The sequential biorefinery approach for biodiesel and glucose production from Spent Coffee Grounds

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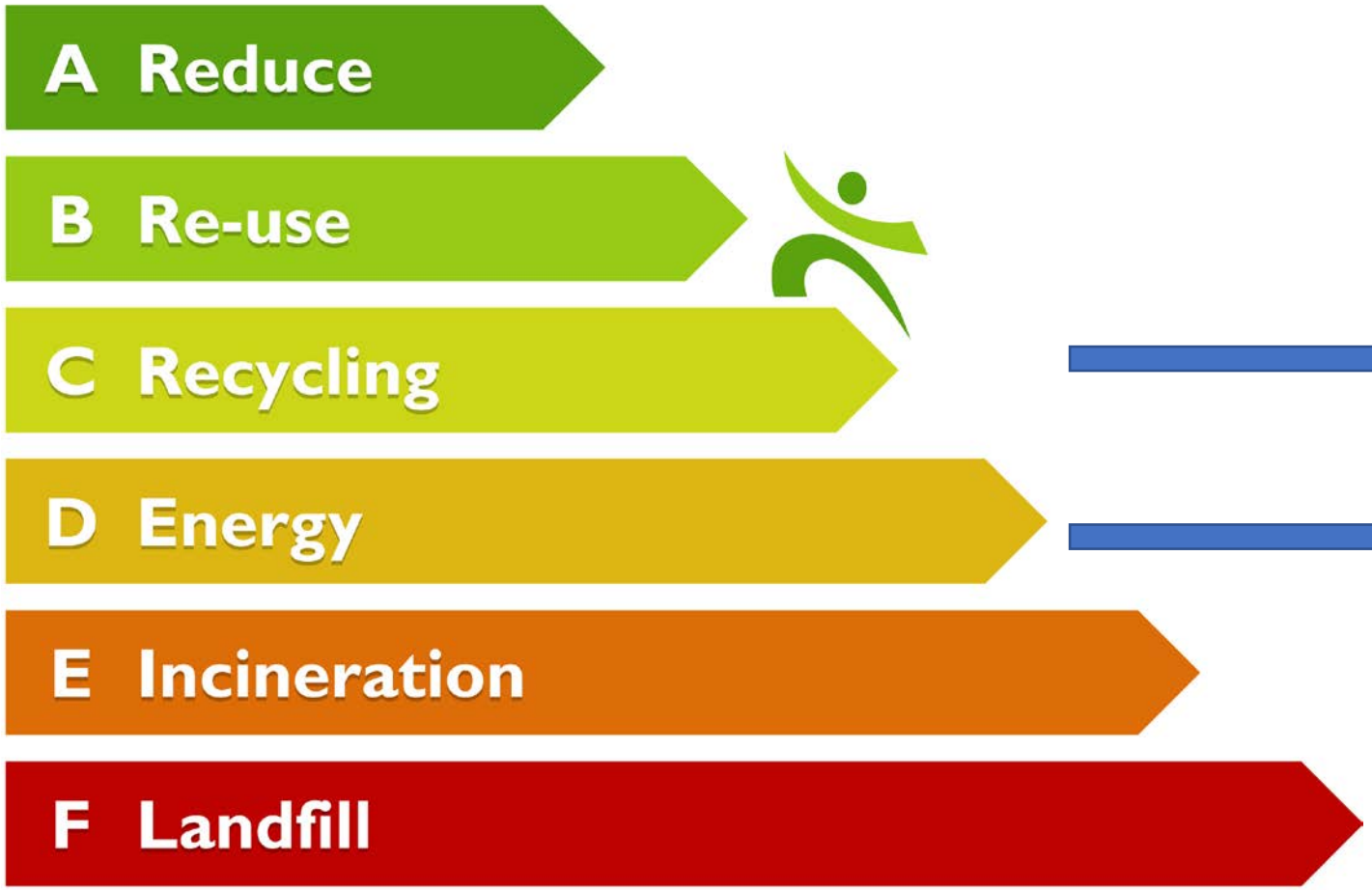
The Waste Hierarchy approach



High added value production (SCP, PHAs)
High value molecules recovery
(for pharmaceutical, food, cosmetical or agriculatural uses)

Biofuels
(biogas, bioethanol)

Coffee is one of the most appreciated beverage around the world with a global annual consumption of 9.3 Mtons.

