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BIOENERGY NEWS

A MAGAZINE OF PH.D. PROGRAM IN BIOENERGY

BIOMASS PRODUCTION FOR BIOENERGY

Genetic improvement of plants.
Crop science for bioenergy.
Agricultural engineering.

SOCIOECONOMIC AND ENVIRONMENTAL SUSTAINABILITY

Socio-economic aspects.
Environmental aspects.

BIOREFINERY, BIOFUELS AND ENGINES

Science and technology of biofuels and bioelectricity.
Biorefinery and green chemistry.
Biofuels and engines.

USP UNICAMP unesp

BIOENERGY NEWS

EDITOR / THAÍS SECCHES / RAQUEL DE SOUZA
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contact us

USP – ESALQ – PIRACICABA/SP
Alexandre J. Santos
http://www.esalq.usp.br/pg/programas/bioenergia
pipg.bioen@usp.br
UNICAMP – CAMPINAS/SP
Camila Ferreira Julio/ Andrea Cristina Ferrari
(19) 3521-7592 / 3521-0202
bioenerg@fea.unicamp.br
UNESP – INSTITUTO DE PESQUISA EM BIOENERGIA – RIO CLARO/SP
Luís Ricardo M. Oliveira
pipg.bioenergia@ipben.unesp.br

STUDENTS

ADRIANA MENDES
AGLAER NASIA CABRAL LEOCADIO
ANA BEATRIZ SOARES AGUIAR
BRUNA CRISTINA GALLO
CARLA ISABEL FLORES RODRIGUEZ
DANIELLA FLÁVIA SAID HEID S. SILVA
DANIELLE MATIAS RODRIGUES
FABIANE MOREIRA VIEIRA
FABRÍCIO MIGUEL FARINASSI
FRANCISCO LUCAS CHAVES ALMEIDA
GUILHERME PESSOA NOGUEIRA
HENRIQUE REAL GUIMARÃES
JADE RIBEIRO DOS SANTOS
JÉSSICA MARCON BRESSANIN
JORGE EDUAR CARDONA FLOREZ
LAIS ALBUQUERQUE GIRALDI
LAUREN MAINE SANTOS MENANDRO
LEANDRO CAROLINO GONZAGA
MARCELO ANTUNES GAUTO
MARIA FERNANDA SÚA ROJAS
MARIA PAULA CARDEAL VOLPI
MARIA PAULA GIULIANETTI DE ALMEIDA
MARIA PAULA JIMENEZ CASTRO
MARILENE ELIZABETE PAVAN RODRIGUES
MAYARA CHAGAS DE ÁVILA
NARIÊ RINKE DIAS DE SOUZA
PILAR DIB
RAFAEL BONI
RAFAEL LEONARDO DE ALMEIDA
RAQUEL DE SOUZA
SARAH TENELLI
THAIS OLIVEIRA SECCHES
THAYNARA KÉSSIA ESPÍNDOLA PEREIRA
THIAGO NEITZEL
TOMAZ CARRARO PEREIRA

Ph.D. Candidate: Guilherme Pessoa Nogueira

PERSONAL INFORMATION

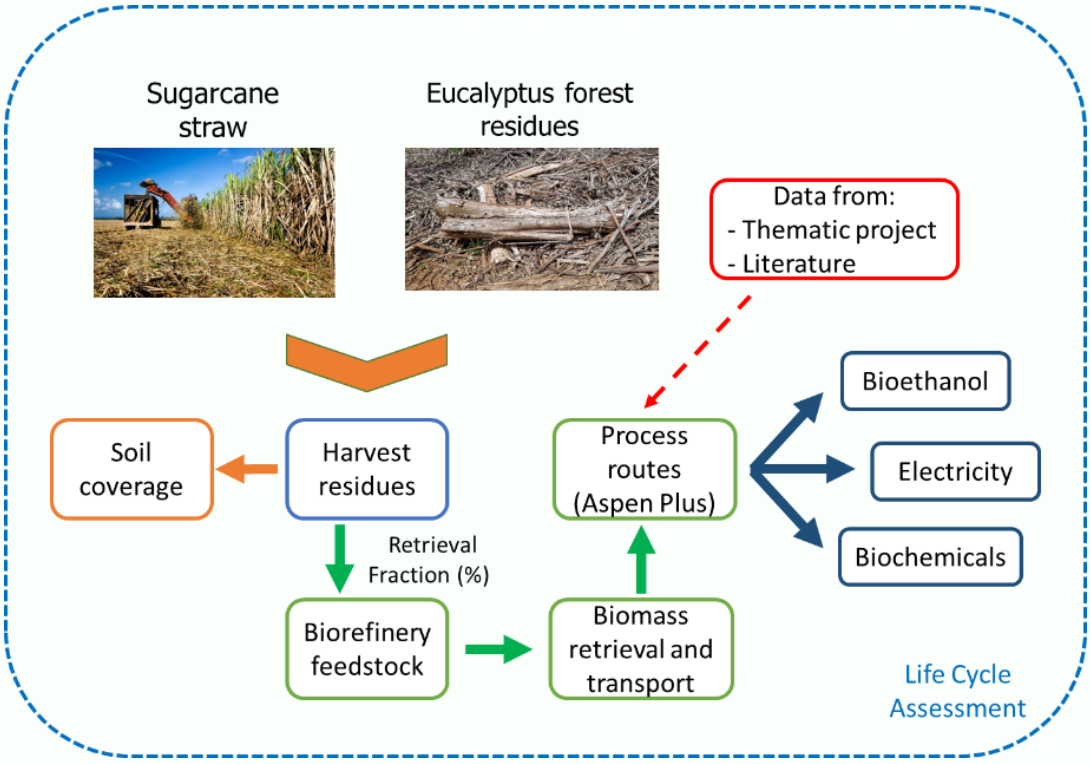
Supervisor: Carla Kazue Nakao Cavaliero (FEM – UNICAMP)
Co-supervisor: Marina Oliveira de Souza Dias (ICT – UNIFESP)
Funding agency: FAPESP (Process 2018/20173-0)
Enrolment date: 01/08/2017
Conclusion (estimative): 30/04/2022
Lattes CV: lattes.cnpq.br/0195277091871469
LinkedIn: in/guilherme-nogueira

PROJECT'S TITLE

Technical and environmental assessment of sugarcane straw and eucalyptus forest residues as feedstocks for biorefineries at São Paulo State.

SUMMARY

My Ph.D. project aims to evaluate the technical feasibility and environmental impacts related to the use of two non-conventional lignocellulosic feedstocks residues (sugarcane straw and eucalyptus forest residues) to produce biofuels and biochemicals in the context of biorefineries on São Paulo state. This will be done through the design and simulation of biorefinery process routes and later application of the Life Cycle Assessment (LCA) tool. The biorefinery main products are bioethanol and electricity, with some routes considering the production of biochemicals. This work is a contribution to FAPESP/BBSRC joint project (2015/50612-8).



HIGHLIGHTS

- Biorefining potential of lignocellulosic harvest residues;
- Design and simulation of biorefinery process routes;
- Construction of Life Cycle Inventories (LCIs);
- Evaluation of carbon footprint and other environmental impacts;

TIMELINE AND MAIN RESULTS

2s/2017	Enrolment on Bioenergy Ph.D. program
	Courses on LCA methodology, biorefineries and renewable energy sources
	Literature review and FAPESP project submission
	Participation at Workshop on Second Generation Bioethanol and Biorefining (CTBE)
	Part of the organizing committee of I Bioenergy Symposium (FEA-UNICAMP)
	Became a CAPES scholarship holder
	FAPESP/BBSRC project workshop
1s/2018	Courses on bioenergy sustainability, biomass production and academic writing in English
	Data gathering for biorefinery process routes
	Study of eucalyptus and sugarcane cultures: soil coverage vs retrieval
	Review of LCA studies on bioenergy
	Technical visit at Suzano: eucalyptus harvest
	Participation at ISNaPol 2018 with poster presentation
2s/2018	Passed on the first qualification exam
	Participation on FAPESP SPSAS on water-energy-food nexus with poster presentation
	Graduate teaching assistant (PED) internship with Prof. Marcus Forte (FEA-UNICAMP)
	Acquisition of an Aspen Plus user license
	Became a FAPESP scholarship holder (#2018/20173-0)
	Elected Bioenergy Ph.D. Program's Student President (Aug/18 – Jul/19)
	Managed Bioenergy Program Weekly Seminars with Prof. Gonçalo Pereira
	Started biorefinery process simulations
	FAPESP/BBSRC project workshop
1s/2019	UNICAMP/TUDelft course on Strategic Communication and Bio-based Economy
	Adquired license for SimaPro and EcoInvent
	Started YouTube broadcasting of Bioenergy Program Weekly Seminars
	FAPESP BEPE scholarship awarded (#2019/10439-6)
	Implementation of Anaerobic digestion into the process design
	Finished four biorefinery scenarios on Aspen Plus
	Scientific writing course with Prof. Gilson Volpato at UNICAMP
2s/2019	FAPESP/BBSRC project workshop
	Went to University of Bath for BEPE internship (Sep/19 to Mar/20)
	Implementation of eucalyptus and sugarcane inventories on SimaPro
	Development of retrieval routes life cycle inventories for residues
	Courses and workshops at University of Bath
	Submission of FAPESP annual report (#1)
	Adaptation of Aspen simulations into LCIs
	Participation at "Balancing Resource Efficiency with Climate Change" workshop
	First visit at Imperial College London
	First complete LCA scenario completed for eucalyptus residues (preliminary)
1s/2020	Three complete LCA scenarios for sugarcane straw (preliminary)
	Preliminary impact assessments (LCIA)
	Identification of enzymes as major environmental bottleneck

	More courses and workshops at university of Bath Visit to University of Aberystwyth Second visit to Imperial College London – EUCALC workshop Return to Brazil and submission of BEPE report to FAPESP Started collaborative work with BBSRC/FAPESP project members Further work on previous LCA Collaboration with Felipe Ferrari (LCA Ionic Liquid pretreatment) Collaboration with Fernando Barbosa (LCA oligosaccharides production)
2s/2020	Writing and submission of first paper (eucalyptus forest residues LCA) Writing and submission of collaborative paper (LCA oligosaccharides) Writing and submission of book chapter (harvest residues and LCA) Further work on previous LCA Poster presentation at EUBCE 2020 (doi.org/10.5071/28thEUBCE2020-3BV.4.2) Poster presentation at BBEST 2020 Submission of FAPESP annual report (#2) Graduate teaching assistant (PED) with Prof. Andreas Gombert (FEA-UNICAMP)
1s/2021	First paper published (doi.org/10.1016/j.jclepro.2021.126956) Ongoing collaborative work with University of Aberystwyth Second qualification exam (May/21) Further work on previous LCA Writing and submission of second paper (enzyme role on 2G ethanol LCA) Writing and submission of collaborative paper (LCA ionic liquids) Soft skills course at UNICAMP

CHALLENGES AND STRATEGIES TO OVERCOME THEM

To be a Ph.D. candidate on the Bioenergy Program is a challenge itself. Which demands a strong and interdisciplinary knowledge, covering biomass production, biorefining and sustainability. And achieving this solid background is a daily and laborious process, involving reading, events, classes, courses, news, networking and much more, within my research subject and outside of it. As for my project, this background was crucial to enable the data gathering process for the biorefineries design and simulation, and Life Cycle Assessment.

Data sources are also a challenge. Both the simulations and the life cycle inventories demand complete and traceable data, that are not always attainable and available. And, to overcome this, there are some strategies available: get multiple and complementary data sources; communicate with experts; making assumptions. All which contributes to raise the uncertainty of the study results, demanding sensitivity analysis and double checking.

Collaborative works were also a challenge, since they often involve an interdisciplinary team, so communicating ideas and concepts must attain the central ideas and considerer the depth of knowledge from the other team members within my field. This also works the other way, since my understanding of their fields can, sometimes, be very basic. Thanks to the Bioenergy Program courses, this barrier can be easily overcome.

Ph.D. Candidate: Maria Paula Jiménez Castro

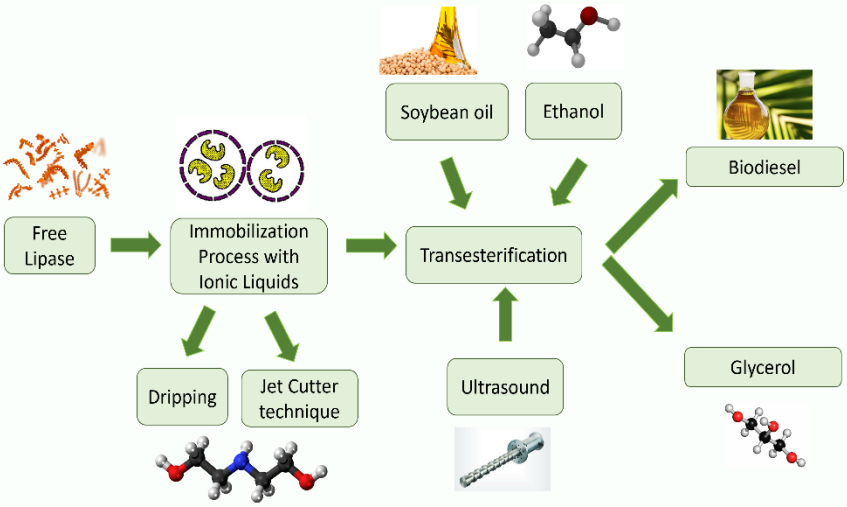
PERSONAL INFORMATION

Supervisor: Prof. Marcus Bruno Soares Forte,
Enrolment date: 02/2020
Conclusion (estimative): 02/2024
Lattes CV: http://lattes.cnpq.br/7785128347353306
LinkedIn: https://www.linkedin.com/in/maria-paula-jim%C3%A9nez-castro-702751190/

PROJECT'S TITLE

Biodiesel production in stirred reactors by jet cutter immobilized lipase with ionic liquids and ultrasound-assisted transesterification

SUMMARY



Biodiesel is an excellent alternative to fossil fuels; however, its production is based on chemical routes that used catalysts which can negatively impact the environment. Therefore, biocatalyst as lipase is an interesting route to have a more ecofriendly process and better results. Thus, immobilized that enzyme is the best way to avoid problems like its difficult recovery, besides, agglomeration of immobilized enzyme particles should be avoided for its easier reuse. For that reason, this work aims to use a technique that can give a smaller size called jet cutter. Further, avoiding loss of enzyme and low yield, this project will use different ionic liquids to enhance enzyme stability and affinity with the substrate to produce biodiesel in stirred reactors that will have ultrasound to enhance mass transfer characteristics leading to reduced reaction times and potentially lower cost.

HIGHLIGHTS

- Use of ionic liquids to improve enzymes activity and stability.
- Apply ultrasound to enhances mass transfer characteristics leading to reduced reaction times and potentially lower production cost.
- To study the best conditions (temperature, oil/alcohol ratio and surface velocity) to convert biodiesel from vegetal oil in stirred reactors.
- Production of biodiesel in stirred reactors with ultrasound for optimize the process.

TIMELINE AND MAIN RESULTS

1s/2020

- Subject BI003- Social, economic, and environmental sustainability
- Subject TP003- Biotransformation of agroindustrial products

2s/2020

- Subject BI002- Biomass transformations processes in biofuels
- Subject QBQ2502 – Enzymology (University of São Paulo- USP)

1s/2021

- Article writing (Trends in lipase immobilization: Bibliometric review and patent analysis). It was submitted and accepted by the Journal Process Biochemistry.
- Book chapter writing (Brettanomyces: from supporting actors to protagonists). It will be considered in the Book entitled “Yeasts: from Nature to Bioprocesses".

