



LIFE14 ENV/ES/000326



# **Valorization of citrus industry by products. Natural gelling agent. Application in vegetable based filling for bakery industry**

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Bucharest, 15<sup>th</sup> June 2016



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## SUMMARY

### INTRODUCTION

### PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE

### LIFECITRUS PROJECT

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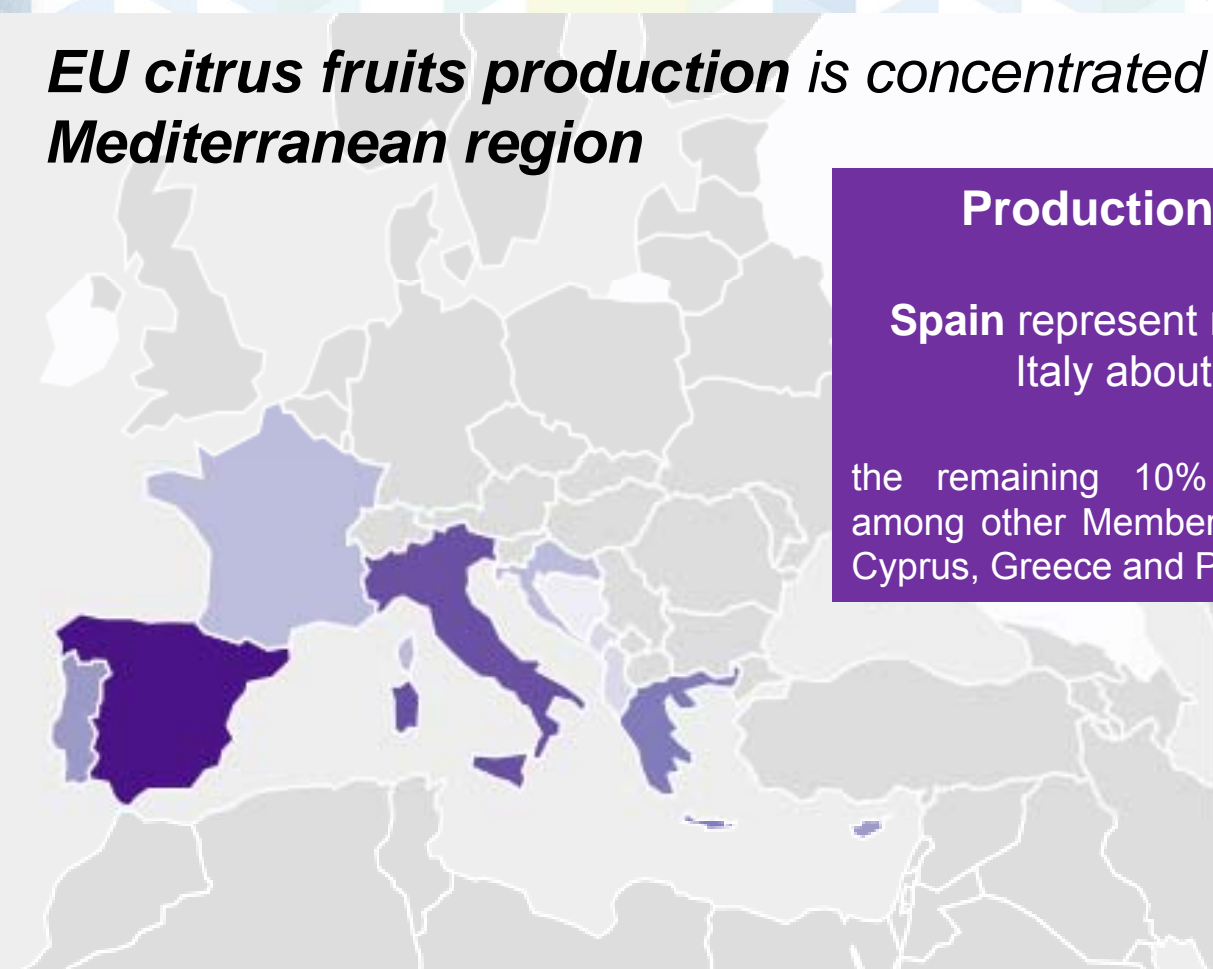




## INTRODUCTION



***EU citrus fruits production is concentrated in the Mediterranean region***



### **Production EU-28**

**Spain** represent nearly **60%**  
Italy about **30%**

the remaining 10% is distributed  
among other Member States, mainly  
Cyprus, Greece and Portugal.



## INTRODUCTION



### LEMON PRODUCTION SPAIN 2014/2015 HARVEST AND 2015/2016 HARVEST PREDICT (TONS)

	Producción C. 2014/15	1ª Estimación 2015/16 Septiembre 2015	2ª Estimación 2015/16 Enero 2016
LIMON FINO	800.000	664.400	550.000
LIMÓN VERNA	300.000	186.000	160.000
TOTAL LIMON	1.100.000	850.400	710.000

**~ 70 % of the  
production**

#### Histórico de Producción de LIMON en España

	Campaña 2007/2008	Campaña 2008/2009	Campaña 2009/2010	Campaña 2010/2011	Campaña 2011/2012	Campaña 2012/2013	Campaña 2013/2014	Campaña 2014/2015	Campaña 2015/2016*
Producción	553.000	946.000	682.000	936.000	977.000	830.000	1.024.000	1.100.000	710.000

TONELADAS

\* Aforo de cosecha de Ailimpo 28 Enero 2016

**Annual turnover around 700 million**







## INTRODUCTION



The largest part of the lemon crop has been harvested and shipped for fresh use.

The **lemon processing industry** was primarily a by-product operation, using that volume of fruit which could not be sold profitably in operations of the fresh market.