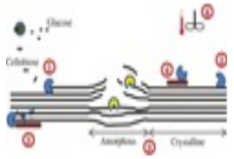
Spent Coffee Grounds (SCG), annual amount of 6M tons generated at international level.

Currently SCG are mainly incinerated or simply collected with the Organic Fraction of the Municipal Solid Wastes (OFMSW) and disposed in landfill.

6 Mtons of SCG

Coffee oil extraction by Soxhlet

Residual solid fraction



Acid/Enzymatic Hydrolysis for Fermentable Sugars production

Residual solid fraction

Biogas by anaerobic digestion

Coffee oil

Transesterifiation for biodiesel production

Based on this configuration, SCG will be used for:

- the extraction of **high economic value molecules (tocopherols, linoleic acid, chlorogenic acid, Cafestol and Kahweol);**
- **biodiesel production** by transesterification reactions of the extracted coffee oil ;
- **Sugars production** from the remaining solid matrix of SCG
- **biogas production**

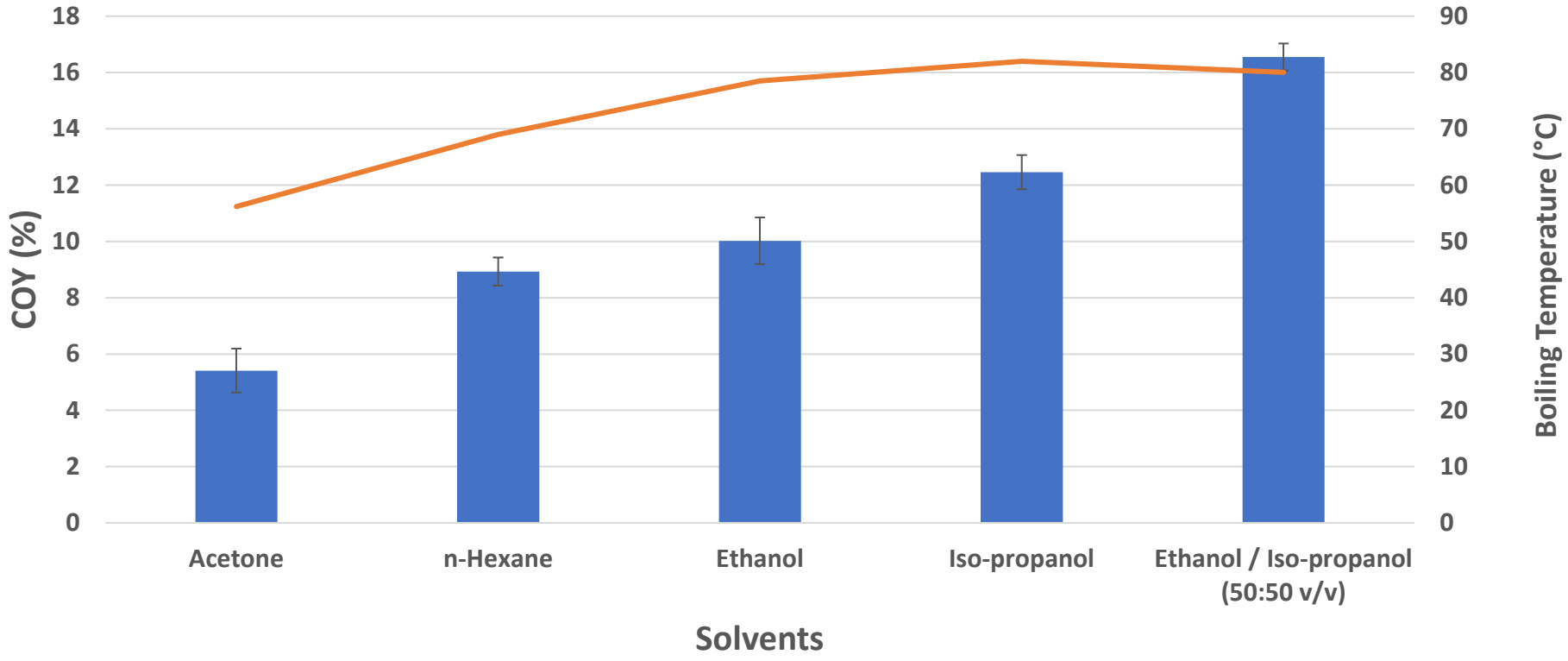
Coffee oil extraction

10 g of dried was located in a Soxhlet extractor. 300 mL of polar and no-polar solvents (acetone, ethanol, iso-propanol and n-hexane and a 50:50 (*v/v*) mixture of the ethanol and iso-propanol, were tested).