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: To find the best process condition

Strategies: to do a Design of Experiments (DOE) with all the parameters.

Challenge: To choose the best ionic liquid

Strategies: to read and research on different scientific basis and to make some tests with some of them.

Challenge: Covid-19 pandemic

Strategies: To optimize the time that I will have at the laboratory.

PhD Candidate: Pilar Dib

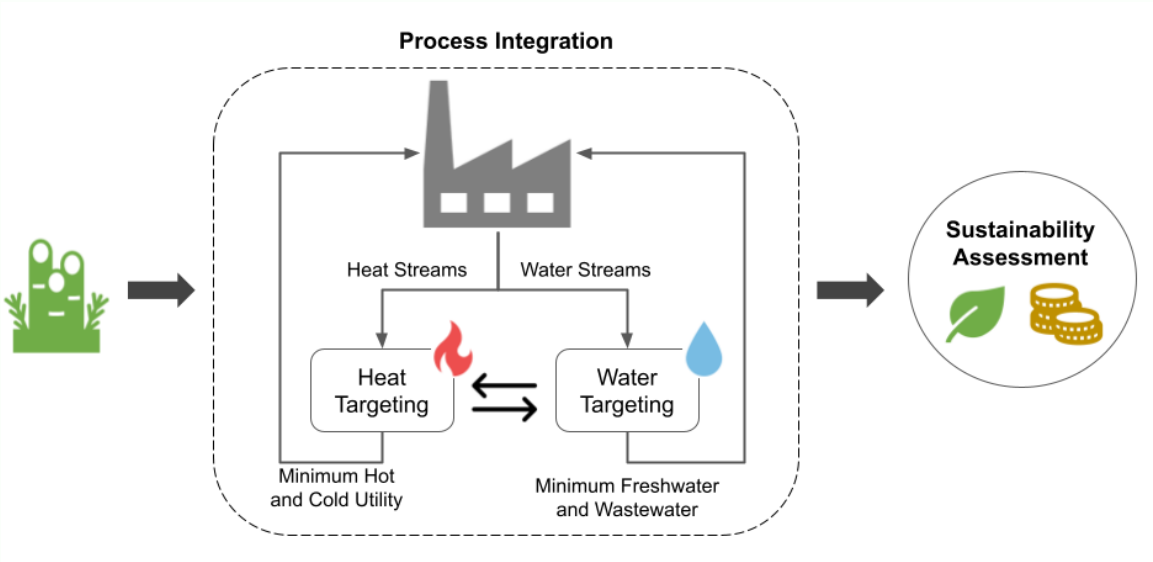
PERSONAL INFORMATION

Advisor: Tassia Lopes Junqueira – Faculty of Food Engineering (FEA/Unicamp), Brazilian Center for Research in Energy and Materials (CNPEM)
Funding agency: FAPESP
Enrollment date: 1S2019
Conclusion (estimate): 03/2023
Lattes CV: http://lattes.cnpq.br/6871650364621704
LinkedIn: https://www.linkedin.com/in/pilar-dib

PROJECT'S TITLE

Evaluation of heat and water integration alternatives in sugarcane biorefineries

SUMMARY



HIGHLIGHTS

- Heat pinch analysis provided a higher reduction in utilities than the integration currently adopted by the sugar-energy industry
- Heat pinch analysis also provided a reduction in water use resulting from a decrease in cold utility

TIMELINE AND MAIN RESULTS

1s/2019

- Literature review of heat and water pinch analysis methodologies
- Subject BI001 – Fundamentals of biomass production
- Subject BI003 – Social, economic, and environmental sustainability
- Subject IQ403 – Energy efficiency in chemical processes

2s/2019

- Selection of process streams with potential for integration
- Poster presentation at the *Congresso de Estudantes do CNPEM II* of the project titled "Evaluation of combined pinch analysis and mathematical programming methods for the heat and water integration of sugarcane biorefineries".
- Subject BI002 – Biomass conversion process into biofuels
- Subject PE172 – Life cycle analysis applied to energy

1s/2020

- Simulation of 1G scenarios to obtain mass and energy balances
- Heat Integration of 1G scenarios to obtain energy targets

2s/2020

- Area Qualification Exam

1s/2021

- Water balance of 1G scenarios and selection of contaminants
- Preliminary water targets
- Subject IQ350 – Design of experiments

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: Data extraction of quality of water

Strategies: collect information on water contaminants from literature case studies and reports.

Challenge: performing the integration of heat and water simultaneously

Strategies: sequential approaches are better at handling more complex cases and result in simpler problem formulations.

Ph.D. Candidate: Thaís Oliveira Secchess

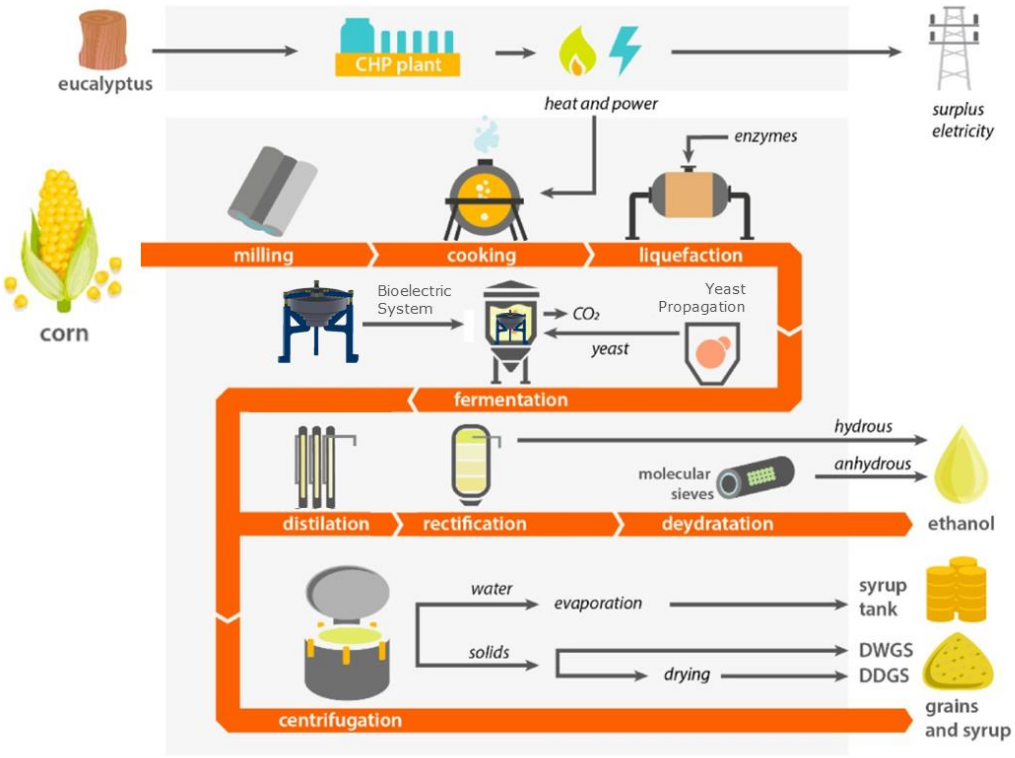
PERSONAL INFORMATION

Supervisor: Prof. Gonçalo Pereira, Ph.D.
Co-Supervisor: Prof. Marcelo Falsarella Carazzolle, Ph.D.
Funding agency: CNPq
Enrolment date: 08/2019
Conclusion (estimative): 09/2023
Lattes CV: http://lattes.cnpq.br/0863071985777349
LinkedIn: https://www.linkedin.com/mwlite/in/thais-s-428189141

PROJECT'S TITLE

Development of a fermentative process to produce Corn Ethanol using a Bioelectric System

SUMMARY



In the context of the attempt to increase the fermentative yield, several studies have shown that the application of electric current during fermentation can stimulate the metabolism of several microorganisms, including yeasts. In Brazil, the company MAHLE Metal Leve SA developed a new technology applied in the production of 1G ethanol on an industrial scale (MBE2 technology) which consists of a bioelectric system that operates in industrial fermenters and resulted in a greater ethanol production of around 10%. In this project, we intend to study the effects of the bioelectric fermentation process applied to Corn Ethanol, which has been growing in Brazil and proving to be an advantageous technology. The proposal is to integrate the bioelectric system into the conventional dry milling process, in which the whole corn grain is processed to produce ethanol and the starch-free material is recovered at the end of the process as a co-product (DGGs). As a result, higher yields are expected in the production of ethanol and co-products.

HIGHLIGHTS

- Design and construction of the bioelectric system based on MAHLE's patent (MBE2), designed for fermentation in a 1L reactor.
- Structuring of the corn ethanol production system on a laboratory scale (milling, cooking, liquefaction, saccharification and fermentation);
- Validation of the effect of the bioelectric system on 1G ethanol fermentation;
- Fermentations of corn ethanol (without the bioelectric system) with different strains of Brazilian industrial yeasts compared to Ethanol Red (Paper in finalization).
- Optimization of corn ethanol fermentation: stress conditions vs. industial yeast

TIMELINE AND MAIN RESULTS

2s/2019

- Subject BI007 – Advanced Topics in Engines and Biofuel
- Acquisition and installation of equipment and materials for the project.

1s/2020

- Subject BI001 – Fundamentals of biomass production
- Subject BI003 – Social, Economic and Environmental.
- Equipment tests and processes standardization

2s/2020

- Subject NG110 – Special Topics in Genetics
- Subject BI011 – Bioenergy Seminars'
- Optimization of 1G fermentations by varying different parameters.

1s/2021

- Subject BI011 – Bioenergy Seminars'
- Optimization of Corn fermentations by varying different parameters.

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: Covid-19 pandemic.

Strategies: the solution has been to work in restricted hours in the laboratory.

Challenge: Physical and mechanical wear in the bioelectric system
Strategies: Readjust the parameters.

Ph.D. Candidate: Maria Paula Cardeal Volpi

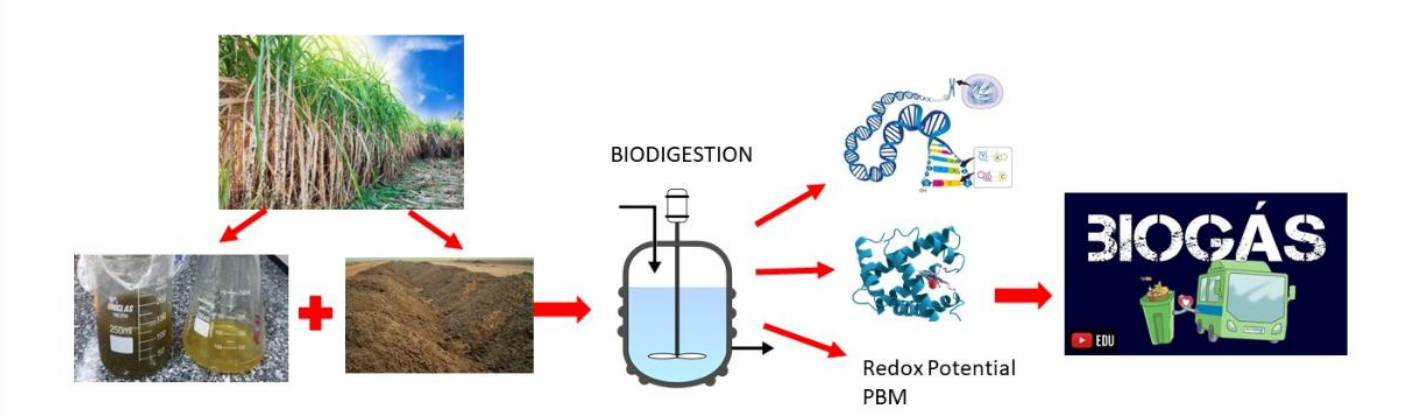
PERSONAL INFORMATION

Supervisor: Bruna de Souza Moraes
Funding agency: Fundação de Amparo à Pesquisa do Estado de São Paulo-FAPESP
Enrolment date: March 2018
Conclusion (estimative): February 2022
Lattes CV: http://lattes.cnpq.br/1765265992388858
LinkedIn: https://www.linkedin.com/in/maria-paula-cardeal-volpi-3424a2172/

PROJECT'S TITLE

Biogas production integrated to the concept of biorefinery for lignocellulosic biomass: operational aspects and use of nanoparticles

SUMMARY



The present project aims to explore biogas production in an innovative concept: integration of the 1G2G ethanol biorefinery through the co-digestion of their residues (e.g., vinasse, filter cake, and pre-treatment residues of straw deacetylation-liquor). The potential production of CH_4 is being explored through Biochemical Methane Potential (BMP-step 1) (each residue separated and co-digestion) and Continuous reactor operation-step 2 (co-digestion). The project includes analysis of proteomics and the identification of the microbial consortium through molecular biology techniques during reactor operation. The continuous production of CH_4 with the use of nanoparticles in the co-digestion system will also be assessed-step 3, opening alternative possibilities for process optimization in sugarcane biorefineries. The development of this project should become one of the first sources of knowledge for the Brazilian production of 2G ethanol coupled with environmental responsibility.

MAIN RESULTS

- The co-digestion of vinasse, filter cake, and deacetylation liquor presented positive synergisms to increase CH_4 yield by at least 16%.
- The deacetylation liquor shows are the co-substrate that enhance methane production in the co-digestion blend and keeping buffer capacity in middle because of its alkaline characteristics

- The reactor operation was effective for providing process parameters for continuous waste treatment and CH_4 production, enabling us to forecast the maximization of residue use within their specific availabilities in the 1G2G sugarcane biorefineries. The upper limit of the organic load rate (OLR) applied without collapsing the reactor was 4.80 gVS $L^{-1}day^{-1}$

- The biomolecular analysis results proved the feasibility of the establishment of the thermophilic methanogenic community (~26% *Thermotage*) from the mesophilic sludge and the change in the microbian community due to the substrate used.

- Energy-producing co-digestion plants could double the installed capacity of sugarcane biorefineries compared to VN-based mono-digestion: 58 MW vs 13.10 MW

TIMELINE AND SCIENTIFIC PRODUCTIONS

1s/2018 In the first semester of 2018, disciplines were taken to fulfill the credits required by the Ph.D. program, and the writing of the FAPESP project for the scholarship application

2s/2018 In the second half of 2018, another lecture was given on the fulfillment of the credits of the program and the BMP experiments were started (step 1), and the FAPESP grant was obtained

1s/2019 The BMP experiments were finalized (step 1) and these results were sent to the congress *IWC - 16th World Conference on Anaerobic Digestion 23-27 June 2019, The Netherlands, Sunday, June 23, 2019 - Thursday, June 27, 2019*. "**Biogas production integrated to the concept of biorefinery for lignocellulosic biomass"**

2s/2019 Started the operation in a semi-fed continuous reactor - s-CSTR for the co-digestion of the vinasse, the deacetylation liquor, and the filter cake (step 2).

