Valorisation of agricultural residues from Andean fruits: case studies

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GAF Grupo de Alimentos Frutales

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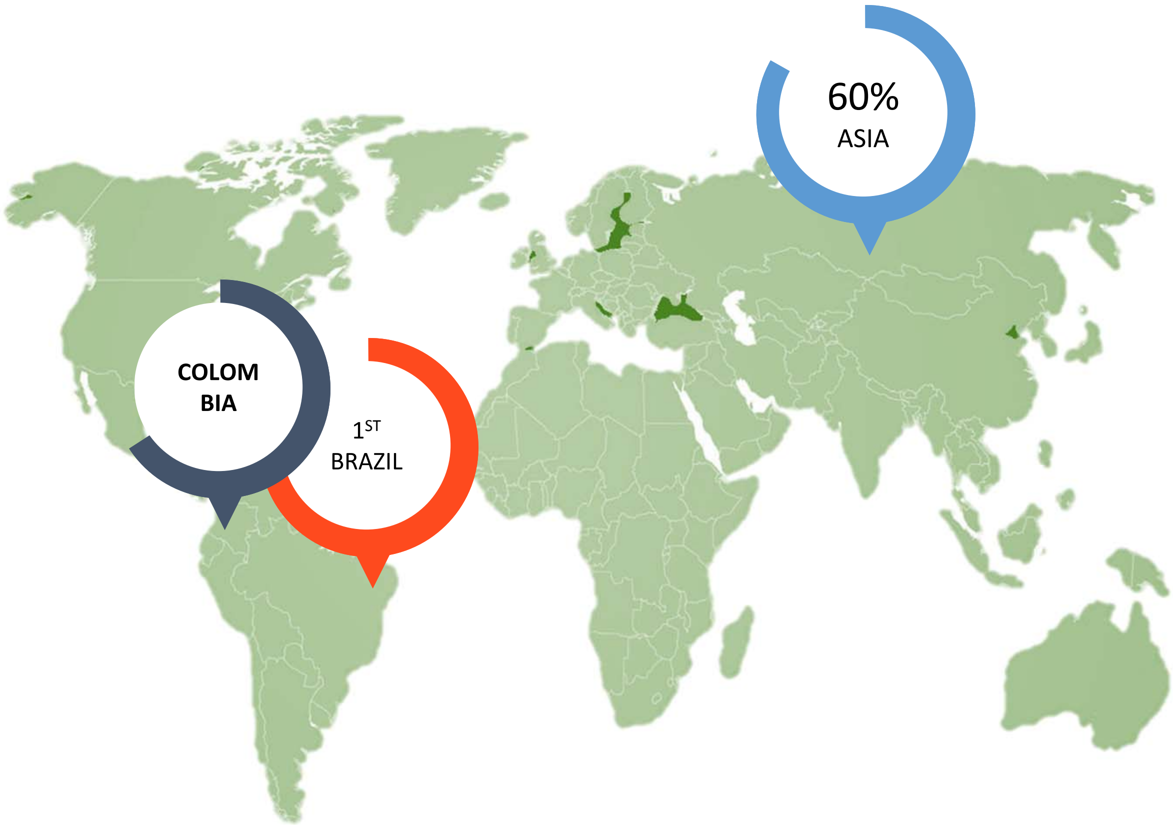
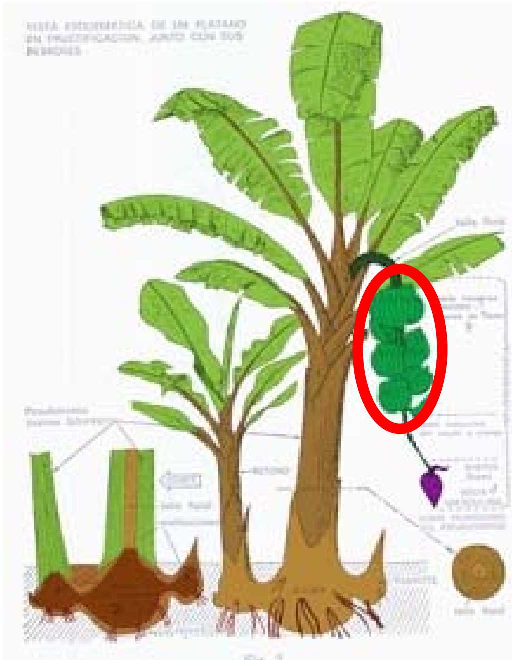
INTRODUCTION