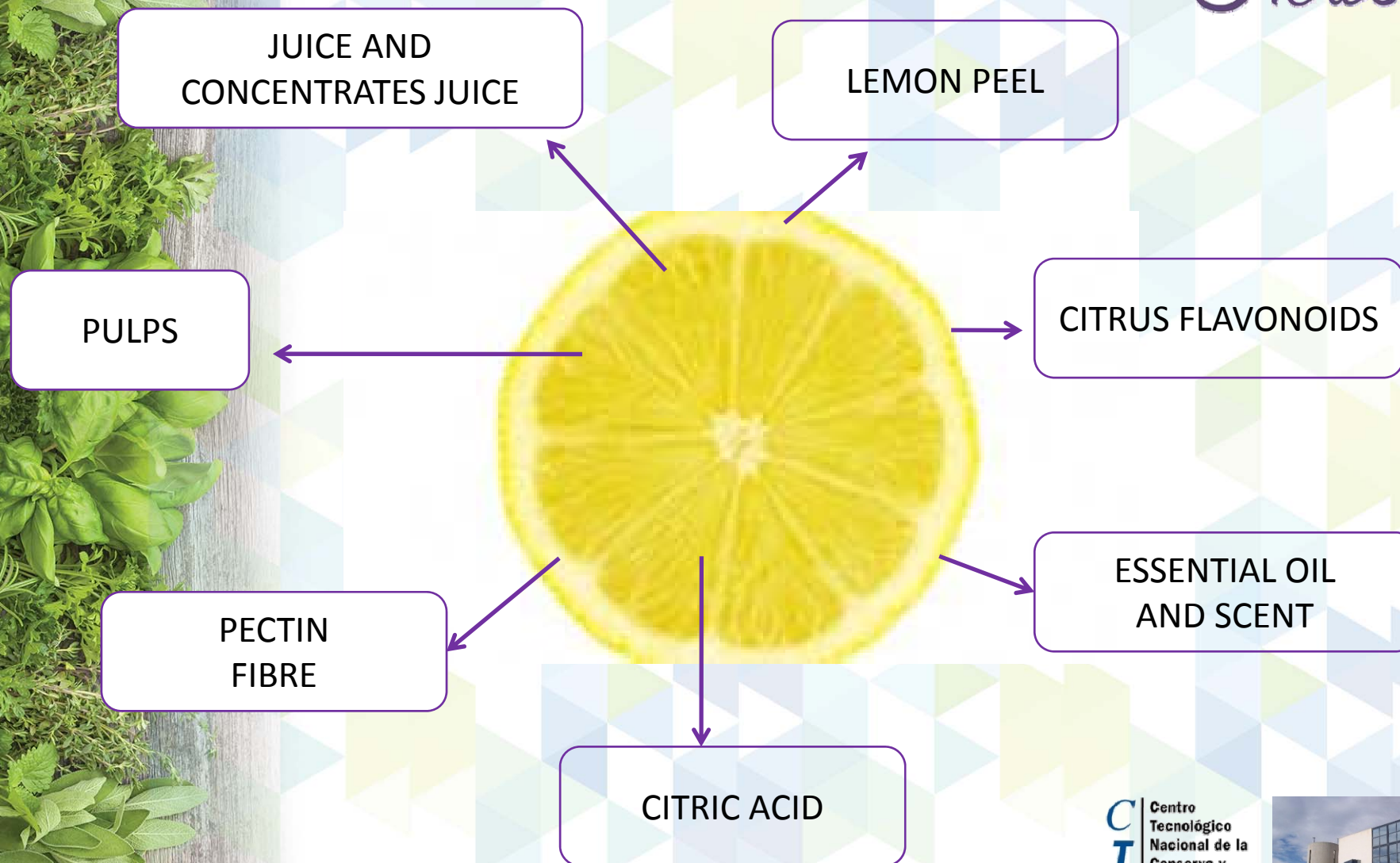
New developments - such as frozen lemonade concentrate and canned single strength lemon juice have changed the relative importance of the market for processed lemon products.



## INTRODUCTION

### Lemon industrial products

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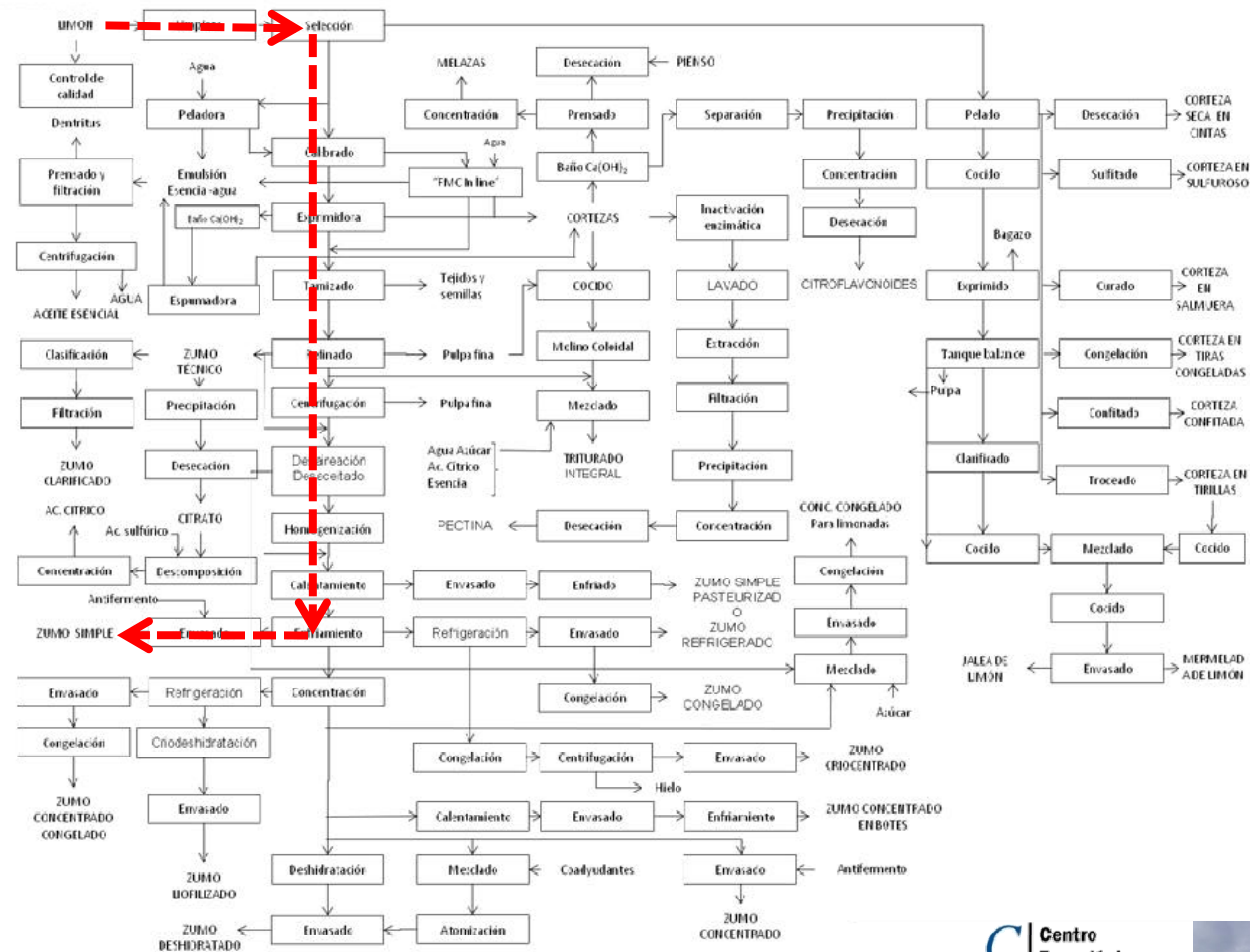