1s/2020 The s-CSTR operation was completed (step 2) and due to the quarantine of coronavirus, the writing of scientific articles, second qualification, and doctoral thesis began

2s/2020 At the end of the 2s/2020, the return to the laboratory was allowed, then experiments with nanoparticles were started to optimize co-digestion in the reactor (step 3). The second qualification was done.
Papers were presented at two congresses: first: *XLIX-Congresso Brasileiro de Engenharia Agrícola-CONEBA 2020, with the paper: "Vinasse co-digestion with filter cake for the optimization of methane production".* Second: *Latin American Meetings on Anaerobic Digestion*, with the paper *"Oxidation Reduction Potential (ORP) for monitoring co-digestion reactor start-up fed with residues from sugarcane industry".*

1s/2021 Currently, the operation is being carried out in a reactor with co-digestion of vinasse, filter cake, and deacetylation liquor with the addition of nanoparticles, aiming to finalize step 3. Will also be asked FAPESP to extend the scholarship to finalize the proteomics analyzes and molecular biology.
The first Ph.D. article was published in the Bioresource Technology journal, entitled: "Anaerobic co-digestion of residues in 1G2G sugarcane biorefineries for

enhanced electricity and biomethane production". It is available at DOI: https://doi.org/10.1016/j.biortech.2021.124999

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Without a doubt, the biggest problem founded was the delay in experimental activities due to the closure of laboratories due to the coronavirus pandemic. With the ban on entry to the laboratories, the schedule was completely delayed, mainly the analysis of proteins and identification of the microbial community, making it necessary to request a scholarship extension to FAPESP. If the scholarship is not extended for another 12 months, the results of the molecular biology will be compromised and cannot be delivered as originally planned.

Ph.D. Candidate: Danielle Matias Rodrigues

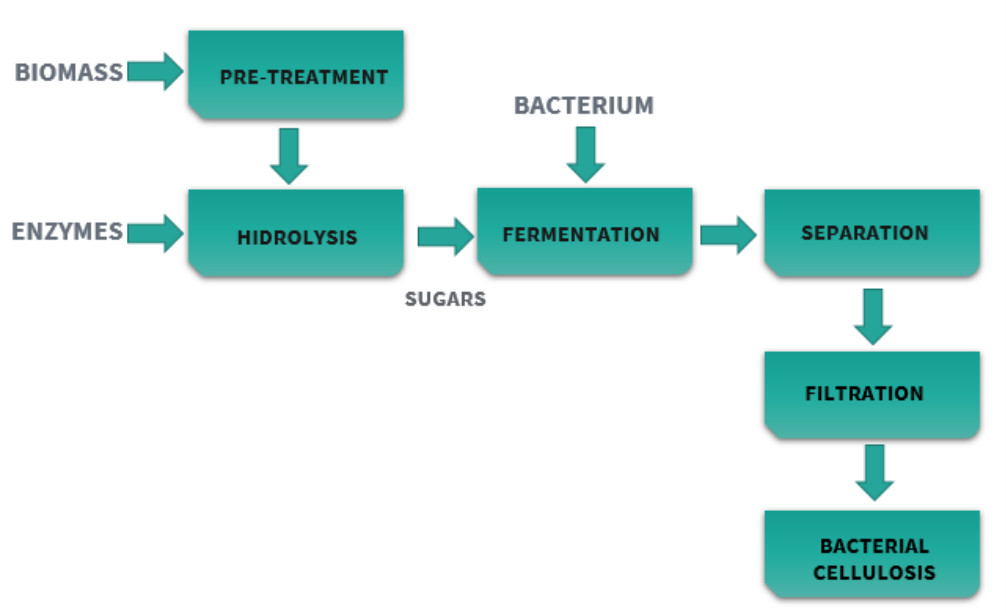
PERSONAL INFORMATION

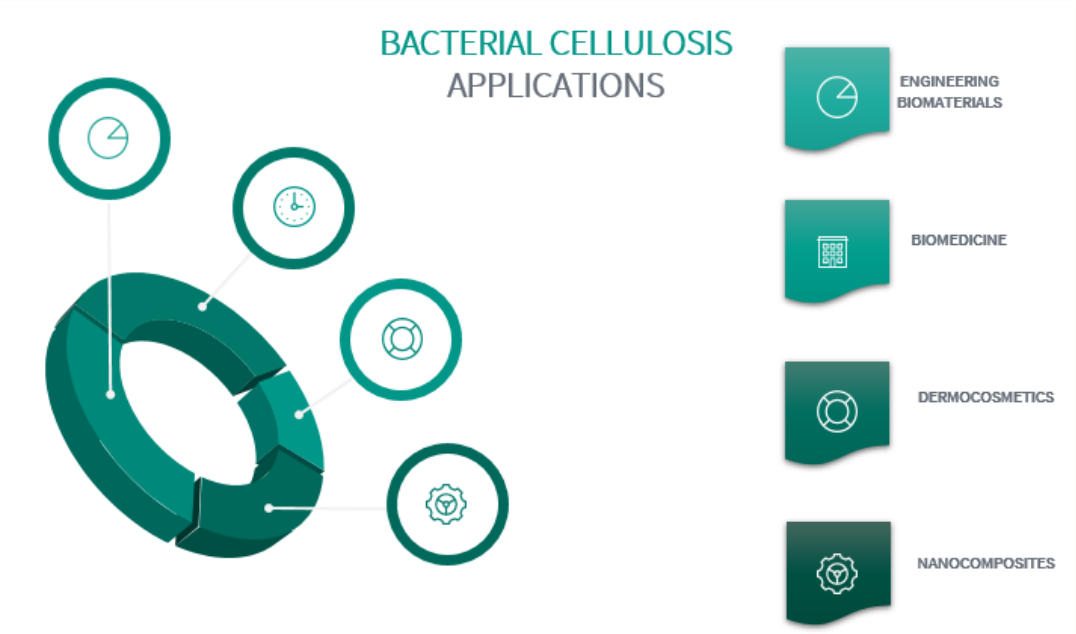
Advisor: Rosana Goldbeck
Funding source:
Admission: Março -2020
Probable completion date: Dezembro-2024
Lattes: http://lattes.cnpq.br/7484531764653005
LinkedIn: https://www.linkedin.com/in/daniellematias/

PROJECT TITLE

Production of bacterial nanocellulose from enzymatic saccharification of lignocellulosic biomass

PROJECT SUMMARY





MAIN RESULTS

• 1 Redirection of the theme, which resulted in better compliance and alignment with the research lines of the Department of Bioenergy

• 2 Construction of basic knowledge through bibliographic research

• 3 Survey and subsequent contact with a partner company (America Biomass Technologies-Portugal) that will contribute inputs for experiments and investigations that may prove to be interesting and pertinent

• 4 Intellectual production: Participation in a book chapter on the theme of biorefinery based on lignocellulosic biomass

• 5 Other contributions and achievements: Creation of the Masters Academy & Industry platform for sharing content related to the theme of Nanobiotechnology. The page currently has 354 followers located mostly in Brazil, Denmark and the United States who work in the sectors of biotechnology, technology centers, research and renewable resources

• 6 Participation in events: Valorization of lignocellulosic biomasses from agro-industrial residues through chemical and biotechnological platforms in biorefinery configurations (CONBIO- Congress of Engineering)

PROGRESSION

1st SEMESTER

Subjects taken

- 1. Biotransformation of agro-industrial products

- 2. Basics of biomass production

- Advance in project review

- Beginning of research related to bacterial nanocellulose

2nd SEMESTER

Subjects taken

- 1. Processes for transforming biomass into biofuels

- 2. Innovation and technology transfer - Participation in the book “Lignocellulose Bioconversion Through White Biotechnology”

- Chapter: Scale up process challenges in lignocellulosic conversion and possible solutions to overcome the hurdles - Change in the theme of the doctoral project

DIFFICULTIES FOUND AND PROPOSED SOLUTION

With the absence of face-to-face classes, I did not have the opportunity to take advantage of the excellent base of subjects linked to the course, since 70% of them related to practical classes in the laboratory and other atmospheres offered by Unicamp. The fear of changing the subject of the doctorate was a challenge because the main aspect of the project was changing the route to something different from what had already been done, however with the basis of the researches raised as well as the articles published by projects carried out within the institution. allowed to create a new safety margin for the execution of the project. The creation of this margin was possible with the help of the project's advisors, partners from other institutions and industry players.

Ph.D. Candidate: Fabricio Miguel Farinassi

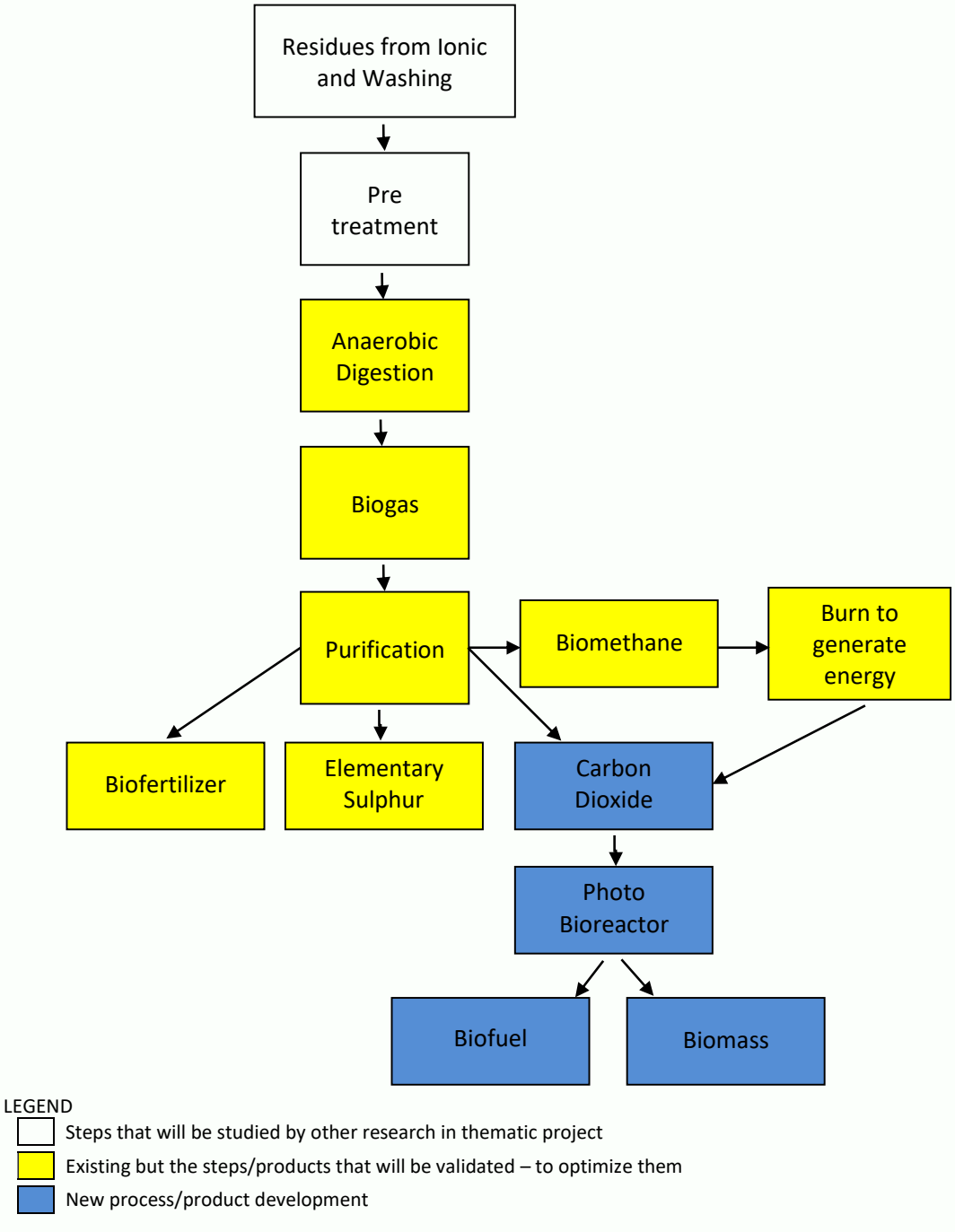
PERSONAL INFORMATION

Supervisor: Gustavo Mockaitis
Funding agency: None
Enrolment date: 03/2019
Conclusion (estimative): 03/2022
Lattes CV: http://lattes.cnpq.br/6762645710455013
LinkedIn: https://www.linkedin.com/in/fabricio-farinassi-b3a68014/

PROJECT'S TITLE

Development of a continuous system to generate biofuel from carbon dioxide from biogas

SUMMARY



The current studies of biogas are focused on biomethane production and purification, through the conversion of sulphidric acid into sulphur and fertilizer and the scrubber washing system to eliminate other compounds. Although the use of biogas has advantages over other renewable sources, it presents as a problem the generation of carbon dioxide that is not used and is discarded in the atmosphere. In addition, the very use and consumption of biomethane generates greenhouse gases during burning. It is necessary to eliminate or minimize the emission of GHG to increase the sustainability of waste energy recovery systems to generate biofuel, in accordance with principles of sustainable development. The hypothesis of the present project is to eliminate and/or minimize the CO_2 emissions and to reuse it as source of carbon to produce biofuel in a closed and balanced system cycle. The main expected result is to develop an innovative technology to use carbon dioxide as energy source. Other objectives are to develop a global process, in closed-cycle, of biomethane generation to eliminate the current technology problems involving limited application of technology and high investment and operational costs and to develop and to install a complete biomethane system in an industry and to create business to treat wastewater from agroindustry and sanitary companies to generate bioenergy, increasing the Brazilian industrial sustainability.