Fruit consumption worldwide grew at **3%** annually in the last decade



AGRICULTURAL FRUIT WASTE

Fruit	Production (Metric tons)		Agricultural residues estimation (Metric tons)	
	World (2016) (1)	Colombia (2017) (2)	World	Colombia
Passion fruit	24.184.510*	119.338	3.200.000 to 3.600.000*	14.000 to 17.000
Guava		70.054		8.000 to 10.000
Tamarillo		186.032		26.000 to 31.000
Blackberry		140.504		18.000 to 23.000
Banana	113.280.302	2.040.497	550.000.000 to 600.000.000	9.000.000 to 11.000.000



*Tropical fruits
(1) FAOSTAT. http://www.fao.org/faostat/en/#data/QC
(2) Agronet. http://www.agronet.gov.co/Paginas/default.aspx

AGRO-INDUSTRIAL FRUIT WASTE

Fruit	Flesh (%)	Peel (%)	Seed (%)
Passion fruit	44-56	45-55	1-8
Guava	60-65	16-18	8-12
Tamarillo	53-58	14-16	20-24
Blackberry	88-96	3-6*	4-12
Banana	63-70	30-37	-

*Calix, peduncle





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SURVEILLANCE ON FRUIT WASTE VALORIZATION

FERTILIZER

BIO ENERGY

PECTIN

FLAVORS

BIO COMPOSITES

FEED

SORBENTS

BIOACTIVES

ORGANIC ACIDS

BIO CATALYSTS

COMPOSTING

SUBSTRATES

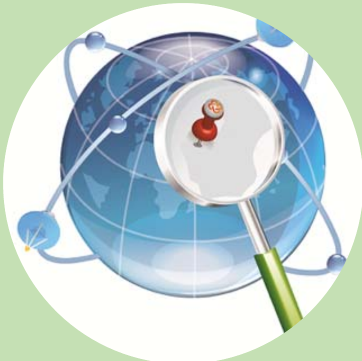
COLORANTS

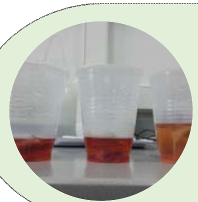
CHEMICALS

FOOD

SURVEILLANCE ON FRUIT WASTE VALORIZATION

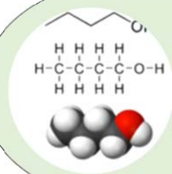
Technological Surveillance





- ✓ Case study 1: Tisanes from peels/seeds of tomato tree and guava fruits

- ✓ Case study 2: Lipase immobilization on foamed epoxy resin support filled with activated stalks