# INTRODUCTION

## Industrial transformation lemon

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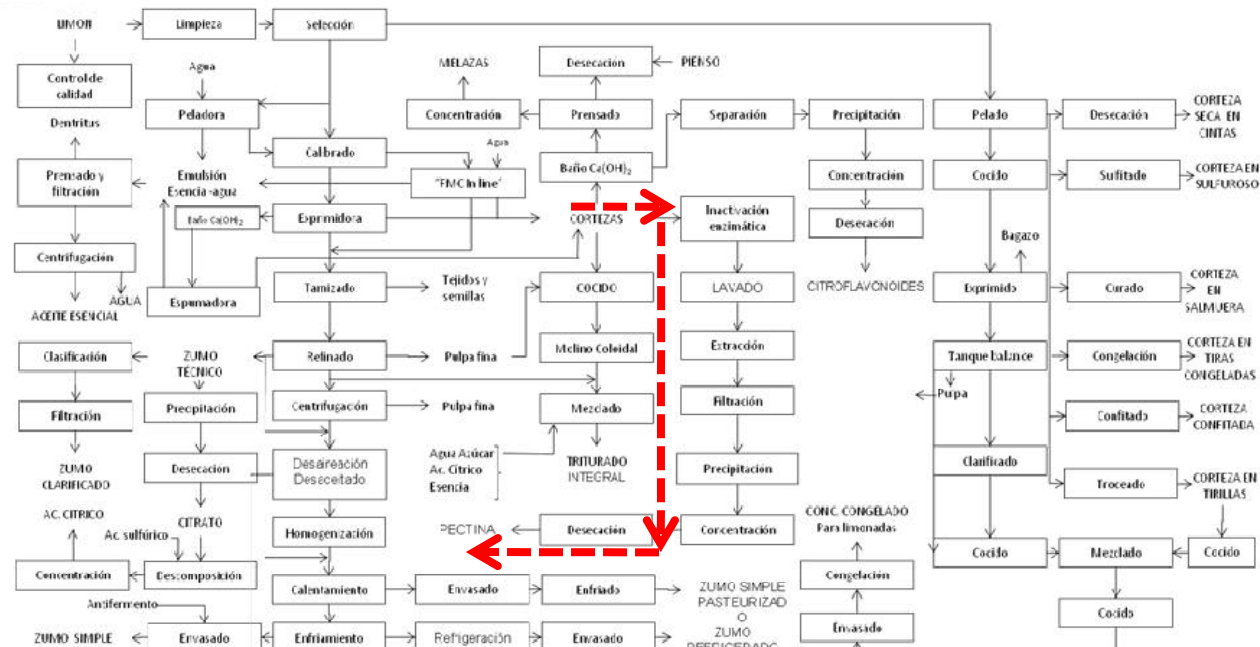


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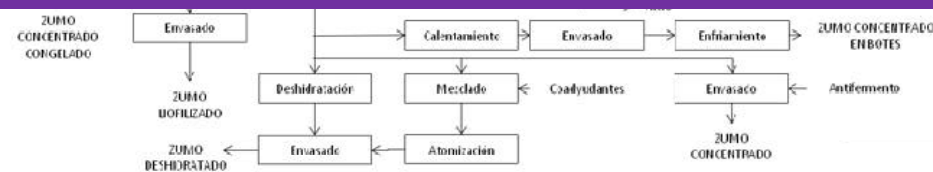


## A close-up, top-down view of a variety of fresh herbs laid out on a rustic wooden surface. The herbs are arranged in a horizontal band across the frame. From left to right, the visible herbs include: sage with its characteristic thick, silvery-green, pointed leaves; flat-leaf parsley with its finely textured, serrated leaves; thyme with its small, opposite, oval-shaped leaves on thin, woody stems; and basil with its large, bright green, slightly wavy-edged leaves. The lighting is bright and even, highlighting the natural colors and textures of the foliage. The wooden background has a visible grain and a warm, slightly weathered appearance.

Good Herbs



Pectin plants are capital and energy intensive operations that require sophisticated operation and control.







## INTRODUCTION



### LEMON INDUSTRY

#### TRANSFORMATION

- JUICE
- CONCENTRATES
- PULP
- ESSENTIAL OIL
- LEMON PEEL **RESIDUE**

#### APPLICATION

- DRINKS
- BAKERY
- ICE CREAM

*The majority of the solid waste product from processing plants is the citrus fruit peel and the membranes from inside the fruit. This material amounts to about 40 to 50% of the entire mass of the incoming fruit.*





## INTRODUCTION



### NOWADAYS

Food industry by-products are disposed in landfills and only partially reused by composting or drying for animal feeding and land fertilizing.