HIGHLIGHTS

- Development of a photobioreactor to convert carbon dioxide into biofuel
- Development of a closed cycle system to treat waste to generate energy and commercial byproducts
- Create a patent system and photobioreactor
- Solve a problem with lignocellulosic residues treating it
- Create an innovative technology to be applied to any organic residue

TIMELINE AND MAIN RESULTS

1s/2019	To take all the obligatory credits of the program – done Set the research program to a FAPESP themed project – done (cancelled) Conclude the research plan according FAPESP model – done
2s/2019	Participate in the mandatory qualification of the program – done Deliver English proficiency test – done Present the Research plan (Qualifying Exam) – done
1s/2020	Validate the techniques and technologies to biomethane production – on going Definition of the initial photobioreactor design – on going Experiments to produce and purify biogas and biomethane
2s/2020	Submission of article to a scientific magazine (A1 or A2) Construction of the photobioreactor Preliminary experiments to produce biofuel using carbon dioxide
1s/2021	Validate the techniques and technologies to biofuel production using carbon dioxide Preliminary experiments to produce biomethane from waste and biofuel from CO_2
2s/2021	Validate the integrated production of biomethane from waste and biofuel from CO_2 Basic and engineering project to photobioreactor construction (scale up) Qualifying Exam
1s/2022	Submission of photobioreactor to be patented (INPI) Pilot and/or industrial photobioreactor construction
2s/2022	Pilot and/or industrial photobioreactor construction and installation

CHALLENGES AND STRATEGIES TO OVERCOME THEM

CHALLENGE	STRATEGY TO OVERCOME IT
Generate biogas from residues of lignocellulosic material	Pretreatment in FAPESP thematic project and factorial experimental planning
To define and to use algae as main microorganism to use carbon dioxide to generate biofuel	To review all available literature and partnership with University of Cadiz and/or Netherland to define it
Integrate biogas production and purification with carbon dioxide use	Make exhaustive tests separately to optimize each of them and then integrate them

Ph.D. Candidate: Thiago Neitzel

PERSONAL INFORMATION

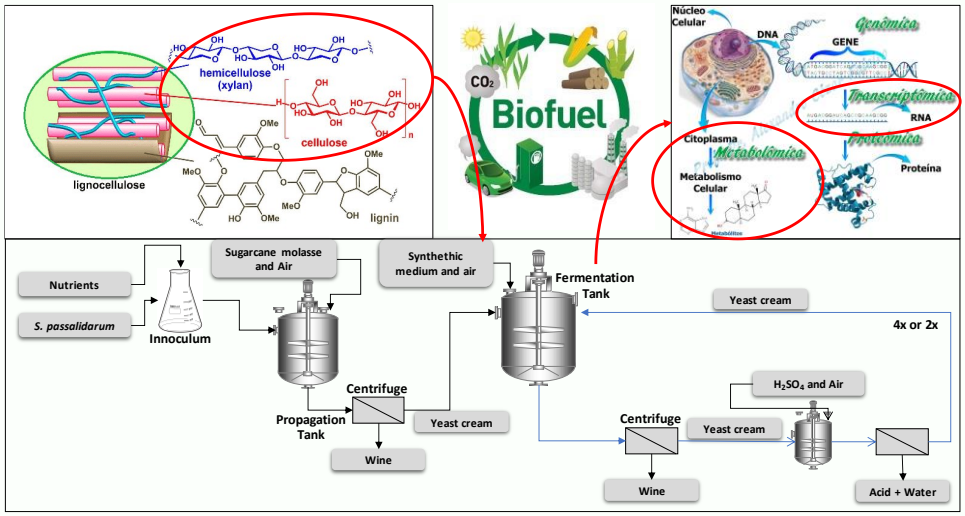
Supervisor: Dr. Professor Jaciane Lutz Ienczak
Co-supervisor: Dr. Leandro Vieira dos Santos
Funding agency: UNIVESP
Enrolment date: 03/2017
Conclusion (estimative): 05/2022
Lattes CV: http://lattes.cnpq.br/6888274785313835
LinkedIn: https://www.linkedin.com/in/thiago-neitzel-a881534a/

PROJECT'S TITLE

A kinetic and multiomic approach of *Spathaspora passalidarum* in the Mellet-Boinot process

SUMMARY

The aim of this work is to clarify the impact of the Melle-Boinot process on the physiologic behavior and performance of second-generation ethanol production by the native xylose-fermenting yeast *Spathaspora passalidarum*. The Melle-Boinot process consists of fed-batch fermentations with cell recycling and sulfuric acid cell refreshment, and it was performed in this study under three conditions: fixed temperature of 30 ºC, temperature decay of 1 ºC per cycle and fixed temperature of 27 ºC. Samples were collected during all cycles to determine fermentative and kinetic parameters; and to access molecular physiology by transcriptomics and metabolomics. A physiological adaptation was observed throughout the recycles under all conditions regardless of the temperature applied, as confirmed by the improvement in the kinetic and fermentation parameters. Regarding the fixed 30 ºC condition, the best condition of this study for industrial application, an increase from the first to the last fermentation cycles on ethanol yield (from 68.87± 3.17 to 90.75± 6.95 %), ethanol volumetric productivity (from 1.34± 0.01 to 1.79± 0.13 $g.L^{-1}.h^{-1}$) and ethanol titer (from 33.29± 0.88 to 44.46± 3.56 $g.L^{-1}$) was observed, respectively. By RNA-seq it was observed that a gene modulation was achieved from the third cell recycle onwards by the number of differentially expressed genes (DEGs) among those samples and this regulation was maintained afterwards. Analysis of DEGs during the process implied in the up-regulation of genes from ATP synthesis, N-Glycan biosynthesis, oxidative phosphorylation and purine metabolism, indicating as important mechanisms for better performance and rapid adaptation throughout recycles. Moreover, the TCA cycle anabolic pathway, gluconeogenesis, glycogen and trehalose biosynthesis, fatty acid and sterol biosynthesis were also relevant. The metabolomics analysis is still on progress. The achieved results demonstrate that the Melle-Boinot fermentation process is a worthy strategy to be applied on 2G ethanol production by native yeasts and elucidate the microbial molecular physiology of xylose conversion providing relevant insights for metabolic engineering in the field of 2G ethanol production.



HIGHLIGHTS

- Three temperature strategies were studied: fixed temperatures and temperature decay.
- Fermentative and kinetic parameters increased throughout the cycles for all conditions.
- Maximum ethanol yield and productivity of 91% and 1.79 g $L.h^{-1}$obtained, respectively.
- Melle-Boinot confirmed as a good strategy for 2G ethanol industry with *S. passalidarum*.

TIMELINE AND MAIN RESULTS

2s/2019

RNA-seq data analysis;
Metabolite extraction and concentration from samples gathered throughout fermentative experiments;
Submission of the paper "Impact of the Melle-Boinot process on the enhancement of second-generation ethanol production by *Spathaspora passalidarum*" on the Renewable Energy journal with results from Chapter 2 of my thesis;
Oral and poster presentation during the Brazilian Center for Research in Energy and Materials' Students Congress
Acted as a tutor on the Virtual University of Sao Paulo (UNIVESP) throughout the whole semester on courses such as: Chemistry, Transport Phenomena and Calculus III.

1s/2020

Concentration of metabolites extracted from samples collected throughout fermentative experiments;
Elaboration of a review paper regarding the wild yeast *Spathaspora passalidarum;*
RNA-seq data treatment and analysis;
Acted as tutor on the Virtual State University of São Paulo (UNIVESP) throughout the whole semester on the following courses: Math Education, Calculus I and II;

2s/2020

Submission of the review paper "Exploiting the Non-conventional Yeast *Spathaspora passalidarum* as a Platform for Hemicellulosic Hydrolysate Conversion into Bioproducts: a Mini Review" on the Bioenergy Research Journal;
Execution and approval on the General Qualifying Exam;
Acted as a tutor on the Virtual University of Sao Paulo (UNIVESP) throughout the whole semester on courses such as: Economics Engineering, Calculus III and Statistics.

Papers Published:

Collograi, K. C., Pereira, I. D. O., Neitzel, T., Martinez-Jimenez, F. D., da Costa, A. C., & Ienczak, J. L. (2021). **Secretome analysis as a tool to elucidate bacterial contamination influence during second-generation ethanol production in a Melle-Boinot process.** *FEMS Yeast Research*.

Martinez-Jimenez, F. D., Neitzel, T., Biazi, L. E., Pereira, I. O., dos Santos, L. V., da Costa, A. C., & Ienczak, J. L. (2021). **Exploiting the Non-conventional Yeast *Spathaspora passalidarum* as a Platform for Hemicellulosic Hydrolysate Conversion into Bioproducts: a Mini Review.** *BioEnergy Research*, 1-20.

Lima, C. S., Neitzel, T., de Oliveira Pereira, I., Rabelo, S. C., Ienczak, J. L., Roberto, I. C., & Rocha, G. J. (2021). **Effect of the Sugarcane Bagasse Deacetylation in the Pentoses Fermentation Process.** *BioEnergy Research*, 1-13.

Neitzel, T., Lima, C. S., Biazi, L. E., Collograi, K. C., da Costa, A. C., dos Santos, L. V., & Ienczak, J. L. (2020). **Impact of the Melle-Boinot process on the enhancement of second-generation ethanol production by *Spathaspora passalidarum*.** *Renewable Energy*, *160*, 1206-1216.

CHALLENGES AND STRATEGIES TO OVERCOME THEM

The main challenges I had during this year was being able to focus considering the global pandemic caused by the COVID-19 and work on writing chapters 1 and 3 of my Thesis. Chapter 2 was almost done and was submitted for publication at the end of 2019 and accepted at the beginning of 2020. Also, all my experiments are finished so my energy has been focused towards writing of papers and chapters of my thesis, mainly Chapters 1 and 3. At the end of 2020 we finally submitted Chapter 1 of my thesis for

publication which consists of a review paper and it was accepted at the beginning of 2021. Also, we had a lot of problems regarding the LC/MS equipment in CNPEM regarding the metabolomics analysis of samples gathered throughout my experiments. We are still looking for a solution to this problem considering CNPEM is not an alternative anymore. At the moment, I'm focusing exclusively on finishing Chapter 3 of my thesis which consists of a paper with the results of the RNA-sequencing of samples collected during experiments done in 2018 and 2019.

Ph.D. Student: Adriana Mendes

PERSONAL INFORMATION

Supervisor: Prof. Marcelo Menossi Teixeira, Ph.D.
Funding agency: CNPq
Enrolment date: 03/2019
Conclusion (estimative): 03/2023
Lattes CV:
http://buscatextual.cnpq.br/buscatextual/visualizacv.do?id=K4819781U0
LinkedIn: https://www.linkedin.com/in/adriana-mendes-840444125/

PROJECT'S TITLE

Evaluation of transgenic sugarcane expressing the *HaHb4* gene related to drought tolerance

SUMMARY

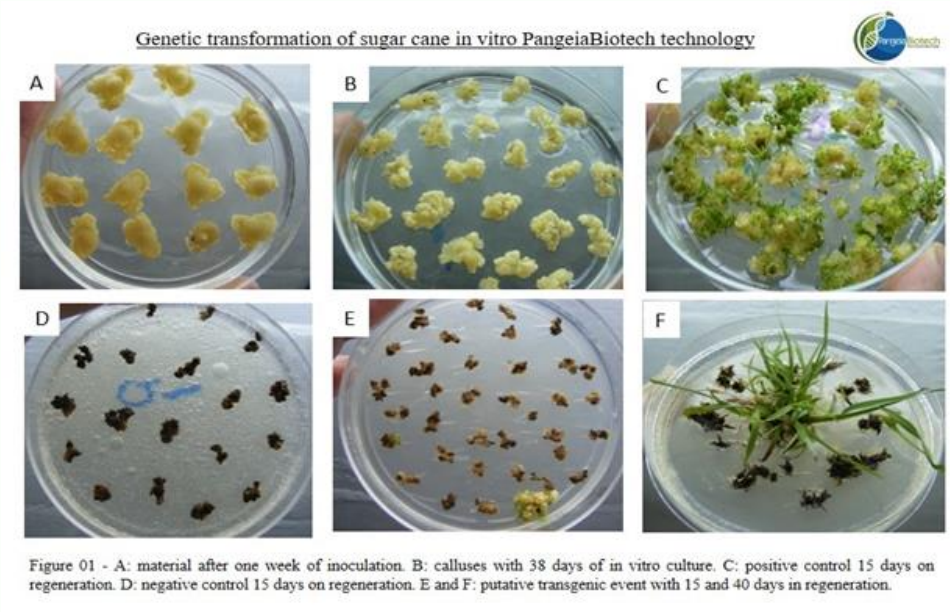


Figure 01 - A: material after one week of inoculation. B: calluses with 38 days of in vitro culture. C: positive control 15 days on regeneration. D: negative control 15 days on regeneration. E and F: putative transgenic event with 15 and 40 days in regeneration.

The production of sugarcane in Brazil, in the 2020/2021 harvest, was 642,069.7 million tons. Since its introduction in Brazil, it has been of great economic importance for the country due to the production of sugar and ethanol, both for import and export. Some of the most notable phenotypes in sugarcane plants exposed to water deficit are the reduction in stem length and tillering and the increase in leaf senescence, causing a decrease in the photosynthetic area. These factors are directly linked to the decrease in crop production and productivity. The gene *HaHb4* encodes a transcription factor (subfamily HD-ZIP 1) from sunflower that is induced in response to abiotic stresses, such as drought and salinity, and also by ethylene, abscisic acid and jasmonic acid. Transgenic *Arabidopsis thaliana,* soybean (*Glycine max*) and wheat (*Triticum aestivum*) overexpressing *HaHb4* showed higher tolerance to water deficit during the stages of vegetative development. As the *HaHb4* gene increased drought tolerance both in dicots and monocots, our hypothesis is that a similar protective effect will also be observed in sugarcane. We will overexpress *HaHb4* under the control of a constitutive promoter (pUBi from maize) as done in the three species above mentioned. We will also use the the *pZmRab17* promoter from maize, that is induced by water deficit, to lead the *HaHb4* expression mainly under stress conditions and our hypothesis is that this will produce an even better impact on the effects of the gene. These constructs will be transferred to sugarcane (SP80-3280) and energy cane (Vertix 2) using *Agrobacterium tumefaciens*.

HIGHLIGHTS

- Construction of two DNA vectors containing the gene *HaHb4*, under the control of the constitutive promoter pUBi and the *pZmRAB17*, induced by water deficit.
- To evaluate whether the overexpression of the gene *HaHb4* in sugarcane plants increases tolerance to water deficit in plants grown in a greenhouse.

TIMELINE AND MAIN RESULTS

1s/2019

 Subject BI001 – Fundamentals of biomass production

 Subject BI005 – Advanced Topics in Biofuel Manufacturing Processes

1s/2020

 Subject NV432 – Molecular bases of plant development

 From the *HaHB4* gene sequence that is publicly available, we synthetized the coding region. Two different gene constructs were produced: one containing a constitutive promoter *pZmUbi* and another containing the drought induced promoter, *pZmRab17.* The production of transgenic sugarcane plants (SP80-3280) with these two constructions is being carried out in collaboration which PangeiaBiotech (Campinas, Brazil).

2s/2020

 Qualification of area

 Initial molecular step

 Subject BI002 - Processes for the Transformation of Biomass into Biofuels

1s/2021

 Transformation genetic of sugarcane

2s/2021

 Cultivation of transformed plants

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: drought tolerant plant

Strategies: The overexpression of transcription factors under the control of constitutive promoters, such as pUBi, can cause pleiotropic effects. Therefore, we proposed the use of a drought-inducible promoter, *pZmRab17*. Some transgenes, namely those involved in gene regulations, such as transcription factors, need a fine tuning of the expression levels to get the desired phenotype. Since the insertion of the transgene is random, to increase the chance of having plants with the correct expression levels, we will obtain around 50 independent transformants for each construct.

Ph.D. Candidate: Maria Paula Giulianetti de Almeida

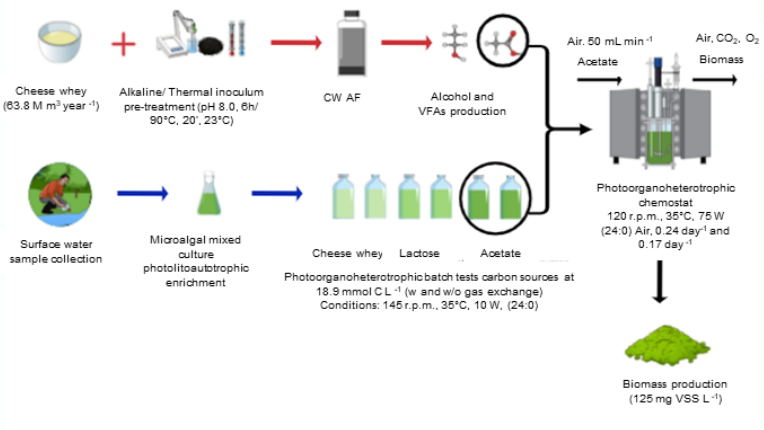
PERSONAL INFORMATION

Supervisor: Prof. Dr. Gustavo Mockaitis (Feagri – Unicamp)
Co-Supervisor: Prof. Dr. David Gregory Weissbrodt (TNW/EBT – TU Delft)
Financing source: PSDE (until 1st SEM. 2019)
Enrolment date: 02/2016
Defense date: 02/2022 (estimation)
Lattes: http://lattes.cnpq.br/7405931996056750
LinkedIn: https://www.linkedin.com/in/maria-paula-giulianetti-de-almeida-3a604841/

PROJECT TITLE

Microalgal-Bacterial
Coupling for The Valorisation of Cheese Whey Via Acidogenic Fermentation and Phototrophic Processes.