- ✓ Case study 3: Approaches to biorefineries from fruit waste

CASE STUDY 1: TISANES FROM PEELS AND SEEDS OF TOMATO TREE AND GUAVA FRUITS

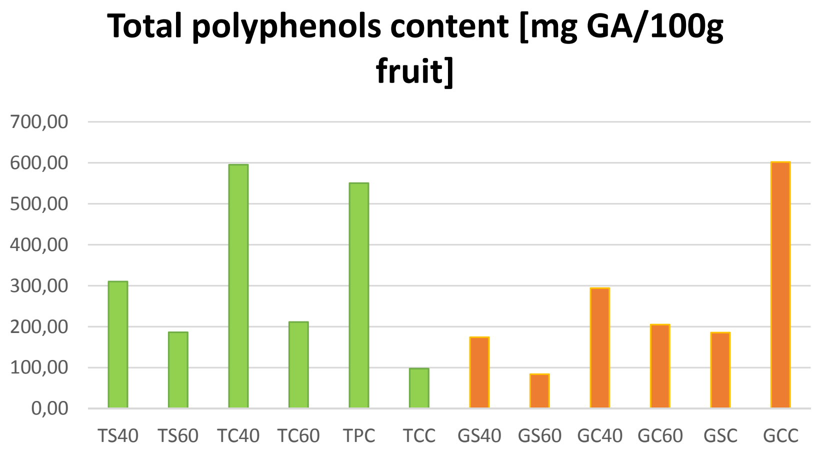
- Tisane preparation
- Chemical characterization of residues
- Determination of antioxidant activity
- Sensory evaluation

Peels and seeds → Washing → Drying (30ºC 12-15 h) → Milling and sieving (40 – 60 mesh) → Mixing (25 – 50 – 75%) → Infusion (1g / 250 ml)

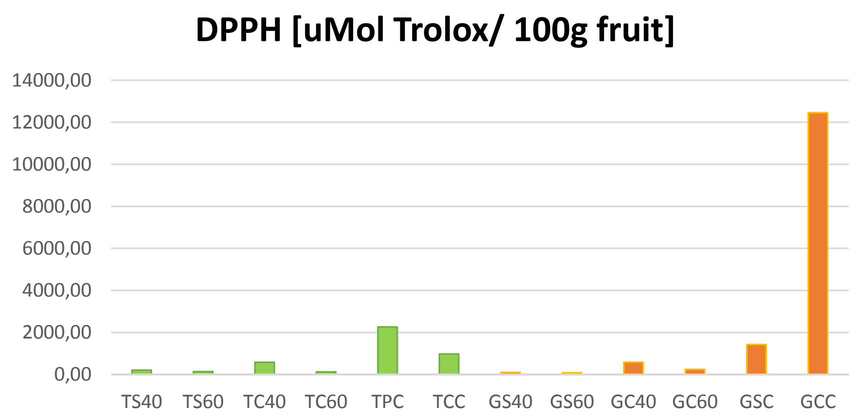
CASE STUDY 1: ANTIOXIDANT CHARACTERIZATION

Total polyphenols content and antioxidant activity of tamarillo and guava fresh fruits.

Fruit	Total Polyphenols content [mg GA/100 g fruit]	DPPH [µMol trolox/ 100 g fruit]	ABTS [µMol trolox/ 100 g fruit]
Tamarillo	26.24±3.44	1195.19±180.62	138.77±82.28
Guava	95.76±34.80	6019±1121.70	29.18±8.24