All the solvents were tested at 85°C, value higher than boiling temperature of the different solvents

$$\text{COY (\% w/w)} = \frac{M\ oil}{M\ SCG} \text{ x } 100$$

Coffee oil extraction yield (COY)



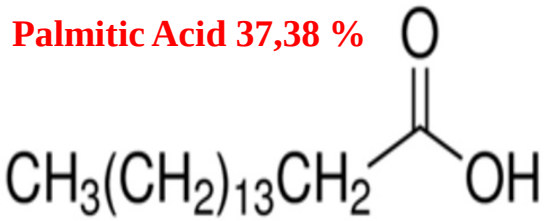
n-hexane is characterized by high value, $K_{ow} = 4.5 \times 10^4$, revealing its hydrophobic nature.

Instead, iso-propanol ($K_{ow} = 0.64$) and ethanol ($K_{ow}=0.54$) have partition coefficients close to one, which means that these solvents, even if are more hydrophilic, are also able to extract hydrophobic components during Soxhlet extraction

Coffee oil compounds

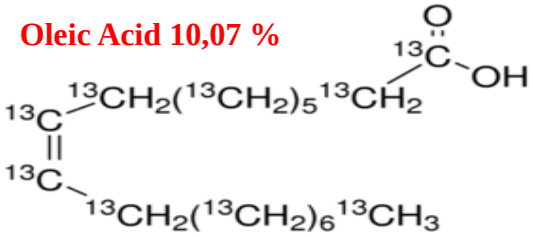
Fatty Acids

Palmitic Acid 37,38 %



Linoleic acid 34,06 %

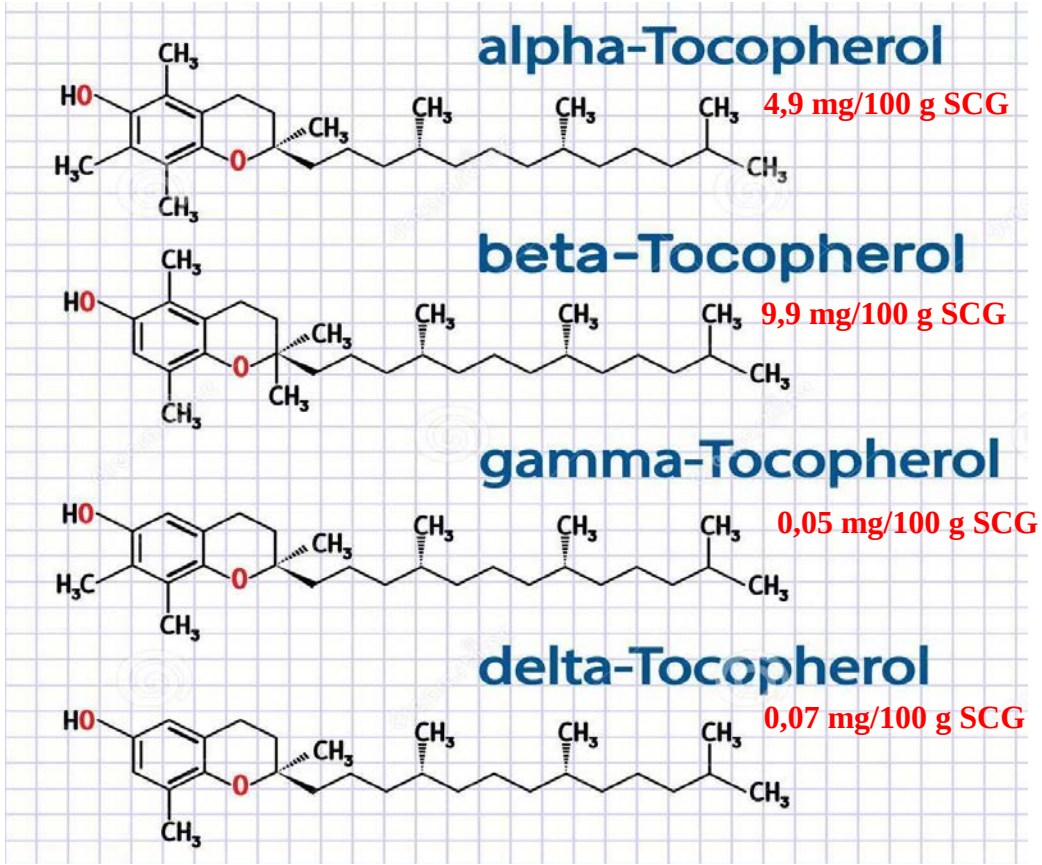
Oleic Acid 10,07 %



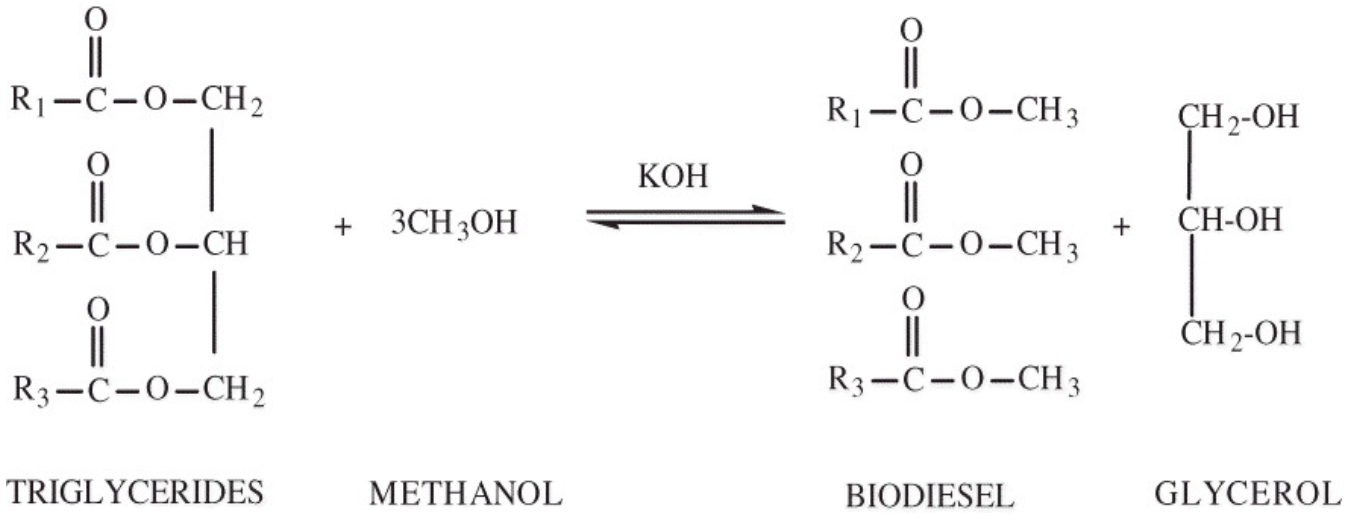
Tocopherols

About 15 mg/100 g SCG

Literature range: 6,5-30 mg/100 SCG



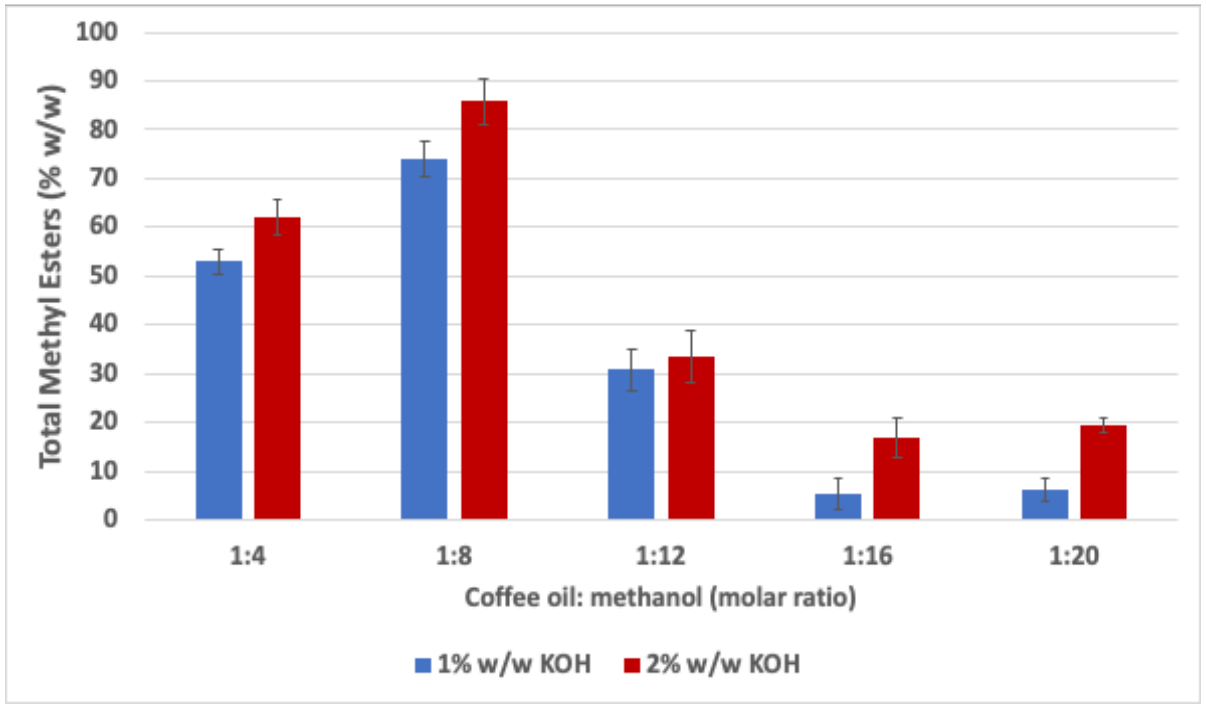
Transesterification of the coffee oil for biodiesel production



Transesterification tests at:

- different molar ratios of coffee oil: methanol of 1:4; 1:8; 1:12; 1:16; 1:20
- Two different potassium hydroxide (KOH) of 1 and 2% w/w, referred to the coffee oils content.

Transesterification of the coffee oil for biodiesel production



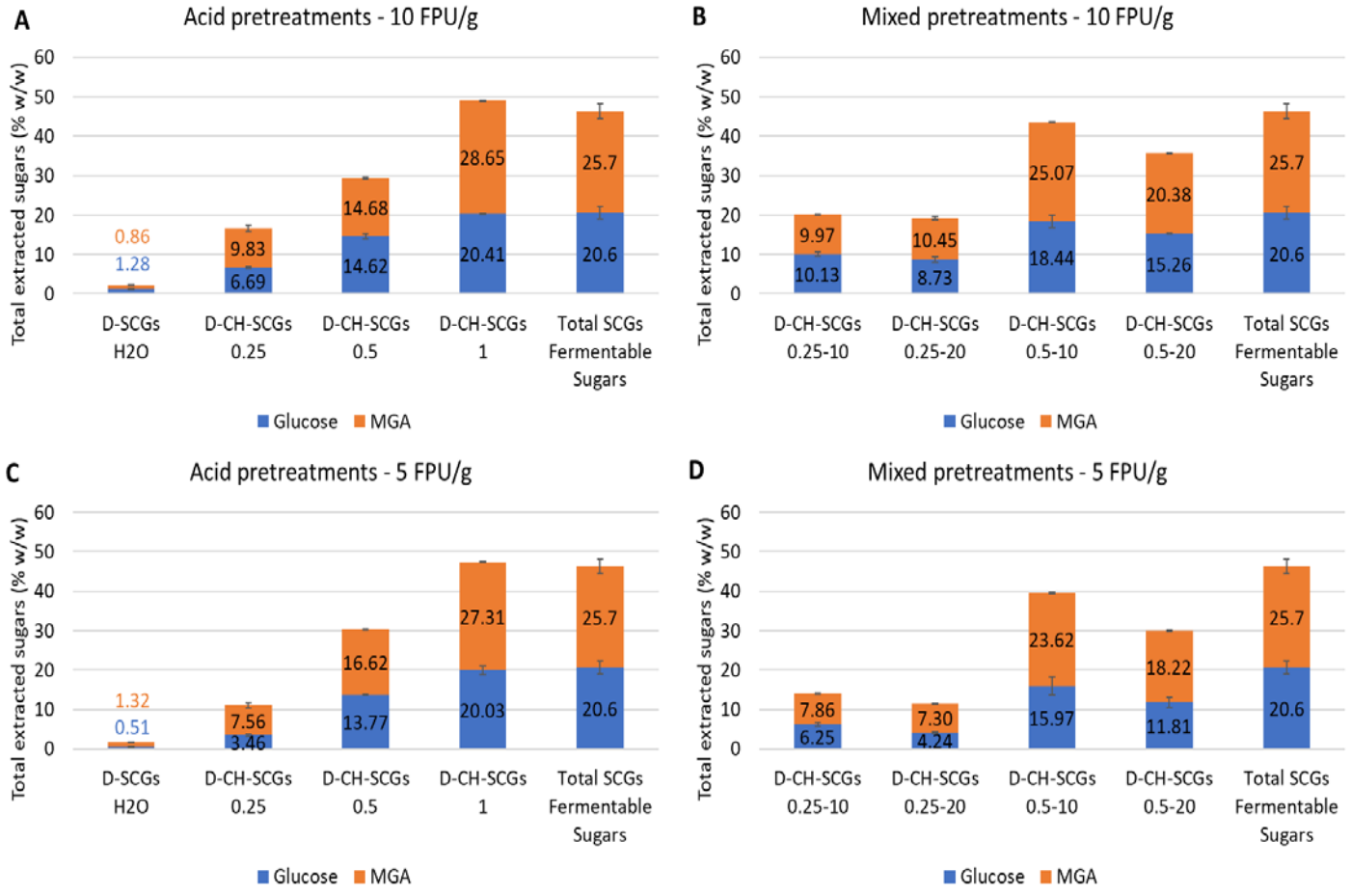
Content of **Methyl ester** from the transesterification of	% w/w
Myristic acid	0.1
Palmitic acid	**30.0**
Palmitoleic Acid	0.1
Heptadecanoic acid	0.2
Stearic acid	5.8
Oleic acid	8.7
Linoleic acid	**37.6**
Arachidic acid	1.8
Gadoleic acid	0.2
Behenic acid	0.3