Often small quantities of peel that is still wet can be fed to cattle. Larger quantities of peel will ferment before they are eaten, attract flies and become nuisances.

**Not adequate solution due to huge volume of citrus waste source for plagues and pathologies**



*The management of such wastes represents a critical issue for food industries that process tons of feedstock every year.*



The lemon residues generation in the Region of Murcia fluctuate as follows:

- From 80,000 to 140,000 tons/year

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**+ negative environmental effects**

Slurries which can ferment  
and contaminate soil and  
aquifers



## VALORIZATION

*Moreover, it is vital before engaging in a fruit juice operation to make plans on how to economically dispose of the peel and other solid wastes from the operations.*






## INTRODUCTION



Many by-products can be made from the residue of juice operations

### Citrus speciality products:

- Pectin
- Pectin pomace and dietary fibre
- Dried citrus peel
- Pulp wash
- Juice sacks and whole juice vesicles
- Beverage bases and clouding agents
- Healthful, nutraceutical citrus beverages
- Fractionated citrus oils and D-limonene
- Citrus molasses and beverage alcohol base
- Flavonoids and limonene.



Modern eco-compatible technologies offer more efficient strategies to recycle these wastes in order to use them as a sustainable source for the extraction of value added-chemicals such as different kinds of polysaccharides useful for manifold applications.



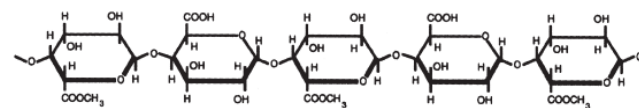


## INTRODUCTION



### Pectin pomace and dietary fibre

**Pectins**, also known as pectic polysaccharides, are rich in galacturonic acid. Several distinct polysaccharides have been identified and characterised within the pectic group. Homogalacturonans are linear chains of  $\alpha$ -(1–4)-linked D-galacturonic acid.



Section of an HM-pectin molecule with degree of esterification ~60%.

### Properties

- Gelling in acid and presence of sugars
- When pectin is heated with sugar a network is formed, which will harden during cooling

### USES

- Gelling and thickening agent





## INTRODUCTION



### **Pectin pomace and dietary fibre**

**Dietary fiber** consists of non-starch polysaccharides such as arabinoxylans, cellulose, and many other plant components such as resistant starch, resistant dextrins, inulin, lignin, chitins, pectins, beta-glucans, and oligosaccharides.



is often categorized according to its solubility into **soluble** or **insoluble**.

**Several sources of citrus dietary fibre have been shown to be useful food ingredients, possessing excellent water and fat binding properties.**







## INTRODUCTION



# OUR PROPOSAL:

*Polysaccharides are presently used in all sectors of human activities and in several application such as: food nutrients, food additives and feed production; material science concerning the formulation of polymeric materials for different biotechnological applications; health care for biocompatible materials, drug delivery or as source of biologically active molecules; sustainable energy production by means of biofuels generation (Persin et al., 2010).*

Persin, Z.; Stana-Kleinschek, K.; Foster, T.J.; van Dam, J.E.G.; Boeriu, C.G. & Navard, P. (2010). Challenges and opportunities in polysaccharides research and technology: The EPNOE views for the next decade in the areas of materials, food and health care, Carbohydrate Polymers, Vol.84, No.1, (February 2011), pp. 22-32, ISSN 0144-8617



## INTRODUCTION



# OUR PROPOSAL:

CITRUS WASTE



HIGH-VALUE INGREDIENT

INNOVATIVE PROCESS AT LABORATORY SCALE

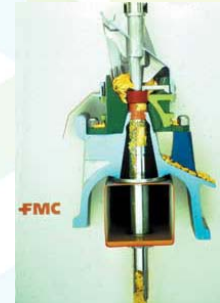
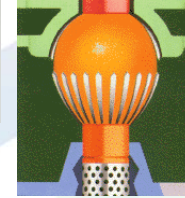
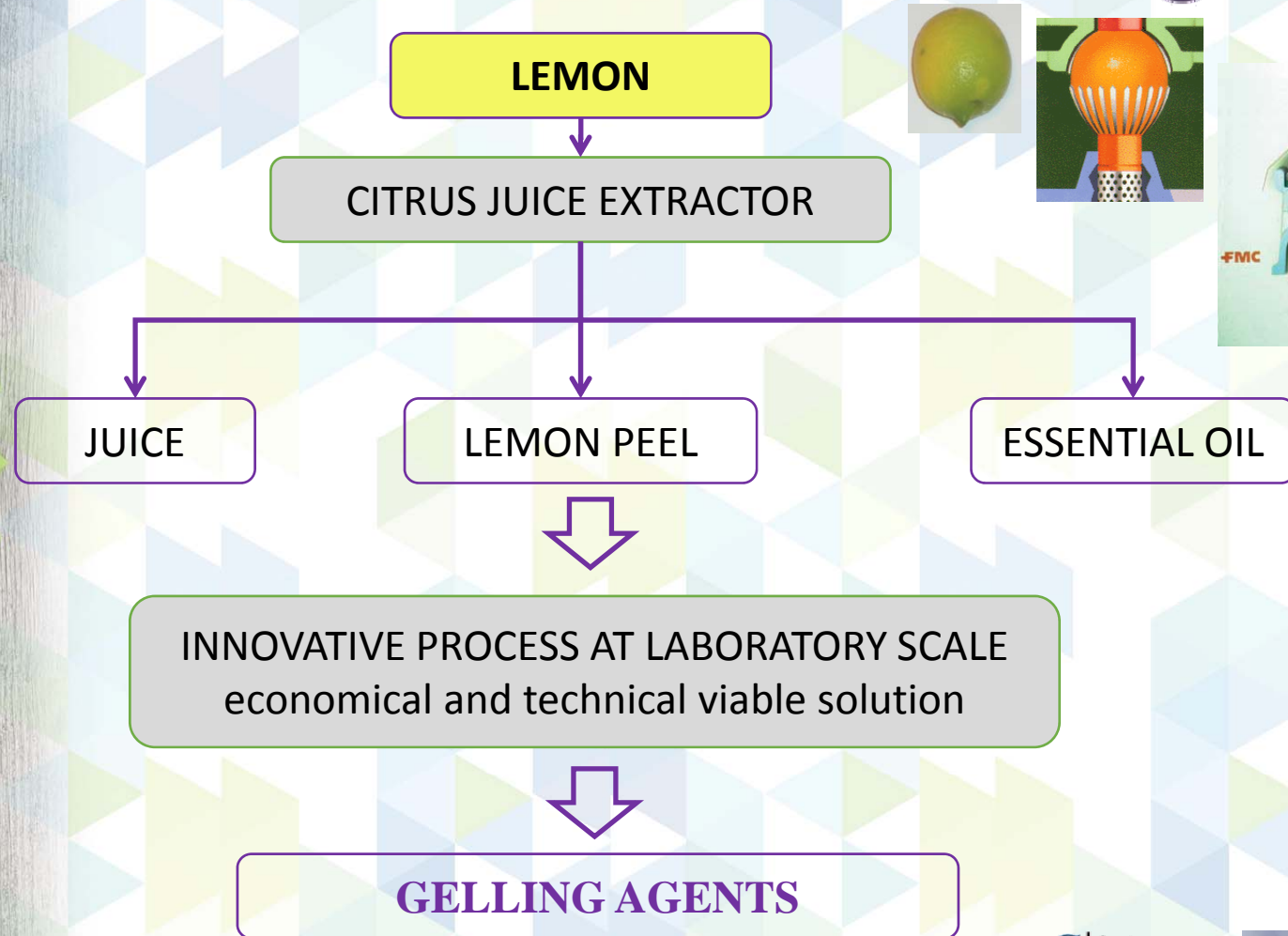