Total polyphenols content of the different fruit residues

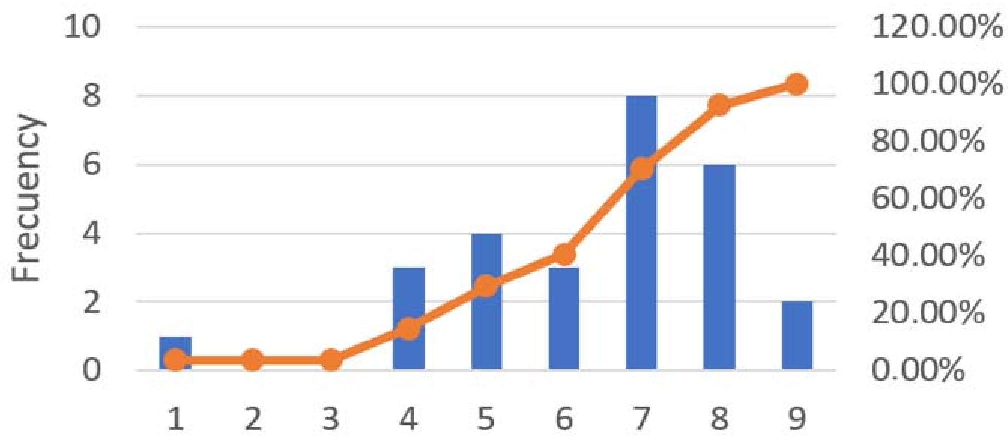


Antioxidant activity measured using DPPH

CASE STUDY 1: SENSORY EVALUATION

Sensory evaluation of tisanes made with tamarillo peels

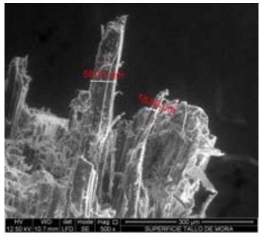
Cupping panel

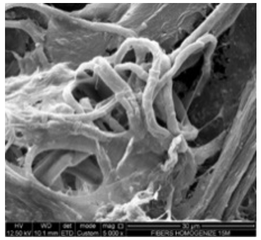


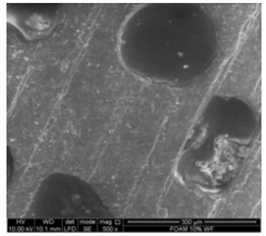
Histogram of flavor evaluation by the panelists

CASE STUDY 2: LIPASE IMMOBILIZATION ON FOAMED EPOXY RESIN SUPPORT FILLED WITH ACTIVATED STALKS

- Materials
- Preparation of pellets
- Lipase immobilization
- Characterization assays





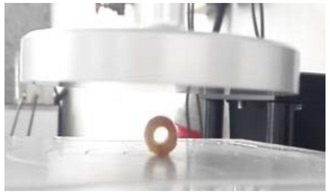


Cultivar residues → (Dry & Mill) → Particle size $\leq 250\ \mu m$ → (Activation reagents) → Activated powder 4.77% wt

Epoxy resin 66.8% wt → (+ Blend) → Hardener 28.38% wt → (+ Blend) → Foaming agent 0.05% wt

Activated powder + Foaming agent → (Blend) → Mix → (Molding) → Pellets → Lipase solution → (Immobilization) → **Immobilized lipase pellets**

CASE STUDY 2: PELLETS CHARACTERIZATION

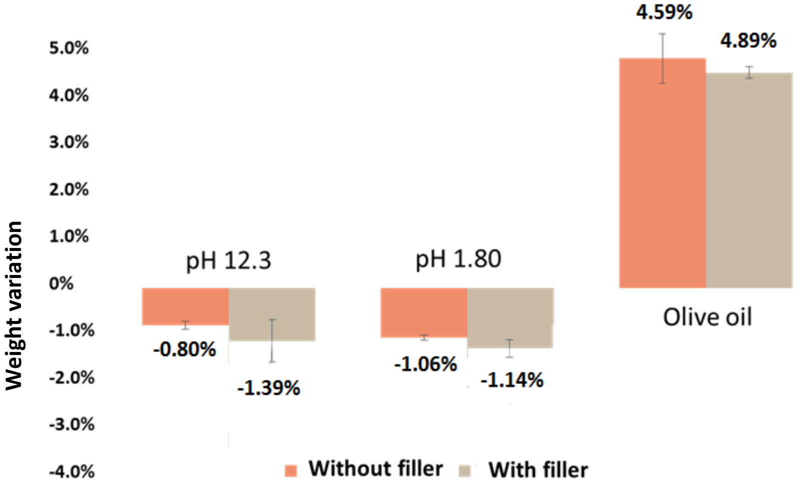


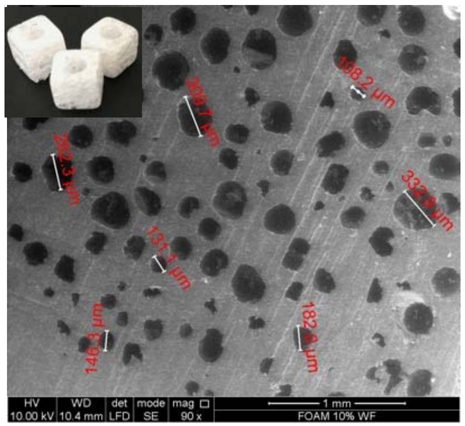
ASTM D4179-01
TA-XT. *plus Texture Analysis*
(TX.XT.Plus, Godalming, UK).