SUMMARY



Cheese whey (CW) is a by-product of the dairy industry presenting a high organic load. Currently, over 63.8 M m^3 $year^{-1}$ of cheese whey is transformed into low-added value products or discarded leading to water bodies eutrophication. Hence, CW surplus can serve as substrate for acidogenic fermentation (AF) for volatile fatty acids (VFAs) and alcohol production. VFAs (i.e., acetate) can be further valorised serving as an organic carbon source for microalgal mixotrophic biomass growth for biofuels production or other added-values products with industrial, pharmaceutical, commercial and environmental interests. Our project considers different selective pressures (i.e. inoculum pre-treatment, initial pH and headspace pressure) in anaerobic fermentation to increase VFAs and alcohol production in batches and microalgal phototrophic processes for the valorisation of cheese whey.

HIGHLIGHTS

- Systematic review of CW from its discovery to technologies available for its valorisation. Proposal for a closed-loop CW biorefinery. First manuscript to published in The *Evolving Scholar*, an open access preprint repository by TU Delft.
- Selective pressures are responsible for diverging metabolic pathways producing different VFAs spectra in batch assays. In special, inoculum thermal pre-treatment halts methanogenesis.
- Acetate is a suitable an organic carbon source for photoorganoheterotrophic microalgal biomass growth.
- A lower dilution rate of 0.17 d^{-1} sustained microalgal-bacterial symbiotic relationship producing 125 mg $_{VSS}$ L^{-1} of biomass with 95% of acetate consumption in a 2 L continuous-flow stirred-tank photobioreactor (CSTR).

TIMELINE AND MAIN RESULTS

2016

- Completition of all credits required by the programme (30 credits).
- Summer course: Biogas & Anaerobic Digestion Training Course, Unicamp/University of South Denmark (30h).
- Winter course: Communication & Policy for a Biobased Economy, Unicamp/TU Delft (60h).

2017

- Beginning of the experimental phase – Cheese whey AF and microalgal mixed culture cultivation
- Undergraduate student research programme daily supervisor in the CW AF project.
- High school student research programme (PIBIC-JR) daily supervisor in the microalgae project.

- Participation in the XXV Unicamp PIBIC Conference.
- Teaching Internship Programme (PED) – Fundaments of Microbiology and Water Quality.
- Summer course: Bioeconomy: Different Stakeholders - Different Perspectives, BBW FORWERTS, Germany (45h).
- I Bioenergy Symposium – participation on the symposium organisation and poster presentation.

2018

- Continuation of the experimental part of thesis
- Teaching Internship Programme (PED) – Laboratorial Practices for Environmental Research
- XIII Latin American Workshop and Symposium on Anaerobic Digestion (DAALXIII), Colombia – poster presentation.

2019

- Doctorate sandwich programme (PSDE-CAPES) at Delft University of Technology (TU Delft), The Netherlands in the 1st sem./ 2019 Co-supervisor: Prof. Dr. David G. Weissbrodt.
- Courses: Environmental Biotechnology (80h), Environmental Biotechnology and Microbiology (168h) and Predict-it! (22h) – TU Delft.
- Daily supervision of a master student on microalgal photoorgaonheterotrophic biomass production to valorise cheese whey.
- Anaerobic Digestion Conference – AD16. 16th IWA World Conference on Anaerobic Digestion. (Poster presentation). Participation as poster judge at AD16.

2020

- Data analysis, thesis writing and submission of first review in *The Evolving Scholar* preprint repository.
- Course: Effluents Treatments and Resource Recovery by Using Microalgae (1h).
- ACS Fall national Virtual Meeting and Exposition – Oral presentation.
- MELiSSA 2020 Conference (Oral presentation of our Research Group – Prof. Dr. David G. Weissbrodt).
- Daily supervision of a master student on mathematical model for microalgal mixotrophic triaglycerol production for CW valorisation.

2021

- Data analysis, thesis writing and manuscripts writing for journal submissions.
- Participation in the organising committee of the 9th Microbial Ecology & Water Engineering (MEWE) Specialist Conference of the international Water Association (IWA).

DIFFICULTIES FOUND AND PROPOSED SOLUTIONS

Challenge: Difficulty in finding specific chemical reagents for making the chosen microalgal growth media
Strategies: Getting donation from laboratories from different schools and institutes at Unicamp (i.e., FEA, FEQ, IQ). Importing of a specific chemical reagent not found in the country, which took 6 months.

Challenge: Microalgal mixed culture would not grow in with the conditions provided (i.e. medium and light regime).
Strategies: Change of cultivation media, light intensity and light regime.

Challenge: Difficulty in obtaining a light cabinet that would prevent any external light incidence during microalgal cultivation.
Strategies: Construction of a light cabinet made out of PIR plates.

Challenge: Light to be installed in the cabinet would not illuminate the CSTR as a whole.
Strategies: Loan of a light-jacket that provided continuous illumination in all sides of the reactor.

Challenge:
Strategies: Daily supervision of master students from abroad with weekly meetings and progress monitoring.

Challenge: Bacterial and microalgal cultures metagenomics analysis
Strategies: Collaboration with National Research Council Canada specialists on bioengineering and microbiology of wastewater systems.

Ph.D. Student: Jade Ribeiro dos Santos

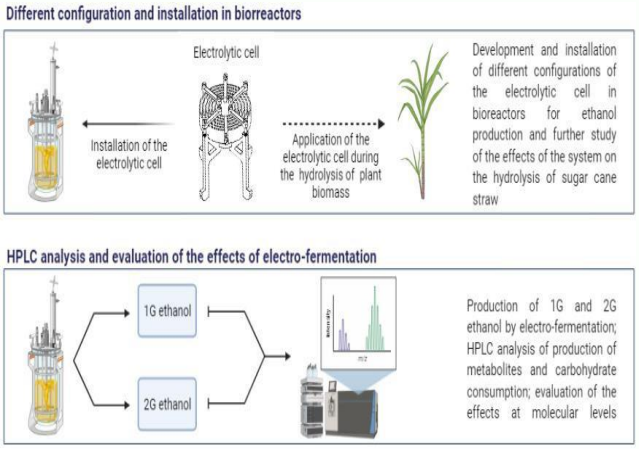
PERSONAL INFORMATION

Supervisor: Prof. Marcelo Falsarella Carazzolle, Ph.D.
Co-Supervisor: Prof. Gonçalo Amarante Guimarães Pereira, Ph.D.
Funding agency: CNPq
Enrolment date: 03/2020
Conclusion: 03/2025
Lattes CV: http://lattes.cnpq.br/2464397814073268
LinkedIn: http://linkedin.com/in/jade-ribeiro12

PROJECT'S TITLE

Development of a fermentation process for second generation ethanol production using a bioelectric system

SUMMARY



The second generation (2G) ethanol is based on the utilization of lignocellulosic biomass, mainly agro-industrial residues. The utilization of those residues allows an increase of ethanol production per planted area since it gives a new end for the waste materials. New technologies are being developed to enhance the production of bioproducts. One of those technologies is the electro-fermentation, a type of bioelectrochemical system. This system is based on the application of an electric current through an electrolytic cell used in the bioreactor during ethanol production, thus changing the redox balance, which influences the metabolic pathways of microorganisms, improving the fermentation process. This improvement can reduce the production costs, making ethanol more cost-competitive, what can reduce the utilization of fossil fuels. Aiming at this objective, this project consists of evaluating the effects of application of electrodes during fermentation for the production of 2G ethanol. It will be used two modified *Saccharomyces cerevisiae* strains capable of assimilate xylose; and the effects of the process at molecular levels will be evaluated.

HIGHLIGHTS

- It was observed a decrease in cell growth with the application of voltage during electro-fermentation for1G ethanol production;
- It was possible to produce the same amount of ethanol with less glucose consumption when a voltagewas applied;
- It was observed that the production of glycerol was slightly higher when a voltage was applied, comparedto fermentation without the use of the electrolytic cell;
- The growth of the modified *S. cerevisiae* strain is negatively affected by the presence of inhibitors,normally generated in the pre-treatment of biomass for the production of 2G ethanol

TIMELINE AND MAIN RESULTS

1s/2020

● Construction of the electrolytic cell

2s/2020

● Subject BI002 - Processes for the Transformation of Biomass into Biofuels;

● Subject NG110 - Special Topics in Genetics;

● Subject NG296 - Academic writing;

● Installation of the electrolytic cell and standardization of parameters;

● Comparative evaluation between fermentation and electro-fermentation based on the synthesis ofmetabolites during the production of 1G ethanol;

1s/2021

● Subject BI003 - Social, Economic and Environmental Sustainability;

● Evaluation of the best composition of the medium for use in the production of 2G ethanol applying differentvoltages in the bioelectric system;

● Study of the inhibitory concentration of a redox-mediating compound added in the medium;

● Analysis of the impact of the electro-fermentation on yeast metabolism

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: Acquisition of the lignocellulose biomass sugarcane straw.
Strategies: Partnership with the company GranBio, that provided sugarcane straw pretreated by steamexplosion.

Challenge: COVID-19 pandemic, that hindered the possibility to remain in the laboratory to carry out theexperiments.
Strategies: After a few months of the onset of the pandemic in Brazil, a schedule was organized withlaboratory collaborators to stay in the laboratory with reduced time.

Challenge: The increase in the resistance of the material used in the assembly of the electrolytic cell.
Strategies: Review the choice of the materials used in the project and promote others.

Challenge: The design of the electrolytic cell used in the experiments.
Strategies: Promote improved designs.

Ph.D. Candidate: Ana Beatriz Soares Aguiar

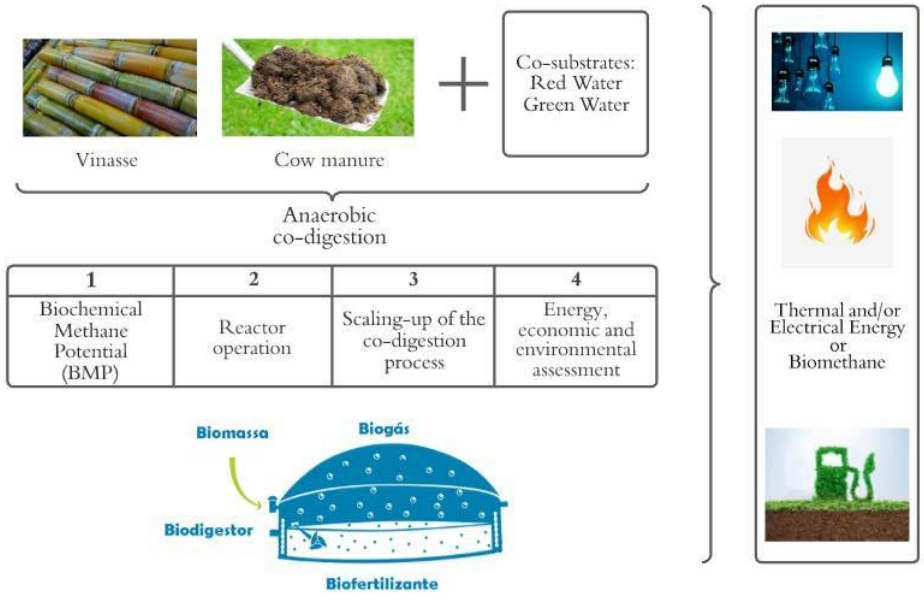
PERSONAL INFORMATION

Supervisor: Bruna de Souza Moraes, Ph.D.
Co-supervisor: Renata Piacentini Rodriguez,
Ph.D. Funding Source: Under analysis (FAPESP)
Admission: 03/15/2021
Probable completion date: 02/2025
Lattes: http://lattes.cnpq.br/7272812902289704
LinkedIn: https://www.linkedin.com/in/ana-beatriz-aguiar-13ba44131/

PROJECT'S TITLE

Biogas production from the integration of vinasse with livestock residues

SUMMARY



The vinasse generated in the ethanol and sugar production process is one of the main effluents in the system and requires adequate treatment. The same occurs with residues derived from livestock, which cause environmental impacts and must be treated before their final disposal. In this context, anaerobic digestion presents itself as an effective alternative in the treatment of these residues and, mainly, by the generation of by-products that can be used energetically, such as biogas. This work proposes the integration of the sugar-energy and livestock sectors through the co-digestion of its main residues, aiming at the production of biogas and its energyuse throughout the year.

HIGHLIGHTS

- Previous analysis of scenarios with different co-substrates from experiments carried out on a bench scale, which will be prospected based on information from the literature and Biochemical Potential of Methane (BPM) tests;

- Operation of bench-scale reactors (Continuous Stirring Tank Reactor - CSTR) to obtain systemoperating parameters;
- Planning the scale-up of the process developed on a bench;
- Energy, economic and environmental assessment throughout the entire project according toprospected scenarios and experimental results obtained.

TIMELINE AND MAIN RESULTS

1st semester of 2021:

- Subject BI001 – Fundamentals of biomass production
- Subject BI010 – Industrial Processes of Biomass Conversion and Energy Planning
- Subject BI011 – Seminars on Bioenergy and Bioeconomic
- Reading and bibliographical survey about the

research.2nd semester of 2021:

- Subject AA002 – Doctoral thesis
- Subject BI002 – Processes for the Transformation of Biomass into Biofuels
- Subject IC777 – Anaerobic Biological Systems and Processes
- Reading and bibliographical survey about the research.