Enzymatic hydrolysis for sugars production

Sample name	H_2SO_4 % (v/v)	Glycerol % (v/v)
D-SCGs-H_2O	-	-
D-CH-SCGs-0.25	0.25	-
D-CH-SCGs-0.5	0.50	-
D-CH-SCGs-1	1.00	-
D-CH-SCGs-10	-	10
D-CH-SCGs-20	-	20
D-CH-SCGs-40	-	40
D-CH-SCGs-80	-	80
D-CH-SCGs-0.25-10	0.25	10
D-CH-SCGs-0.25-20	0.25	20
D-CH-SCGs-0.5-10	0.50	10
D-CH-SCGs-0.5-20	0.50	20

After the pretreatment SCG were carried out using the commercial enzyme cocktail Cellic CTec 2 (Novozymes). Enzyme activity, expressed as filter paper units (FPUs), was set at 5 and 10 FPUs/g_{SCG}, while the TS concentration was of 15% w/v.

Enzymatic hydrolysis for sugars production



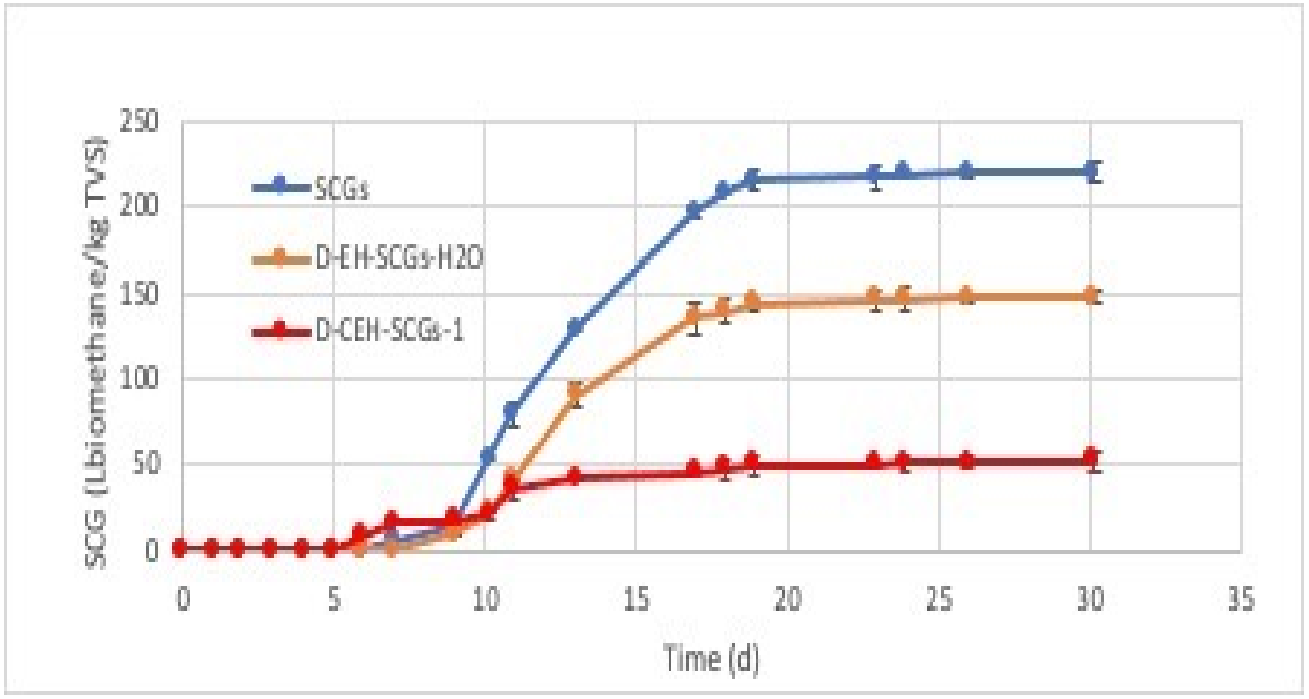