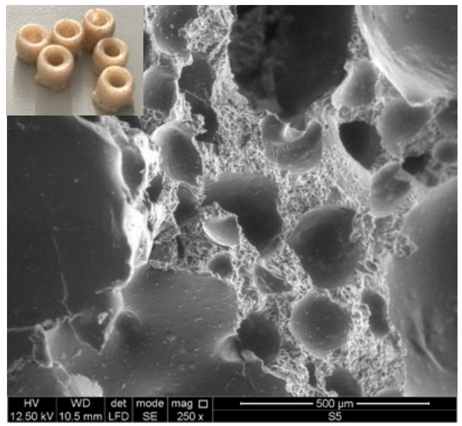
SIZE (mm)		RADIAL CRUSHING STRENGTH (N)	
Diameter	Heigth	Mean ± SD	Reference
9.1	5.17	27.50 ± 8.64	(1)
9.1	6.59	34.20 ± 11.20	(1)
8.1	5.60	58.39 ± 11.17	This work (2)
8.1	5.60	40.41 ± 7.08	This work (3)

n = 3 (1) Wu, D., Zhou, J., & Li, Y. (2007). Mechanical strength of solid catalysts: Recent developments and future prospects. *AIChE journal*, *53*(10), 2618-2629. (2) Cylinder pellet without lipase (3) Cylinder pellet with lipase

Pellets were immersed in olive oil, akaline and acidic water solutions (24 hr, 60°C)







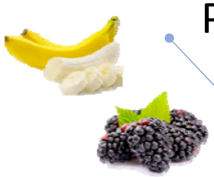
CASE STUDY 2: CATALYTIC PARAMETERS

SHAPE	PROTEIN LOAD (mg/g support)	CYCLE	LIPASE ACTIVITY (U/g support)	
			Mean ± SD	Reference
Cylinder	10-27	1	33.93±3.17	This work
		2	19.13±3.34	This work
		3	13.32±1.08	This work
		4	12.02±0.71	This work
Sphere	80-90	1	17.13±0.87	(1)

n = 3
Lipase activity was estimated by the hydrolysis of olive oil method (2)
U= micro mole of fatty acids released mL $^{-1}$ of enzyme extract per minute

(1) Knezevic Z. et al. (2006). Immobilization of lipase from Candida rugosa on Eupergit® C supports by covalent attachment. Biochemical Engineering Journal 30, 269–278.
(2) Prazeres, J. N. D., Cruz, J. A. B., & Pastore, G. M. (2006). Characterization of alkaline lipase from Fusarium oxysporum and the effect of different surfactants and detergents on the enzyme activity. *Brazilian Journal of Microbiology*, 37(4), 505-509.

CASE STUDY 3: APPROACHES TO BIOREFINERIES FROM FRUIT WASTE



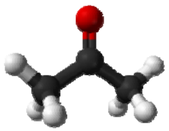
Plantain

Blackberry

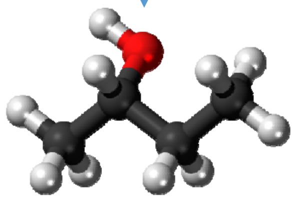
Butanol is an important chemical with many applications in the production of solvents, plasticizers, butylamines, amino resins, butyl acetates, detergents, cosmetics, vitamins, etc. Also it is used as fuel extender or fuel substitute (3).

Raw material for biobutanol production

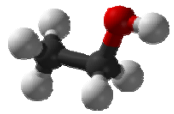
- Molasess, whey
- Starch
- **Lignocellulosic biomass**



Acetone



Butanol



Ethanol

(3) G. K. Donaldson, A. C. Eliot, D. Flint, L. A. Maggio-Hall, and V. Nagarajan, "Fermentive production of four carbon alcohols," *US Pat. …*, 2010.