Ph.D. Candidate: Fabiane Moreira Vieira

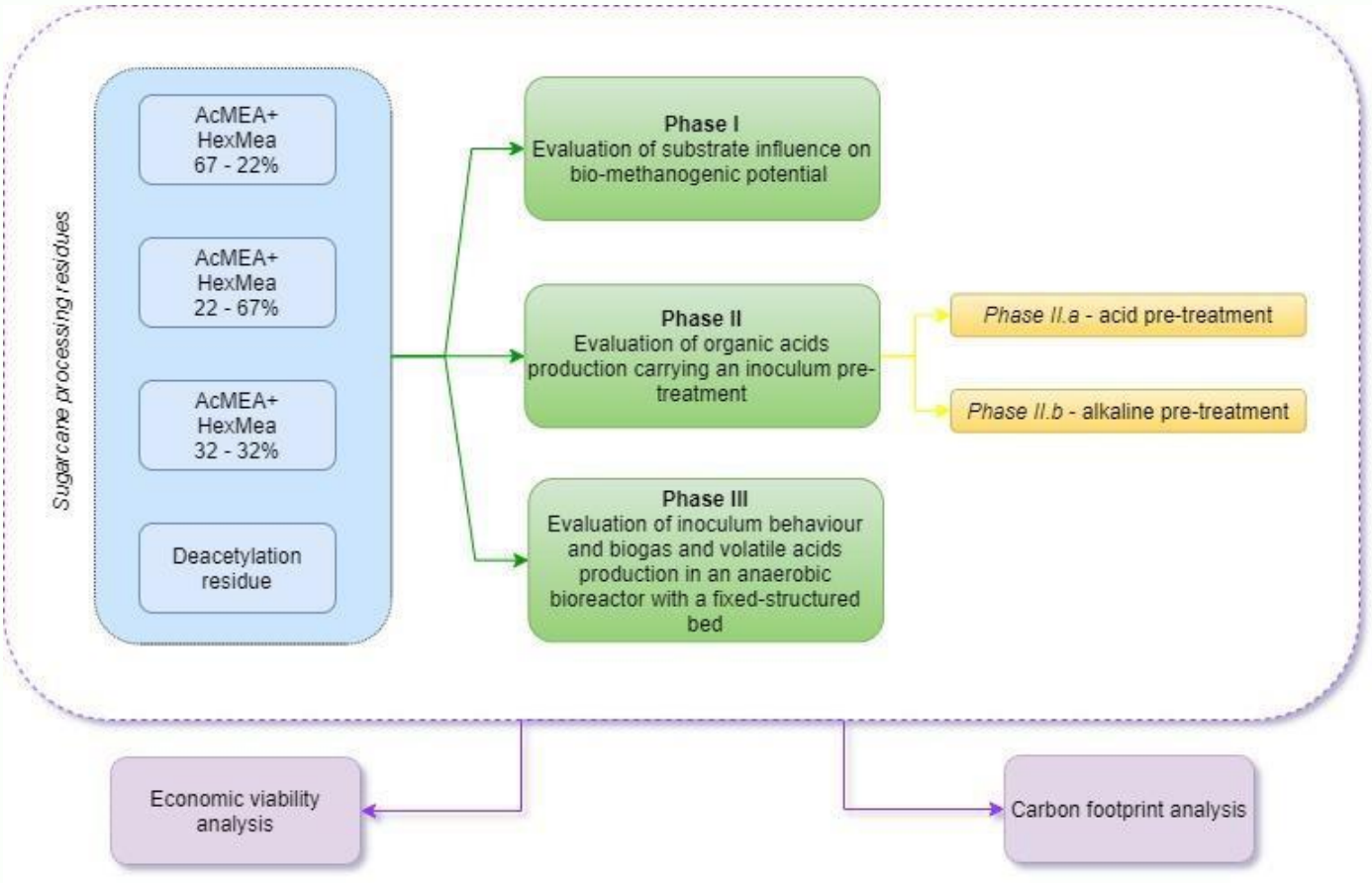
PERSONAL INFORMATION

Supervisor: Prof. Dr. Gustavo Mockaitis
Funding agency: Capes
Enrolment date: 02/2019
Conclusion: 05/2024
Lattes CV: http://lattes.cnpq.br/6636509165662371
LinkedIn: www.linkedin.com/in/fabianemoreiravieira

PROJECT'S TITLE

Biogas and volatile acids production by anaerobic digestion of biomass obtained from sugarcane processing residues.

SUMMARY



HIGHLIGHTS

- Innovative in terms of utilization of substrates
- Use of agricultural waste processing residues that are difficult to handle for disposal
- Cheaper method to obtain biogas and volatile acids.

TIMELINE AND MAIN RESULTS

1s/2019 Ph.D. candidate is completed the following subjects:

- BI003
- BI005

2s/2019 Ph.D. candidate completed the following subjects, and it was supposed to start in the laboratory at the end of the semester.

- BI001
- TP319

Due to the Covid-19 pandemic and the restrictions imposed by the University of Campinas it was not possible to start the experiments so far. That is why the Ph.D. candidate is working from home in paper writing. The student is also taking classes in a biogas expertise course.

1s/2020 PED C (internship) and paper writing.

2s/2020 Paper writing and biogas expertise course.

- PIBIC-EM guidance

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Although the experiments were not started yet, the Ph.D. candidate is writing a review entitled "Potential Assays in Anaerobic Digestion: kinetics, variable screening, optimization, and microbiological assessment" which allows the student to perform a deep review about her subject of study even though it is not possible to attend the laboratory frequently.

Ph.D. Candidate: Francisco Lucas Chaves Almeida

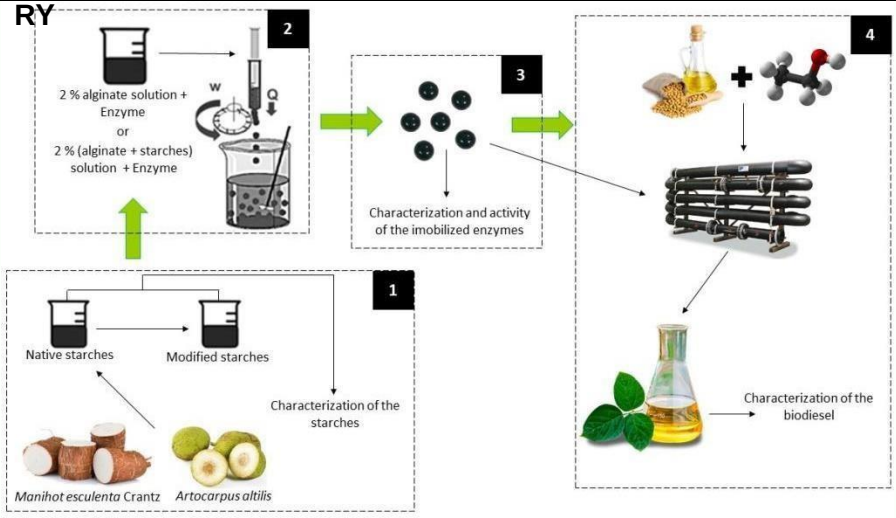
PERSONAL INFORMATION

Supervisor: Prof. Marcus Bruno Soares Forte, Ph.D.
Co-Supervisor: Profa. Ana Sílvia Prata, Ph.D.
Funding agency: FAPESP
Enrolment date: 02/25/2019
Conclusion (estimative): 02/2024
Lattes CV: http://lattes.cnpq.br/0850652772061818
LinkedIn: https://www.linkedin.com/in/francisco-lucas-chaves-almeida-b1a128150/

PROJECT'S TITLE

Immobilization of lipase by jet cutter technique and biodiesel production using the biocatalyst in tubularreactors

SUMMARY



The use of lipases as a biocatalyst for industrial applications is an interesting route due to technical aspects but also to reduce environmental impacts caused by the use of chemical catalysts. Gel immobilization of the enzyme allows its reuse and avoids contamination of the product with residual portions of free enzyme. However, a typical technique available for enzyme immobilization is based on dripping driven by gravity, which produces big particles and low rate of production. The reduction of size can improve the mass transfer by increasing the contact area. Thus, aiming to increase the rate of particles production and reduce the size ofparticles, the objective of this work is to encapsulate lipase, using a tool designed to cut the jet produced by pumping, called as Jet Cutter and its application for biodiesel production in tubular reactors.

HIGHLIGHTS

- Production of high amount of particles of low rate and high the contact area what present satisfactory results for esterification activity; immobilization yield; activity expressed and recovered activity;
- Understand the behavior of enzyme inside of microcapsule per medium of confocal laser scanning microscopy, and evaluate a possible relation (positive or negative) from this behavior with the production of biodiesel in tubular reactors;
- Diminution of financial costs of process of immobilized, through the substitution of sodium alginate per native and modified starches of cassava and breadfruit
- To study the best conditions (temperature, oil/alcohol ratio and surface velocity) to convert biodiesel from vegetal oil in tubular reactors;
- Biodiesel production in tubular reactors with the use of immobilized lipases as biocatalyst and characterize the biodiesel by chromatographic analysis.

TIMELINE AND MAIN RESULTS

1s/2019

- Subject TP109 – Analysis of food from chromatography
- Subject TP359 – Biotechnology production of ingredients for food industry

2s/2019

- Teaching Training Internship (Metabolic Engineering)
- Subject TP357 – Microencapsulation applied to Food and Nutrients
- Qualification of area (Work Plan) – Approved
- Course of "Biotechnological tools related to the production of biofuels" - Center for Research andDevelopment in Industrial Fermentations/ La Plata – Argentina

1s/2020

- Development of the first article (review) of the thesis that has been published in Journal of Biofuels, Bioproducts & Biorefining (Biodiesel production by lipase-catalyzed reactions: bibliometric analysis and study of trends);
- Development of testes concerning the methodology to measure the lipase activity (titrimetric method) and biodiesel characterization (High-Performance Liquid Chromatography)

2s/2020

- Subject TP121– Topics on Food Engineering (Scientific Writing)
- Subject BI002- Biomass Transformations Processes in Biofuels
- Subject QBQ2502 – Enzymology (University of São Paulo- USP)
- Development of the second article (Review) of the thesis that has submitted in the Journal Process Biochemistry (Trends in lipase immobilization: Bibliometric review and patent analysis)
- Scientific Initiation Project Submission (Validity from 2020-2021)

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: Acquisition of starches raw materials.

Strategies: Partnership with group of research in food science and technology coordinated Profa. Dra. Elisândra Costa Almeida, of Department of management and agroindustrial technology of Center for Human, Social and Agrarian Sciences of Federal University of Paraíba, and send of search project of scientific initiation for obtention and modification of starches.

Challenge: Maintenance of glutaraldehyde functions (added to immobilization solution) when modified alternative starches replaces sodium alginate.

Strategies: Production of modified starches, which could provide the glutaraldehyde function and/or may provide the same glutaraldehyde-alginate interaction.

Challenge: Pandemic of Covid-19 that has interfered in the previously planned schedule.

Strategies: Use of the methodology of Design of Experiments to understand the main factors to be studied in the process.

Ph.D. Candidate: Aglaer Nasia Cabral Leocádio

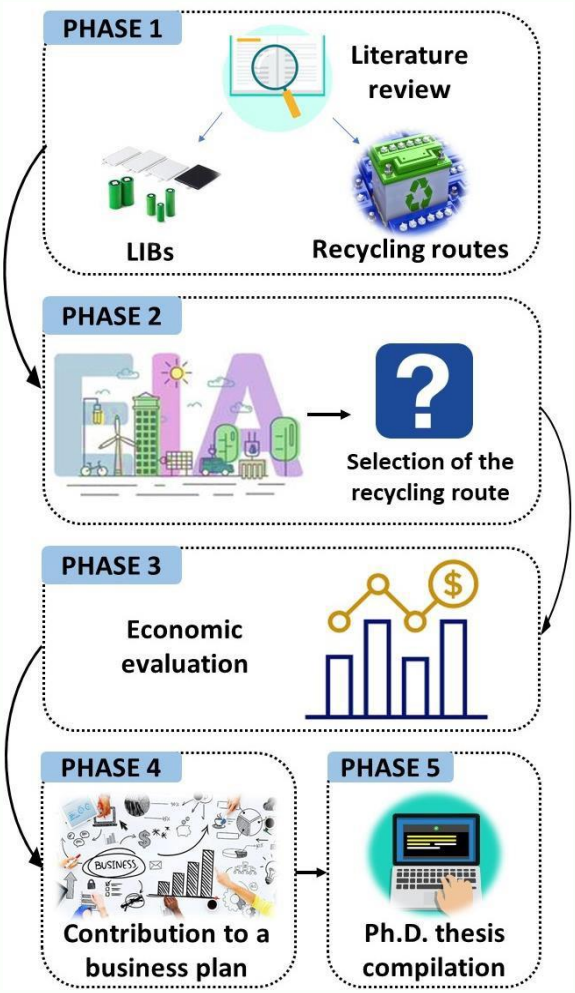
PERSONAL INFORMATION

Advisor: Carla Kazue Nakao Cavaliero
Supervisor partner company: Gustavo Tineli**Funding Source:** DAI-CNPQ
Course entry: 2019.2
Probable completion date: 2023.2
Lattes: http://lattes.cnpq.br/1173564515043744
LinkedIn: https://www.linkedin.com/in/aglaercabral-0b875712b/

TITLE OF WORK

Proposals to development of a sustainable recycling chain of Lithium-Ion Batteries in Brazil.

PROJECT SUMMARY (Graphic Summary)



The first phase is intended for an in-depth study based on a literature review on LIBs (composition, production, use phase and end-of-life), and on their recycling routes (technical, economic and environmental aspects). The second phase focuses on the technical and environmental assessment of recycling routes based on the Brazilian context, using life cycle assessment tools. This phase will also provide preliminary information on the structure of the battery recycling industry in Brazil, which will be needed for the third phase. After that, select the best recycling route under technical-environmental assessment. The economic evaluation of the recycling route will take place in the third phase. These assessments aim to provide contributions to the development of your business plan, which will be highlighted in the fourth phase. The final phase corresponds to the compilation of the thesis.

MAIN RESULTS

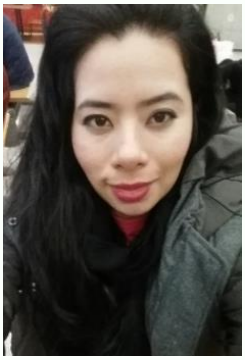
- Completion of the courses of the Ph.D. Program in Bioenergy.
- Literature review on LIBs and recycling routes.
- Virtual presentation on the recycling routes of the LIBs for the ITEMM team.
- Contribution to the writing of subtopic of a book chapter (in Portuguese- *Direito à Energia Elétrica e Potenciais Impactos Ambientais e Sociais*).
- Contribution to the writing of the scientific article for the Brazilian Congress on Energy Planning (in Portuguese – *Oportunidades de segunda vida de baterias veiculares aplicadas no Brasil*).

PROGRESSION

1st semester	Courses of the Ph.D. Program in Bioenergy.
2st semester	Courses of the Ph.D. Program in Bioenergy. Literature review on LIBs and recycling routes. Contribution to the writing of the scientific article for the Brazilian Congress on Energy Planning (in Portuguese – *Oportunidades de segunda vida de baterias veiculares aplicadas no Brasil*).
3st semester	Courses of the Ph.D. Program in Bioenergy. Contribution to the writing of subtopic of a book chapter (*in Portuguese- Direito à Energia Elétrica e Potenciais Impactos Ambientais e Sociais*).

DIFFICULTIES FOUND AND PROPOSED SOLUTION

The main difficulty are the consequences of the pandemic situation in which we find ourselves and the restrictions of physical contact adopted by all, with the intuition of combating the spread of COVID-19, thus, the face-to-face activities that had been aligned with the ITEMM team, were made impossible and converted into virtual meetings.