- 5 FPUs/g_{SCG} allowed to have the same sugars productions than 10 FPUs/g_{SCG};
- Glycerol, the by-product from biodiesel production, had a good effect on the pretreatment allowing the reduction sulfuric acid concentration.

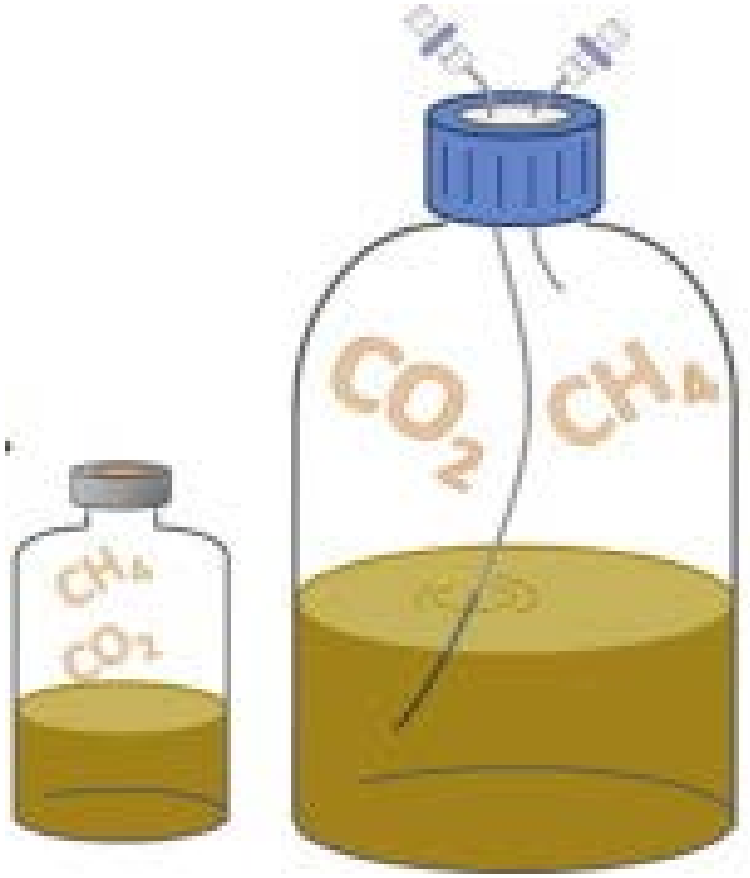
- **The better fermentable sugars content was around 40-45% w/w**

Biogas production from the solid fraction

The remaining solid fraction of SCG, after enzymatic saccharification, was performed for the biogas production by AD in mesophilic conditions.

Biogas production from the solid fraction





Thank you for
the attention

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