LIFECITRUS PROJECT. SEMI-INDUSTRIAL  
SCALE PLANT





## PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE



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## PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE



### **BY PRODUCT LEMON (LEMON PEEL) Raw materials**

Determination	Value
Pathogenic	No detection
Pesticides (mg/Kg)	No detection in organic lemons Detection in conventional: Chlorpyrifos, Chlorpyrifos-methyl, Imazalil (0.26), Pyrimethanil, Prochloraz (0.37), Piriproxyfen
pH	3.47-3.66
Moisture (g/100g)	84.50-88.24
Hesperidin (mg/Kg)	1,287-3,150
Dietary Fiber (g/100g)	6.6-7.0
Pectin (g/100g)	7.0-15.0
Soluble solids (°Brix)	4.0-4.2
% Acid (citric acid)	0.47-0.51

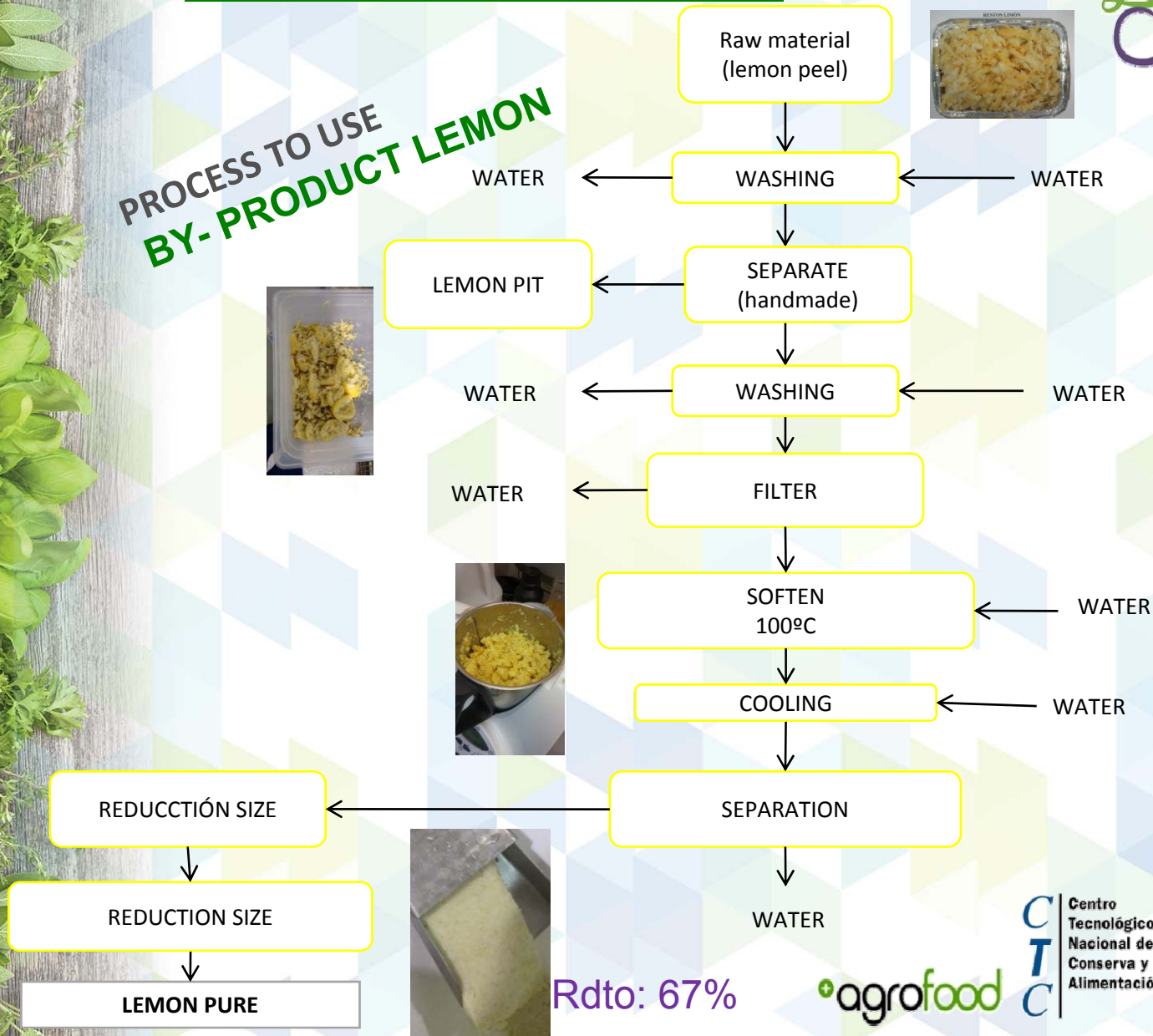




## PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE

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**PROCESS TO USE  
BY-PRODUCT LEMON**