Ph.D. Candidate: Carla Isabel Flores Rodríguez

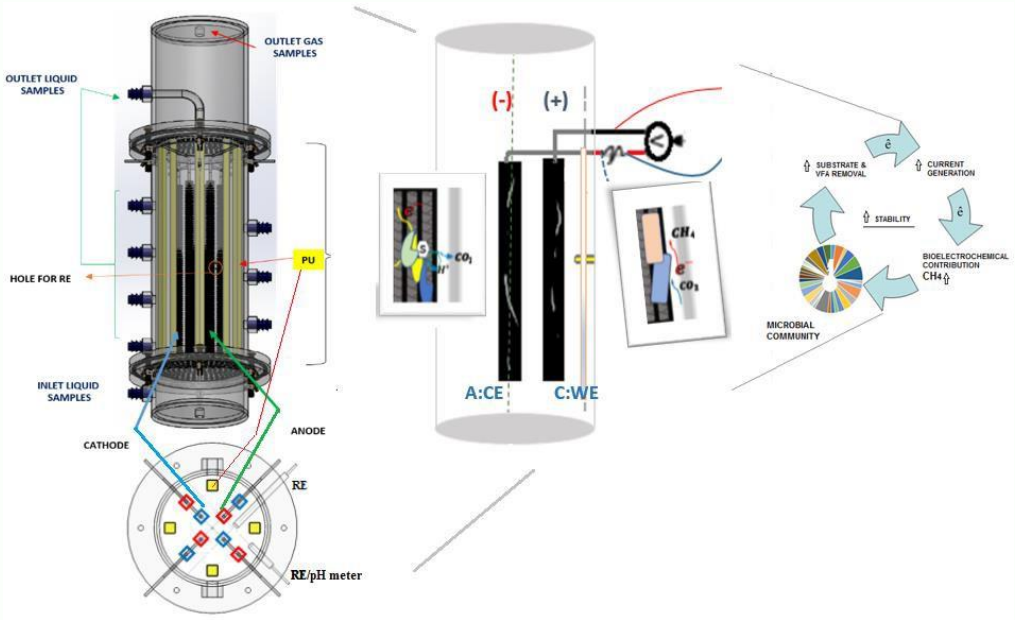
PERSONAL INFORMATION

Supervisor: Gustavo Mockaitis
Funding agency: FAPESP
Enrolment date: 25/02/2019
Conclusion (estimative): 2023
Lattes CV: http://lattes.cnpq.br/1519282614635667
LinkedIn: www.linkedin.com/in/carla-flores-78234912b

PROJECT'S TITLE

Development of a fixed –structured bed reactor with assisted electron transfer for biogas production and wastewater treatment

SUMMARY



Anaerobic digestion (AD) has been widely used to generate methane biogas from organic wastes. The applicationof AD is still limited, owing to the low removal of organic matter, the increased, HRT, neutral pH, and specific chemical contents (ammonium ions, C:N ratio, and volatile fatty acids [VFAs]). To overcome these drawbacks, this study aims to combine the advantages of an up-flow fixed structure bed reactor with the insertion of conductive support material (electrodes). The combination could alters the microbial community, increase the kinetics of electron transfer and drives thermodynamically unfavorable reactions, and thus favor the substrate degradation and bioconversion. Electric stimulations (1.0 – 1.5 V) within the range required for the microbial substrate oxidation will be applied for the bioconversions into biogas production. Chemical and bioelectrochemical behaviours will be measured. The biofilms will be sampled for microbial community analysis.

HIGHLIGHTS

- Design and construct of hybrid reactors.
- Construct a potentiostate and a digital multimeter with data acquisition to measure bioelectrochemical behaviors on the biofilm.
- Read and write the application of artificial neural networks on anaerobic digestion.
- Enhance the prospects for developing hybrid anaerobic reactors at full scale, and producing specialized biofilms as seed granules for industrial application.

TIMELINE AND MAIN RESULTS

1s/2020

1. Proposal Qualification
2. Classes suggested by the advisor
3. Reactor design in solidworks software

2s/2020

1. Construction of reactors
2. Procurement/purchase of electrodes and other importat materials
3. Construction of potentiostate
4. Construction of digital multimeter with data acquisition
5. Software development for data acquisitions
6. Review and write a paper on the use of Neural Networks in AD

CHALLENGES AND STRATEGIES TO OVERCOME THEM

- Not able to buy equipment (dependence on the lab administration, currency change and pandemic)
- limited access in the lab

Ph.d. Candidate: Tomaz Carraro Pereira

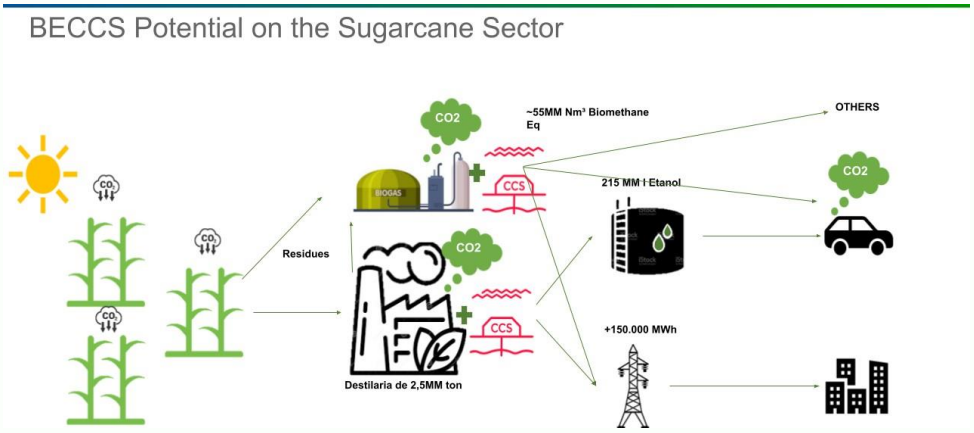
PERSONAL INFORMATION

Academic Advisor: Gustavo Mockaitis (interin) / Marcelo Cunha (accreditation process)
Financing: Personal financing (no scholarship)
Admission: 1st Semester 2021
Estimated Conclusion date: 4th Semester 2024
LinkedIn: https://www.linkedin.com/in/tomaz-pereira-a6408a116/

PROJECT TITLE

Assessment of the Environmental and Socioeconomic Potential of Bioenergy with Carbon Capture and Storage in the Brazilian Economy

PROJECT SUMMARY



The project aims to evaluate BioEnergy with Carbon Capture and Storage ("BECCS") potential in the sugarcane sector.
This industry has the potential to utilize BECCS technologies on several steps of its process, such as ethanol fermentation, biomass combustion in the cogeneration, in the biomethane production from residues and other possible routes.
After evaluating the mostpromising routes, we will assess the conditions for inserting the technology in the Brazilian context and its potential environmental and socioeconomic impacts in the Brazilian economy.

MAIN RESULTS

The final project of PP590 - TOPICS in GEOENGINEERING OF RESERVOIRS "An introduction to Carbon Capture, Utilization and Storage", my group conducted a partial LCA of Blue Hydrogen Production from Natural Gas and Biomethane with focus on the Brazilian Scenario. Our main result obtained was that biomethane combined with CCS has a very high potential for delivering negative emissions. This result was obtained for hydrogen production, but can be expanded for several other projects that utilize hydrogen in a central facility with pre or post capture technologies

PROGRESSION

First Semester: Completion of two courses (PP590 and LBE5001) and literature review

MAIN CHALLENGES

Difficult to consult databases such as Ecoinvent to perform Life Cycle Assessment studies. Currently I am trying toaccess the database utilizing UNICAMP.

Ph.D. Student: Lais Albuquerque Giraldi

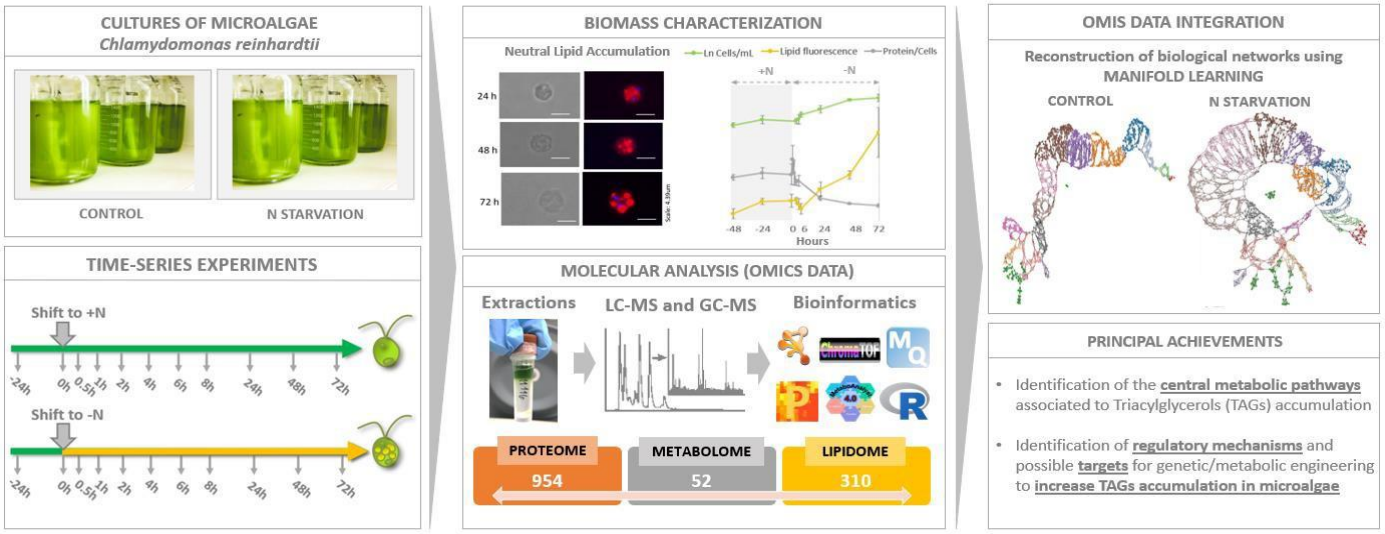
PERSONAL INFORMATION

Supervisor: Prof. Flavia Vischi Winck, Ph.D.
Funding agency:
FAPESP
Enrolment date:
02/26/2016
Conclusion: 08/2021
Lattes CV: lattes.cnpq.br/3929331353992184
LinkedIn: linkedin.com/in/laís-albuquerque-giraldi-49ab74a9

PROJECT'S TITLE

Integrative analysis of proteomics, metabolomics and lipidomics to study the accumulation of neutral lipids inthe microalgae *Chlamydomonas reinhardtii*

SUMMARY



Due to the greenhouse gas emissions reduction goes and the high capacity to accumulate neutral lipids, microalgae have gained interest by the bioenergy sector in the last decade, in order to produce biodiesel. However, in general, high neutral lipid concentrations and high biomass productivity are inversely correlated, therefore, genetic and bioprocess improvements are needed to make the microalgal biomass usage viable and commercially competitive. The aim of the study was to investigate, through an omics data integrative approach, the accumulation of TAGs (Triacylglycerols) in response to N starvation in photoautotrophic condition in *Chlamydomonas reinhardtii*. Time series experiments (with 10 time points) were performed to detect alterations in the proteome, metabolome and lipidome. The biological networks indicated that metabolic pathways of gluconeogenesis, ATP generation process, light reaction in photosynthesis and Arg biosynthetic process were central in the response to N starvation. The nuclear proteome results revealed regulatory mechanisms and novel targets for metabolic/genetic engineer to improve growth and TAGs accumulation. These findings expanded the current knowledge about the molecular mechanisms that lead to the accumulation of TAGs in *C. reinhardtii* under photoautotrophic condition.

HIGHLIGHTS

- A systems biology approach, using multi-omics integration, is essential to generate information and understand the mechanisms involved with the accumulation of Triacylglycerols (TAGs) in microalgae.
- The reconstruction of biological networks (using proteomics, metabolomics and lipidomics) and the nuclear proteome revealed central metabolic pathways, regulatory mechanisms and novel targets associated to N starvation response and TAGs accumulation in microalgae under photoautotrophic condition.

● Our data suggest that N deprivation induces a two-stage regulatory response in the microalgae cells, targeting cell growth control in a first moment followed by regulation towards photosynthesis, amino acids biosynthetic processes, autophagy, and oxidative homeostasis in a second regulatory step which will affectlipids accumulation.

TMELINE AND MAIN RESULTS

2016

- Subject BI001 – Fundamentals of biomass production
- Subject LBE5003 – Social, economic, and environmental sustainability
- Subject NG277 - Principles and Applications of Systems Biology in Plant Physiology (UNICAMP)
- Subject QBQ5802 - Methodologies in Biochemistry and Molecular Biology: Concepts and Applications(Institute of Chemistry - USP)
- Ph.D. FAPESP scholarship was approved (Process 2016/19152-3)

2017

- Supervised Internship in Teaching (PAE) – Subject QBQ0116 Biochemistry: Biomolecules Structureand Metabolism, Institute of Chemistry – USP.
- Tests and development of protocols such as nuclei enrichment protocol, neutral lipid fluorescence, biomolecules extraction and separation (proteins, metabolites, and lipids) and cell counting.
  Time-series experiments in photoautotrophic condition under N starvation and control.Proteomics analysis using UPLC-QTOF-MS (IQ-USP)
  Proteome identification and statistical analysis.

2018

- Paper accepted to publish in collaboration: *Anaerobic phototrophic processes of hydrogen productionby different strains of microalgae Chlamydomonas sp* (doi: 10.1093/femsle/fny073)
- Qualification exam approved.
- Research internship abroad scholarship approved (BEPE-FAPESP) for 9 months at Max PlanckInstitute of Molecular Plant Physiology (MPI-MP), Potsdam, Germany.
- Metabolomics and lipidomics analysis using GC-TOF-MS and UPLC-TOF-MS
- (MPI-MP).Identification and statistical analysis of the metabolome and lipidome.

2019 - 2020

- Paper accepted to publish in collaboration: *A Multi-Omics Extraction Method for the In-Depth Analysis of Synchronized Cultures of the Green Alga Chlamydomonas reinhardtii* (doi:10.3791/59547).
- Paper accepted to publish in collaboration: *Analysis of autotrophic, mixotrophic and heterotrophicphenotypes in the microalgae Chlorella vulgaris using time-resolved proteomics and transcriptomicsapproaches* (doi: 10.1016/j.algal.2020.102060).
- Omics integration and reconstruction of biological nerworks using Manifold Learning

2021

- Thesis writing and defense.

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: Due to the absence of laboratory in the first year (2016) and start of operation of the Laboratoryof Regulatory System Biology (LABIS) (2017), we had problems with infrastructure, lack of equipments andreagents.
Strategies: Collaboration with other research groups from USP and UNICAMP (Prof. Telma Teixeira, Prof.Glaucia Mendes, Prof. Pio Colepcolo and Prof. Flavia Meiotti) and use of the IQ-USP infrastructure.

Challenge: Uncertainty of the Arg metabolic pathways up regulation specificity for the N-

deprivationresponse and TAGs accumulation.
Strategies: It was performed experiments with Arg supplementation and a metanalysis of previous *C.reinhardtii* transcriptomic data under several abiotic stress.

Challenge: Difficult with the analysis and integration of the omics data
Strategies: Participation in EMBL-IB (UK) course related to network analysis and collaboration with experts in bioinformatics (Prof. Diego M. Riaño-Pachon, Rodrigo Dorado Goitia, Dr. Alexandre V. Fassio,Dr. Pedro M. Martins).