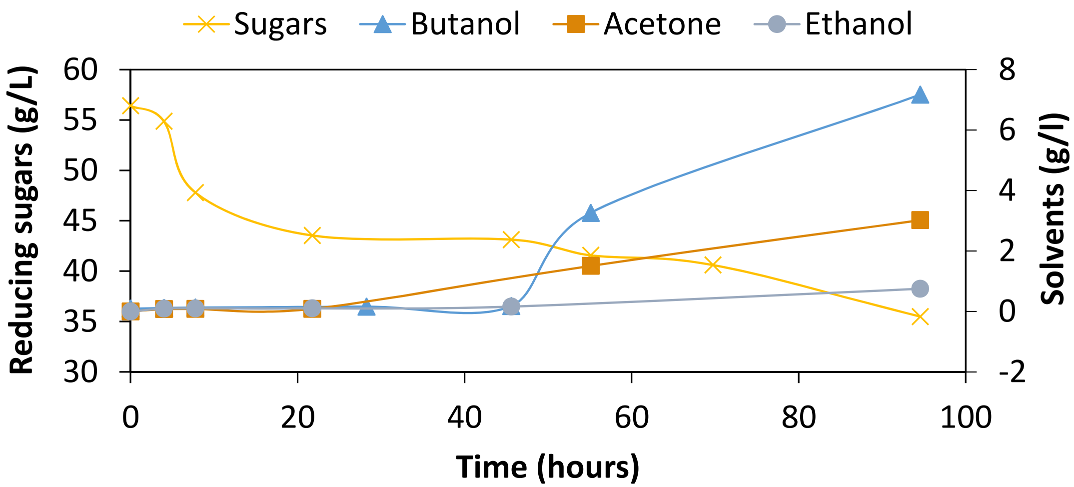
CASE STUDY 3: BUTANOL

The plantain is one the most important crops in Colombia which generates a large amount of waste. Butanol (acetone butanol ethanol or ABE) can be produced from plantain peel due to its lignocellulosic composition (4,5)

Autohydrolysis: 130 ° C, 60 minutes, 1:10 ratio solid-liquid

Enzimatic hydrolysis : 50 ° C, 24 hours, Cellulase complex - NS22086 (Novozymes), β-glucosidase (2)

Fermentation: 37°C, 90 rpm, 100 hours, *Clostridium acetobutylicum*



Sugars consumption and solvents production in the fermentation with plantain peel