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## PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE



### CHARACTERISTICS OF LEMON PURE

Determination	Value
% Acid (citric acid)	0.017-0.035
pH	4.46-4.65

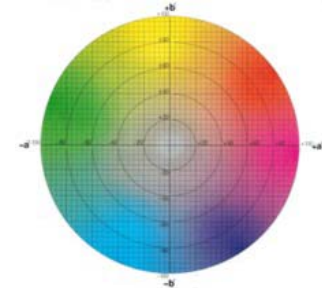
- Whitish pure

Colour viewer (Lab color space- MINOLTA CR-200)

Max: L= 62.20; a= -3.12; b= 17.01

Min: L= 61.96; a= -3.28; b= 16.45

Med: L= 62.12; a= -3.22; b= 16.18



- No bitterness product

- Consistency Measure (Bostwick 60 s): 0

- Granular texture





## PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE



### RESULTS OF INTERESTING COMPOUND IN LEMON PURE

Determination	Value
Hesperidin (mg/Kg)	978-2,849
Pectin (g/100g D-Uronic acid)	1.80-2.34
Dietary Fiber (g/100g)	4.0-6.0

**HESPERIDIN** is a citrus flavonoid with a antioxidant activity. The benefits of are: protección of stomach against ulcers, reduce the probabiliy sufer cardiovascular disease, anticoagulant and antiallergic activity.





# PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE

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## APPLICATIONS

Peach jam (63 °Brix and sugarfree)



Strawberry jam (50 °Brix)



Others: Quince jelly





## PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE



### APPLICATIONS

#### Formulation of peach jam

	63 °Brix (A)	63 °Brix (B)	SUGARFREE
Percentage of fruit (%)	50	50	60
°Brix	63	63	12-14
INGREDIENTS (g)			
Peach pulp	500.00	500.00	600.00
Sugar	557.27	560.91	SUC. 0.40 ASP 1.00
Lemon pure	178.60	150.00	300.00
Concentrate of lemon (400g/L)	30.00	22.00	10.00
WATER			200
-EVAPORATION	-265.87	-232,91	-191.9
FINAL WEIGHT	1,000	1,000	1,000
CALCIUM LACTATE			23.00
SORBITOL			57.50



## PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE

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### APPLICATIONS

#### Physicochemical characterization of peach jam

	63 °Brix (A)	63 °Brix (B)	SUGARFREE
S.S. (°BRIX)	64	64	14
pH	2.89	3.12	4.01
Acid (%Ac. Citric)	1.86	0.85	0.78
Bostwick (60s)	0.3	1.5	2.0
Sineresis (cm)	0	0	0.1
Texture (g)	116.88	85.54	34.58
COLOUR			
L	59.36	61.38	50.82
a	1.75	1.42	-0.27
b	5.17	10.36	9.36





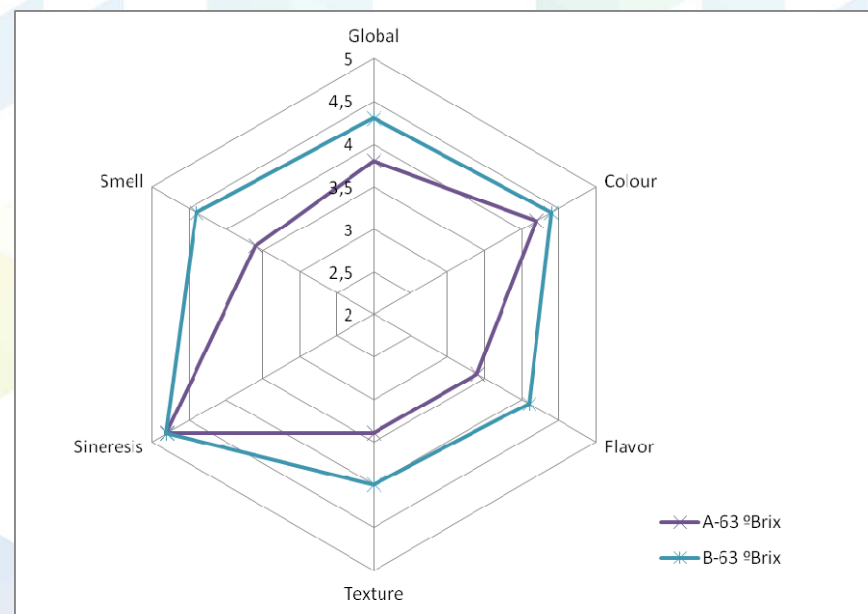
# PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE

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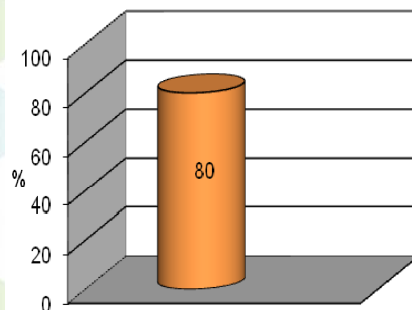
**APPLICATIONS** Peach jam 63 °Brix

