

# Obtaining biomass, essential oils and animal feed from citric pruning waste

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## ABSTRACT

- Purpose

The present work has as aim to present the full recovery system of prune citrus' waste started up at La Vall d'Uixó (Castellon-Spain) by the environmental demo project, LIFE Ecocitric.

- Methods

To accomplish this valorization of waste, the first step is to shred the residue. Then, the first treatment stage separates leaves and branches by means of an innovative sorting system. Essential oils and animal feed will be obtained from the leaves, which undergo two treatment stages. The wood fraction undergoes a bio-drying process.

- Results

Reduction of the environmental impact produced by the incineration in crop field of the agricultural waste. Obtaining new products as: biomass, essential oils, animal feed.

- Conclusions

The integral waste management proposed by the LIFE Ecocitric project it is a viable process, an example of circular economy towards which Europe must walk, being able to turn leaves and limbs coming from the citrus prune into high added value products.

## INTRODUCTION

Spain is the largest producer of citrus fruit of the European Union and the 5<sup>th</sup> in the world with an annual production over 5 million tons during last decade. The Region of Valencia is the main citrus region at the national level, so much for the surface dedicated to this crop (approximately 182.000 hectares, close to the 60% of the national total), so much for the production (more than 3 million tons, nearly the 60% of national production) [1].

At La Vall d'Uixó, municipality of Castellón, the crops surface dedicated to citrus is 1.855 hectares, with a yearly production of about 10.700 tons of waste which management was very difficult and expensive for farmers [2].

**Figure1. Total amount of prune's waste by variety generated at La Vall d'Uixó**

Variety	Tn	Variety	Tn
Arrufatina	362,78	Nadorcoot	51,90
Capola	1,07	Navelate	122,63
Clemenules	6.548,40	Orogrande	184,60
Clemenrubi	130,07	Orogros	1,07
Clemensoon	21,22	Oronules	1.169,53
Esbal	116,61	Oroval	157,75
Fortune	24,38	Ortanique	410,61
Hernandina	529,05	Safor	1,07

Lane-late	546,99	Terreno	43,72
Marisol	154,14	Tomatera	110,41
<b>TOTAL</b>	<b>10.688,01 Tn</b>		

Thus, for the most part of cases agricultural waste coming from citrus prune are burnt in crops fields without any type of leverage, producing a lot of air and land-based pollution, apart from multiply the risk of forest fire.

With this work, it is proposed a waste recovery methodology for their full use as biomass made into pellets, animal food and essential oils, based on the technique and conclusions of the LIFE Ecocitric ongoing environmental demo Project of La Vall d'Uixó (Castellón).

To implement this valorization of waste, the first step is grinding the residue. It is recommended to do it on the field, like this the waste volume decreases and significantly reduces the cost of transport. After being crushed, with a particle size up to 20 mm, and introduced into bigbags, waste is carried to the pilot plant.

Then, at the pilot plant the first treatment stage separates leaves and branches by means of an innovative sorting system. Subsequently, the leaves and branches undergo different transformation processes. The separation system has been designed by means of computational fluid dynamics (CFD).

## **BIOMASS**

The biomass presents a great opportunity for the agricultural sector in the XXI century, offering to recover all its productive potential, without surplus production's problems, with a sustainable approach based in the economic viability and the respect for the environment.

Hereafter it is addressed the production and use of agricultural waste from citrus prune as biomass. The objective is to disseminate the possibilities of this energetic source of huge perspectives for the agricultural sector, but quite complex regarding to the combination of possible sources, process and applications.

Citrus pruning is composed by woody waste with seasonal nature which using means a series of cleaning operations, splintering and transportation that will subsequently transform them into suitable fuel to its employment in electricity production or for the thermal use in boilers.

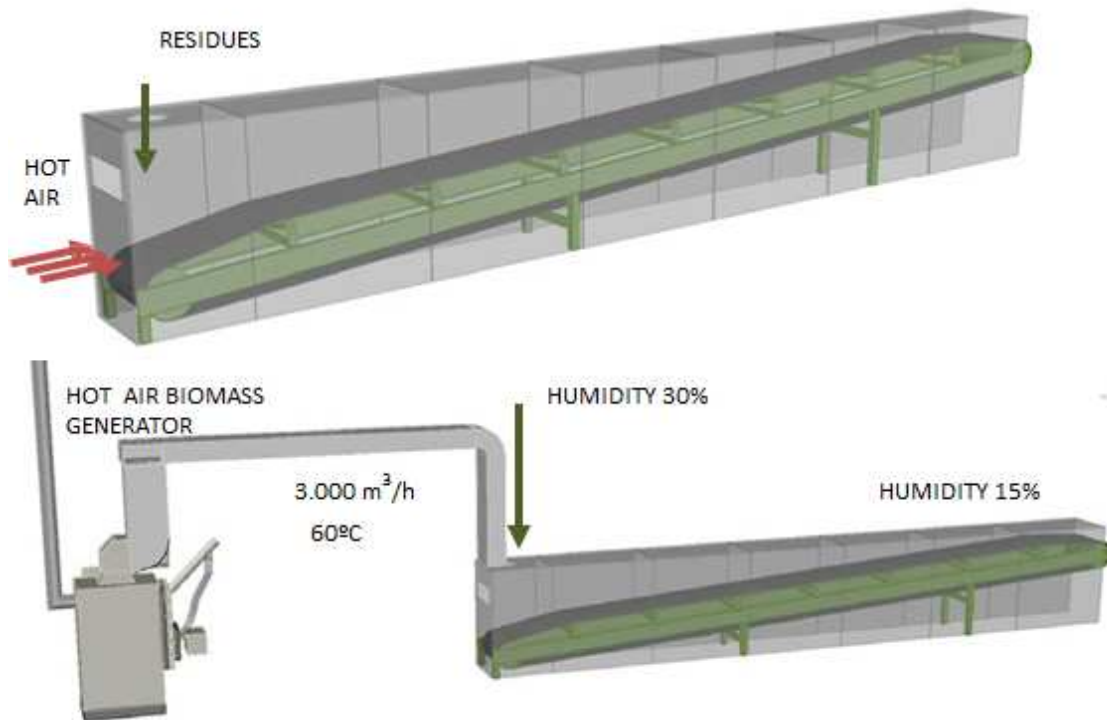
To get a high quality biomass, it is firstly needed to reduce the content of waste's water by drying it, or by bio drying or by thermal drying:

- Bio drying: consists of reducing the humidity and stabilizing biodegradable matter to obtain a product to use as fuel. Therefore, it is used the heat of aerobic fermentation of the biodegradable matter.
- Thermal drying: consists of introducing airflows generated by a generator of biomass, which allows reducing the humidity level of the waste.

The wood fraction in the pilot plant undergoes a bio-drying process by means of microbial action and will be used as biofuel or livestock bedding in the form of wood chips or pellets. To obtain this product, first of all, is done a bio-drying in greenhouse until humidity reaches 25% and subsequently a thermal drying using a biomass furnace. Then, the dry residue (with only 10% of humidity) is crushed and pelletized.

The combination between bio drying and thermal drying it was contemplated as an interesting choice to assess waste of citrus prune. The bio drying might be favoured by its implementation in a greenhouse, wherewith solar light together with the aerobic fermentation causes a fast drop of the humidity during the first days. Then, the thermal drying to reach suitable values is made using the pellet as fuel, consequently the energetic balance of the process is very favourable.

**Figure 2. Bio-drying system**



In this way, in the demonstration plant was achieved the production of a biomass fuel draw from low cost raw material that can be sold as biomass made into pellet or be burnt to generate electric or thermic energy.

The final energy balance is very positive because to dry 1kg of biomass are only required 0,048 kg of pellet. All of that indicates a performance efficiency of 94%. The pellets resulting from the process are accepted as fuel according to DIN 51731, 2012 standards [3].

## ESSENTIAL OILS AND ANIMAL FEED

Essential oils and animal feed will be obtained from the leaves, which undergo two treatment stages. The first is a distillation and digestion process. In this process, citric essences are obtained by means of steam distillation and the remaining proteins and fats undergo dewatering, refining and pelleting to convert them into meal in granulated form that can be used as animal feed with a high protein value.

To do this, the plant has a distillation and condensation system, specifically designed, made up of two stainless steel vats of 29 and 200 liter capacity with lower vapor distributor and gooseneck, and also a steam condensate and oil decantation system. The energy used for steam generation is obtained from a biomass furnace with a steam output of 50kg/h.


The foliar fraction resulting from the separation as well as from distillation undergoes a drying process to reduce the humidity of materials to values about 15% and ensure the proper conservation. Then, the refined and pelleting process allows obtaining a high-quality, stability and durability product to animal feed with easy transportation and storage. The refining of the material is made by a 5,5 kw hammer mill and a 7.5 kW pelletizer machine with which it reached a production of 100 kg/h. The animal feed resulting from the process is free from undesirable substances and of any foreign matter.

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**Figure 3. Nutritional Values of Animal Feed**

Crude Protein	14%
Crude Fat	2,5%
Crude Fibre	17%
ADF	17%
Ashes	12,5%
Humidity	8%
Starch	<2%
Total Sugars	<2%

**Figure 4. Organoleptic Attributes**

Appearance	Absence of foreign matter	
Colour	Greenish	
Smell	Peculiar	
Shape	Citrus meal compacted into a cylinder	

Regarding to essential oils obtained, it should be noted that it is rare to obtain essential oils from leaves of citrus, being their characteristics for special interest.

The essences gotten from the leaves, contrary to the ones obtained for example from the shell or from the flowers, have a transparent colour and they contain aromatic substances called terpene esters which behave as anti-inflammatory, analgesics and antispasmodics.

It is very common that they take part of the formulation of preparations used to treat a wide variety of pain such as migraines. By the same token, they can be used as painkillers and relaxants, with an action power superior to the coumarin. In addition to the therapeutic use, the essences obtained can also be used in the food industry as natural flavourings.

## CONCLUSION

The LIFE Ecocitric project sets out the integral management of citrus waste of which Spain is plenty of and, especially in the Mediterranean area. By means of the demonstration carried out by the LIFE Ecocitric project it is achieved the valorisation of waste currently eliminated by methods which imply high rates of pollution.

The project gets thus to reduce the environmental impact of the current management of agricultural waste and to obtain products such as biomass, essential oils and animal feed.

## ACKNOWLEDGMENTS

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## REFERENCE LIST

1. GV, Generalitat Valenciana (2015) *Estadísticas del sector agroalimentario. Informe*.  
Obtenido desde el <http://www.agricultura.gva.es/la-conselleria/estadisticas/datos-basicos-del-sectoragroalimentario/>
2. IVACE, Instituto Valenciano de Competitividad Empresarial (2015) *Informe sobre cítricos en la Comunidad Valenciana 2015*. Generalitat Valenciana
3. DIN 51731 (2012) Norma DIN 51731 (Germany)