 shows the replicability of the different batches, described above, of lemon puree elaborated in the frame of the LIFECITRUS project. It can be highlight:

- The slightly different between batches could be due to the slurries of by-products during the transport and storage of the raw material.
- The values of fibre in the different batches were between 51.5-56.0 g/100g.
- The batch 2 shows the lower hesperidin value.

Table 31. Comparison of nutritional characteristics of the elaborated lemon puree in different tests.

Parameters	Batch 1 (Dec15)	Batch 2 (April16)	Batch 3 (Dec16)	Batch 4 (Abril17)
pH	3.45	3.54	3.53	3.41
° Brix	6.9	7.1	5	5
Acidity (% citric acid)	0.8	0.95	1.2	1
Moisture (g/100g)	87.3	87	87.6	83.2
Fats (g/100g)	0.3%	<0.1	0.2	0.2
Essential oils (mL/100g)	-	0.5	0.3	0.2
Dietary fibre (g/100g)	6.8	6.7	6.8	9.4
Hesperidin (mg/Kg)	5340	1235	6434	5610

Results in fresh weight

MAIN CONCLUSIONS

In total, 18 drums of 150 kg and 200 kg (12 lemons, 4 oranges, 2 tangerines) have been shipped from the AMC's plant, corresponding to 3163 kg in total: 356 kg have been used in the Action B1, 2627 kg in the Action B2 and 180 kg have been storage for the Actions B3, B4 and B5.Note that the difference between the amount of by-products shipped from AMC partner and the amount of by-products processed is a consequence of the continuous production of slurries, which is thrown out when taking the citrus scraps for processing. In the frame of this action, the processed of non-citrus by-products were planned, but it was impossible due to the seasonable of fruits. Residues from apples were analysed in November 2016, but, due to the small apple seasonality, it was not possible to carry out tests. The test of apple by-product is scheduled at the end of 2017 and it will be done under the Action B3.

Summarizing, 13 tests (7 tests with lemon, 4 orange tests and 2 tangerine tests) 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 reduced from 40 to 15 L of consumed water per kg of citric by-products.

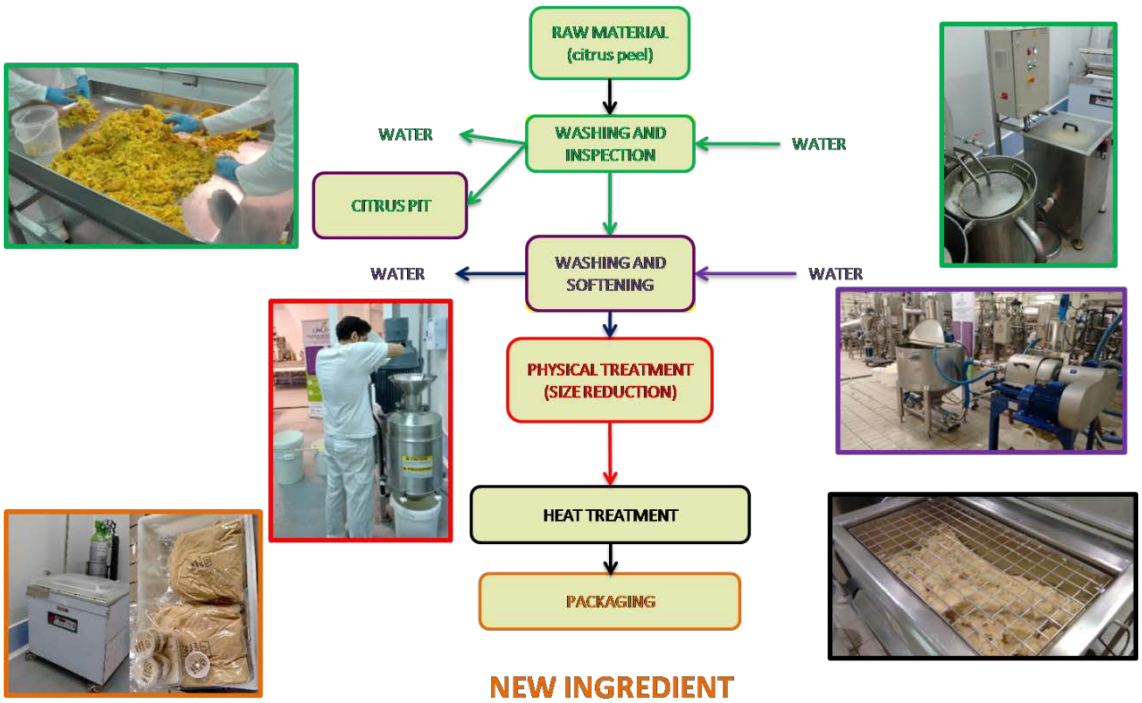
In the first trials the objective of the LIFECITRUS process was to obtain a neutral pH of the elaborated citric purees. The first flowchart reduced the size of the raw material, before the washed and extraction steps, the soluble solids of the citric puree were extracted ant the final pH was around 6. The low values of hesperidin and fibre in the elaborated puree and the huge consumed water in the process concluded that the LIFECITRUS process had to be optimizing with a new flowchart. The raw material sized reduction was done after the washed an extraction step. The new process developed shows a reduction of consuming water and a higher value of hesperidin and fibre in the elaborated puree, the final pH of the elaborated citric puree was similar to the raw material (citric by-product) and the yield of process was increased.

The heat treatment (blanching) step and the packaged in vacuum plastic bags allowed to obtain an edible citric puree with a minimum of 3 months for chilled storage and 6 months for frozen plastic bags. The low pH value (3.0-3.5) of the elaborated citric puree, avoided the pathogens microorganism growing during the shelf life of the elaborated citric purees.

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 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 nutritional characteristics of the 3 citric 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 citric purees elaborated in the frame of LIFECITRUS project are a potential product for use in food as a source of fibre.

The picture 12 shows the development LIFECITRUS process.



Picture 12. LIFECITRUS process flowchart.

Regarding to the food applications of the citric puree, 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 of 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 0.5 mm of the particulates sized of the citric puree was detected by the consumers in all the foods developed, so the sized of particulates was reduced up to 0.1mm.

The main conclusion of B1 and B2 actions 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 disadvantage was the lower value of hesperidin compared with orange and tangerine by-products

Summarizing, it can be concluded that the development LIFECITRUS process for obtaining natural food ingredients from discarded parts of citrus fruits has been optimized and it is environmental sustainable. The new products obtained have been used as a food ingredient for theirs gelling and hydrocolloid properties, high value of fibre and low energy value. The picture 13 shows different food with citric purees developed in the frame of this project period.

Strawberry jam Tea biscuits Vichyssoise

Picture 13. LIFECITRUS food development