**Sensorial Analysis**

Global valoration >3



**Acceptability**



# PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE

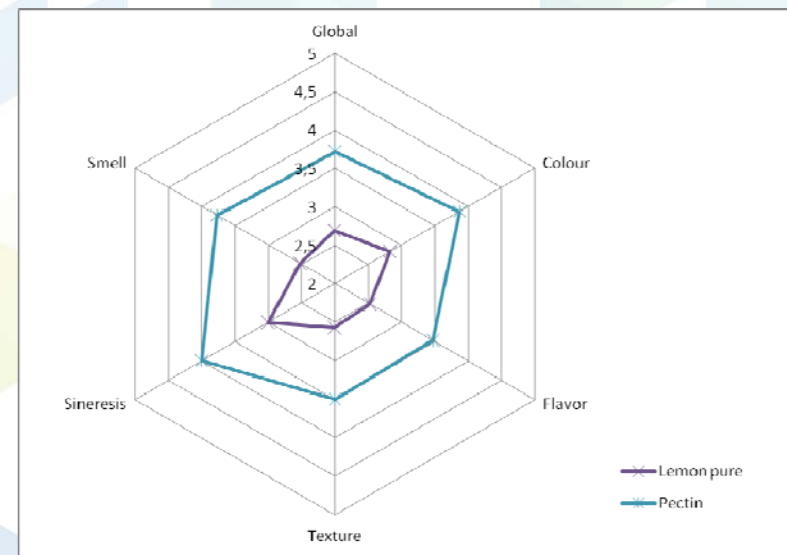
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**APPLICATIONS** Peach sugarfree jam

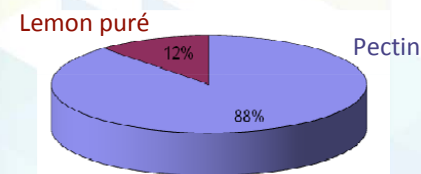
## Sensory Analysis



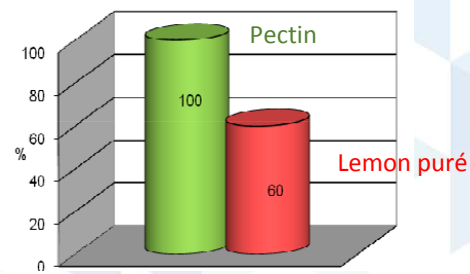
Global valoration < 3



## Preference



## Acceptability



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## PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE

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### APPLICATIONS

#### Formulation of strawberry jam

	50 °Brix
Percentage of fruit (%)	50
°Brix	50
INGREDIENTS (g)	
Strawberries	500.00
Sugar	459.42
Lemon pure	168.0
Concentrate of lemon (400g/L)	10.00
WATER	
-EVAPORATION	-137.42
FINAL WEIGHT	1,000



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## PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE

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### APPLICATIONS

#### Nutritional of strawberry jam

	50 °Brix
S.S. (°BRIX)	48.8
pH	3.36
Total ash (g/100g)	0.3
Total fat (g/100g)	<0.1
Total Carbohydrate (g/100g)	52.1
Moisture (g/100g)	47.3
Protein	0.3
Calories (kcal/100g)	210
Dietary fiber (g/100g)	1.5



vs. Commercial





# PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE

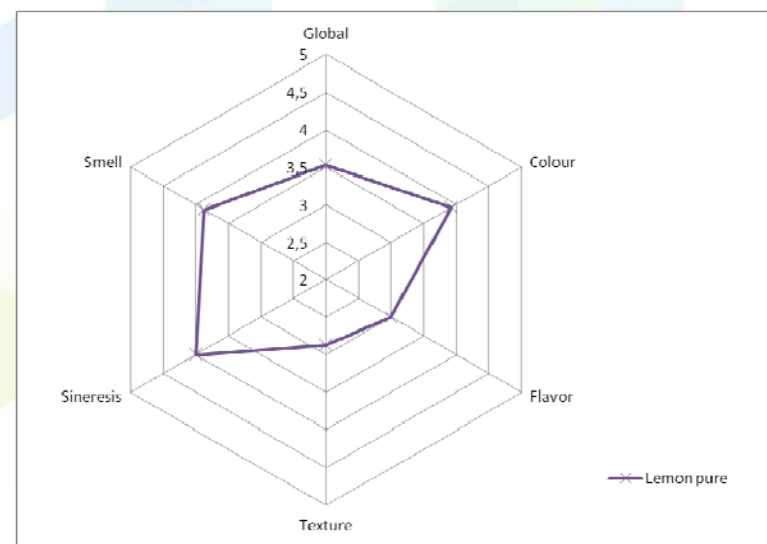
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**APPLICATIONS** Strawberry jam 50 °Brix

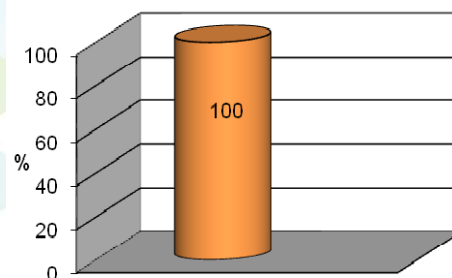
**Sensory**



Global valuation >3



**Acceptability**



# PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE



## ECONOMIC STUDY

INDUSTRIAL PRODUCTION OF LEMON PURE  
6 TONS/H (X 20 H/DAY) = 120 TONS/DAY)

### Production costs:

600 packagings (metal container+ aseptic bag) of 200 kg	7,020 €
Simple aseptic bag	2.70 €
Metal container	9.00 € (12€ new – 3€ residual)
<b>Total packaging cost</b>	<b>11.70 €</b>
Staff: 30 people	4,500 €
Energy and other	3,600 €
Amortization (investment 1,590,000 € -180 days/year → 5 years)	1,965 €
<b>TOTAL COSTS 17,085 €/day</b>	

0.142 €/kg

Zero cost for the raw materials

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## PROCESS TO GET NATURAL GELLING AGENTS. LABORATORY SCALE



### **ECONOMIC STUDY**

VALORIZATION → Cost saving

Lemon pure cost  
0.142 €/Kg

Necessary for 1 kilograme jam  
150 g

Pectin cost  
10.5 €/Kg

Necessary for 1 kilograme jam  
3 g

Cost saving

0.0102 €/kg jam





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



## ACTIONS

01

2015 - 2016

Design and implementation of the process of obtaining natural ingredients from the byproducts of citrus industry in CTC pilot plant