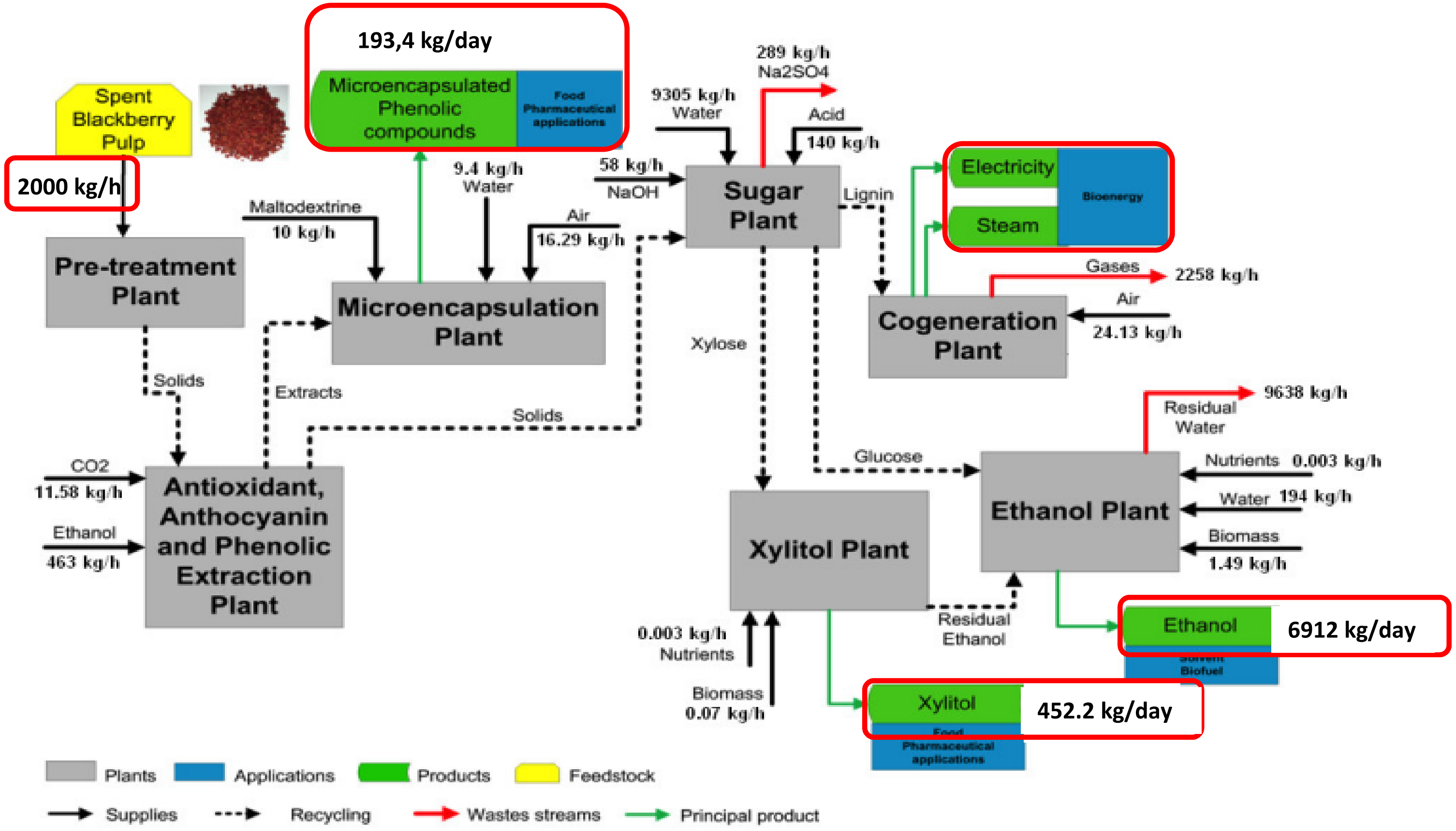
Acetone 3.02 g/L

Butanol 7.17 g/L

Ethanol 0.75 g/L

(4) D. Parra, "Evaluation of the biobutanol production from two agroindustrial wastes generated in the coffee growing region:", 2018.
(5) M. J. Selig, N. Weiss, and Y. Ji, "Enzymatic Saccharification of Lignocellulosic Biomass," 2008.

CASE STUDY 3: SPENT BLACKBERRY PULP



Generally, the blackberry is processed into concentrates, jams and juices and a considerable fraction of the fruit leaves the process as spent blackberry pulp (SBP). The flow of raw material in this case was 2000 kg/h. In an biorefinery approach for the production of ethanol, xylitol, electricity, steam and phenolic compound extracts.

CONCLUSIONS

The increase in consumers' demand has sparked a renewed interest in fruit, their co-products and residues as alternative food source, food ingredients, bioactive and functional components. These materials are also considered for non-food processing as feed, fertilizer and bio-energy resources.

Fruits and vegetable wastes are produced in considerable amounts in agricultural, agro industrial and consumption stages. A number of different marketable products could be obtained from these raw materials.

Tisanes from seeds and peels of two Andean fruits are good source of antioxidants with acceptable sensorial characteristics.

Fruit cultivar stalks could be used as fillers of bio-epoxy matrix carrier for enzyme immobilization.

It is technically possible to use fruit residues to produce energy, beverages, food ingredients and chemicals.

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