02

2016 - 2017

Performing a test programme and conducting a detailed study about innovative process effectiveness, to characterize process parameters

03

2016 - 2017

Feasibility study, Detailed cost-benefit analysis of the proposed process, with previous market study

04

2015 - 2016

Creation and update of a new website, to support the project communication and dissemination actions

05

2016 - 2018

Demonstration and disclosure regional programme and national/European programme, focused on targeted sectors. Demonstration sessions in the pilot plant

06

2017 - 2018

Teaching training courses in CTC, focused on both technicians and operators of the targeted sectors

[www.lifecitrus.eu](http://www.lifecitrus.eu)



Bucharest, 15<sup>th</sup> June 2016





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

### **PROJECT LOCATION:**

Murcia (Spain)

### **DURATION:**

Start: SEPTEMBER 2015 - End: AUGUST 2018



### **PROJECT'S IMPLEMENTORS:**

Coordinating Beneficiary: CTC

Associated Beneficiaries: AGROFOOD and AMC

Project funded by the European Union through the LIFE Programme  
(LIFE Environment & Resource Efficiency)

Total budget approved by the Commission: 886,397 €

EU Contribution: 531,836 €



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

### The project aims:

To demonstrate on a **semi-industrial scale** an innovative industrial process for obtaining natural food ingredients from discarded parts of citrus fruits. It will install a mechanical processing line at a site in Murcia. This will convert tonnes of citrus residue into a natural gelling ingredient for use in the food industry.

To transfer project know-how to industry operators, in order to enable European citrus operators to apply the proposed process and technology at industrial scale.

To promote the use of healthy “clean label” ingredients in agro-food industry.



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**NEW  
INGREDIENT**

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## Characterization of lemon pure

Parameter	Value
<b>Physiochemical laboratory</b>	
pH	4.41
° Brix	0.8
Acid (% citric acid)	0.024
Texture (Bostwick-cm)	0
Colour	Max: L= 60.52; a= -1.19; b= 17.54 Min: L= 60.30; a= -1.24; b= 16.71 Mean: L= 60.40; a= -1.21; b= 17.17
Moisture (g/100g)	90.2
Total fiber(g/100g)	3.6
Total fat (g/100g)	<0.1
Essential oil (mL/100g)	<0.1
Dietary fiber (g/100g)	9.0
<b>Instrumental laboratory</b>	
Pesticides (mg/Kg)	IMAZALIL (0.92); PYRIMETHANIL (0.064); PROCHLORAZ (0.051); THIABENDAZOL (0.036)
Hesperidin (mg/Kg)	215
<b>Microbiology laboratory</b>	
Aerobic (CFUs/g)	210
Molds and yeasts (CFUs/g)	<10

**High fiber product**  
→  
> 6 g/100g  
REGULATION (CE) No 1924/2006

**Without essential oil**  
**Without microbial contamination**





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## APPLICATIONS

### Sponge Cake I

#### Recipe

Sugar: 125 g

Milk: 250 mL

Flour: 250 g

Sunflower oil: 125 mL

1 tablespoon yeast

**Lemon pure: 160 g**



## NUTRITIONAL ANALYSIS

Parameter	Value
Saturated fatty acids (g/100g)	2.32
Total sugars (g/100g)	15.62
Dietary fiber (g/100g)	1.9
Total ash (g/100g)	1.3
Total fat (g/100g)	16.2
Total Carbohydrate (g/100g)	40.3
Proteins (g/100g)	4.5
Moisture (g/100g)	35.8
Calories (kcal/100g)	329

> Commercial

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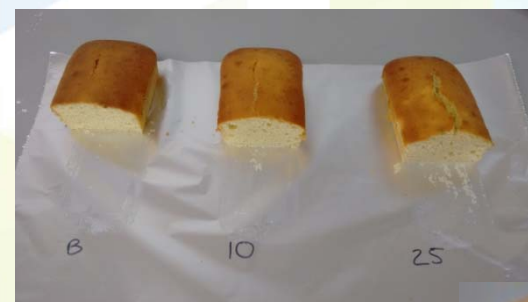
## APPLICATIONS

### Sponge Cake II

#### Recipe

Sugar: 125 g  
Milk: 125 mL  
Flour: 300 g  
Sunflower oil: 125 mL  
2 tablespoon yeast  
4 eggs

4 parts →  
Lemon pure: Control/10g/25g/50g



## NUTRITIONAL ANALYSIS

Parameter	Value		
	Control	10 g lemon pure	25g lemon pure
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



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## APPLICATIONS Jams

FORMULATION  
STRAWBERRY  
JAM

63 °Brix	
Percentage of fruit (%)	50
°Brix	63
INGREDIENTS (g)	
Strawberries	500,00
Sugar	584,92
Lemon pure	168,00
Concentrate of lemon (400g/L)	10,00
WATER	
-EVAPORATION	-262,92
FINAL WEIGHT	1000,00



Sensorial analysis → ACCEPT (>3)

## NUTRITIONAL ANALYSIS

Parameter	Value
Saturated fatty acids (g/100g)	<0.1
Total sugars (g/100g)	58.88
Dietary fiber (g/100g)	1.5
Total ash (g/100g)	0.3
Total fat (g/100g)	0.1
Total Carbohydrate (g/100g)	61.2
Proteins (g/100g)	0.3
Moisture (g/100g)	36.6
Calories (kcal/100g)	250

> Commercial  
(1.2 g/100g)

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LIFECITRUS PROJECT

[www.lifecitrus.eu](http://www.lifecitrus.eu)



LIFE14 ENV/ES/000326

*Good Herbs*

## OTHER APPLICATIONS – SWEET FILLING



## OTHER APPLICATIONS – SAVOURY FILLING

to bind ingredients



agrofood

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Good  
Herbs

# THANKS A LOT!!

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Erasmus+