Ph.D. Student: Maria Fernanda Sua Rojas

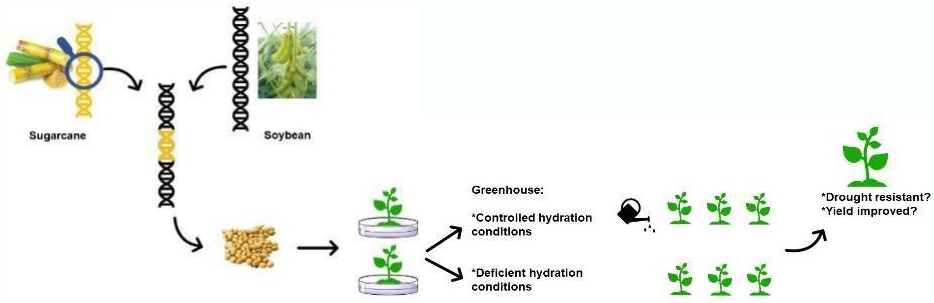
PERSONAL INFORMATION

Supervisor: Marcelo Menossi, Ph.D.
Co-Supervisor: Lucia Mattiello, Ph.D.
Funding agency: CNPq
Enrolment date: August/01/2019
Conclusion (estimative): August/2023
Lattes CV: lattes.cnpq.br/5221411135509102
LinkedIn: linkedin.com/in/ maria-fernanda-súa-rojas-2aa708158

PROJECT'S TITLE

Evaluation of transgenic soybean expressing genes related to drought tolerance for the increase of agricultural sustainability

SUMMARY



Brazil is projected to be the largest soybean (*Glycine max* (L.) Merril) producer in the world in 2020/21. The potential soybean productivity is influenced and often limited by various abiotic and biotic factors throughout the crop cycle. We have identified several genes from sugarcane that are able to increase the tolerance to water deficit, salinity and oxidative stress in transgenic Arabidopsis, tobacco, and sugarcane plants. Our hypothesis is that the mechanisms controlled by these genes are conserved and the phenotypes observed in these three species could be reproduced in genetically modified soybean. Therefore, we aim to evaluate the tolerance to water deficit in transgenic soybean overexpressingfive sugarcane genes.

HIGHLIGHTS

- The vectors with the three expression cassettes of interest were transferred to *Agrobacterium tumefaciens* to transform the soybean half-seed cotyledonary explants.
- Soybean shoots from plants transformed with the positive control pCAMBIA3301 presented a GUSstaining, indicating they are transgenic.
- The PAT (phosphinotricine acetyltransferase) strip teste indicated that of some events transformed withone of the expression cassettes was positive, confirming the transgenic status.

TIMELINE AND MAIN RESULTS

2s/2019

- ✓ Subject QP464 - Special Topics in Interdisciplinary Chemistry II

1s/2020

- ✓ Subject BI001 - Fundamentals of Biomass Production.
- ✓ Subject BI003 - Social, Economic and Environmental Sustainability.
- ✓ Development of teste protocols to establishment the transformation of soybean with a controlvector.

2s/2020

- ✓ Soybean transformation protocol test with vectors carrying the genes of interest.
- ✓ Development of test protocols to improve the regeneration of wild type soybean tissues.
- ✓ Elongated and rooted wild soybean plants cultivated *in vitro* were obtained in our laboratory.
- ✓ Independent putative transgenic events were confirmed by GUS staining.

1s/2021

- ✓ Independent putative transgenic events with GUS positive staining were elongate.

2s/2021

- ✓ Independent putative transgenic events were confirmed by the PAT strip teste.

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: To obtain the fertile transgenic plants in the greenhouse
Strategies: Continue with the optimization of the protocol for tissue regeneration and selection of transgenic soybean, as well as with the improvement of the conditions of acclimatization to increase thesurvival of in vitro plants transferred to greenhouse.

Ph.D. Student: Marilene Pavan

PERSONAL INFORMATION

Academic Advisor: Prof. Dr. Gonçalo Pereira - UNICAMP **Co-advisors:** Dra. Simone Pereira / Dra. Carolina Grassi
Financing: self-financing
Admission: 1st Semester 2020
Estimated Conclusion date: 2nd Semester 2023
LinkedIn: https://www.linkedin.com/in/marilene-pavan/

PROJECT TITLE

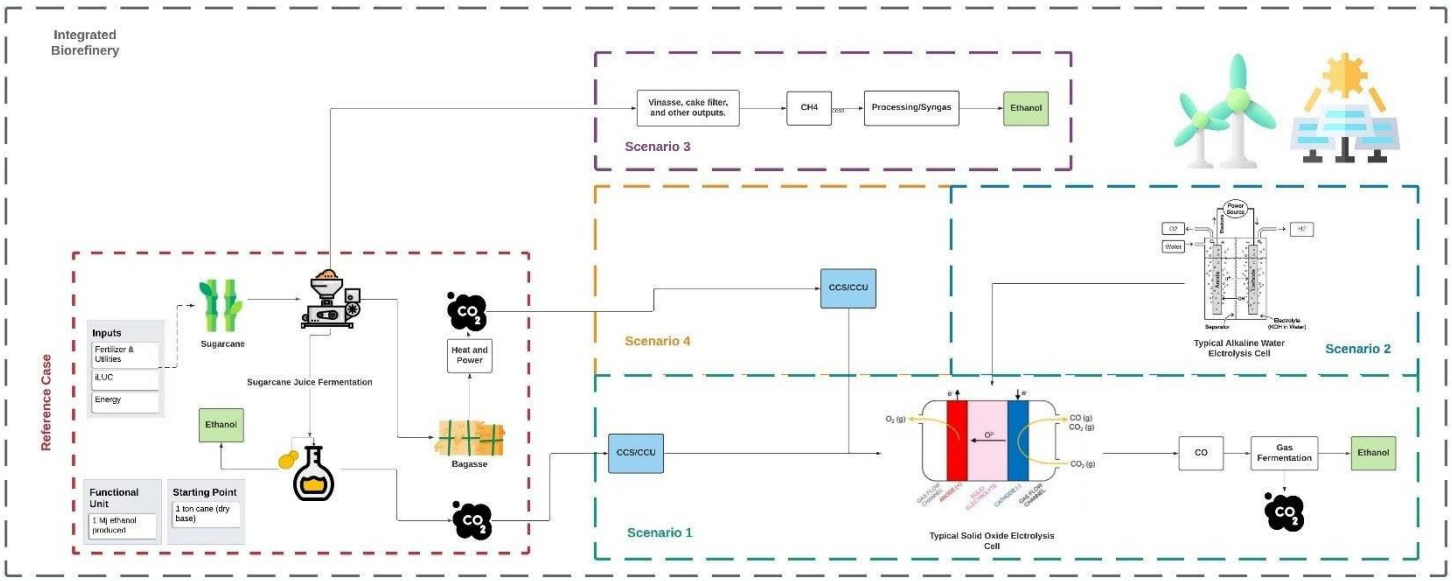
Theoretical Model for an Integrated Sugarcane and Gas Fermentation Biorefinery to Produce Ethanol in Brazil.

PROJECT SUMMARY

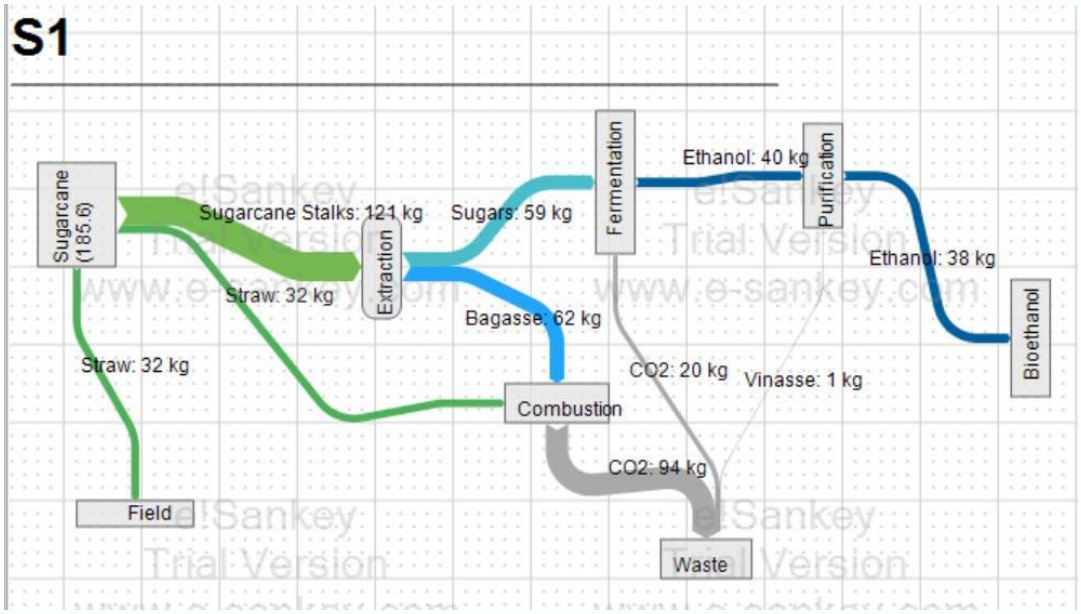
The integrated biorefinery concept offers an attractive route to increase fuel ethanol production from biomass and nonconventional feedstocks. This project explores the technological and economic feasibility and the environmental impacts of integrating first-generation (1G) ethanol and gas fermentation processes in a regular Brazilian sugarcane mill facility. The main goal is to explore the theoretical maximum volume of ethanol produced if all the carbon captured during the photosynthesis process by the sugarcane plant could be converted into this biofuel.

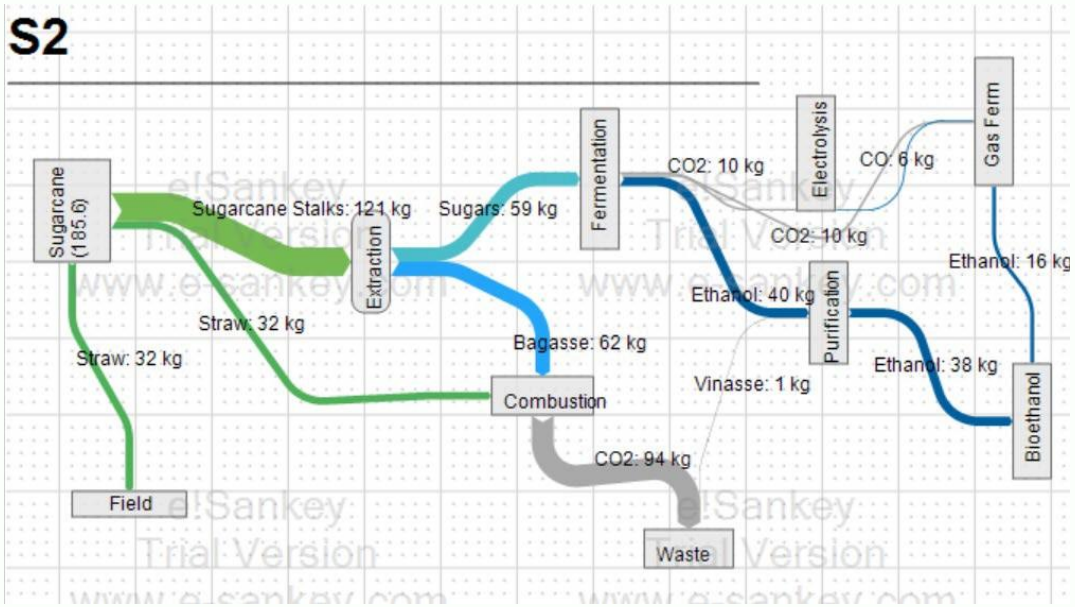
Commercially available gas fermentation technologies produce ethanol from waste gases generated during industrial processes. Hence, waste gases produced during the sugarcane fermentation process could be captured and reused to increase the ethanol production of a sugarcane mill without competing with food and land. The technical, economic, and environmental aspects of an integrated ethanol biorefinery, producing ethanol both from sugarcane and from the residues generated during its processes, such as CO2 and CH4, will be explored.

Methodologies employed include life cycle analysis of the integrated biorefinery, technical, economic analysis, volume of ethanol added due to biogenic CO2 gas fermentation, technology prospection and evaluation for electrolysis and carbon capture, analysis of the possible gains of this integration via Renovabio policy and RenovaCalc tool.



Analysis of carbon flux showed the amount of carbon (C) from sugarcane (feedstock) going to waste, electricity generation, and actual product (ethanol) in a standard Brazilian Biorefinery. We compared the latter (S1) with an integrated biorefinery coupled with a gas fermentation facility (S2). We showed that an increase from 38kg ethanol to 54kg is possible when the biogenic CO2 is utilized to produce more ethanol via gas fermentation.





We also collected data regarding the energy content of sugarcane and ethanol, electricity requirements, sugarcane harvesting and cultivation, ethanol production, electrolysis efficiency demand and efficiency, carbon capture efficiency, among others (tables below).

Some preliminary results indicate that a volume of 92,679,760,575.2 l of ethanol could be added to a standard plant if a gas fermentation facility would be integrated to consume the biogenic CO2 released from yeast fermentation. This is an increase of 30%. This volume would be responsible for the displacement of 66,199,829.0 L of gasoline if used as fuel. This represents 154,271,287,062.3 gCO2eq avoided or a reduction of 62% reduction, classifying this gas fermentation ethanol as an advanced fuel.

Also, a decrease of 12% in CO2 emissions during production could be accounted for due to this CO2 capture.

General	
1L ethanol	0.783kg
Functional Unit (sugarcane ethanol LCA)	1 MJ of hydrous ethanol
Ethanol energy content	23.4 MJ/l
Stoichiometry	90kg glucose = 46kg ethanol + 44kg CO2
LHV Anhydrous Ethanol	28.2 MJ/kg
LHV Type A Gasoline	43.5 MJ/kg
Carbon intensity (both production and usage) Type A Gasoline	86.4 gCO2eq/MJ
L EtOH / L gas	1.4
Gasoline energy content	34.2 MJ/L
System Boundaries	From sugar farming to ethanol combustion

Electricity & Electrolysis	
Electricity necessary to purify 1MJ ethanol	0.47MJ
1 MJ	0.277778 kWh
Electricity necessary to electrolyze water to H2 to produce 1MJ ethanol	1.47MJ
Water necessary to electrolyze water to H2 to produce 1MJ ethanol	0.08L
Electricity necessary to electrolyze CO2 to CO to produce 1MJ ethanol	0.51MJ
Electricity necessary to to purify 1MJ ethanol	0.47MJ
Total electricity requirement for CO2 to ethanol production	1.98MJ / 0.55kWh

Sugarcane	
Yield	83.1 t/ha/year
Size	30,000 ha
1000kg sugarcane	1926 MJ ethanol
1000kg sugarcane	69.3 kg ethanol hydrous
1000kg sugarcane	890.6 kg vinasse
Region	Center South (90% Brazilian sugarcane production)
Harvesting method	100% mechanically harvested
1000kg sugarcane	150kg sugars (15%, 2,500MJ)
	135kg stalk fibers (bagasse, 13.5%, 2,400MJ)
	140kg leaf fibers (straw, 14%, 2,500MJ)
	575kg water (57.5%)
CO2 fermentation	0.83kg/L EtOH
CO2 capture (90%)	0.75kg/L EtOH
Reference Case GHG emissions	21.7 gCO2eq/MJ
Average rate of harvesting	500 tsc/h
Average harvesting period	210 days
Ethanol production GHG emissions	2.6 gCO2eq/MJ
Use phase of Anhydrous ethanol	1 gCO2eq/MJ

1000kg Sugarcane
1926MJ Ethanol
69.3kg Ethanol
150kg sugars (15%, 2,500MJ)
135kg stalk fibers (bagasse, 13.5%, 2,400MJ)
140kg leaf fibers (straw, 14%, 2,500MJ)
575kg water (57.5%)
105.5 kWh/tsc electricity surplus

Furthermore, the 92,679,760,575.2 L ethanol produced via gas fermentation could generate 132,400 CBios, which would be translated in the gains below, based in different, but feasible, forecasted values for each CBio:

$4 - $529,600.00
$10- 1,324,000.00
$40 – 5,296,000.00

In addition, as part of the final project of the discipline PP590 - “An introduction to Carbon Capture, Utilization, and Storage,” we conducted a partial LCA of Blue Hydrogen Production from Natural Gas and Biomethane (from vinasse) with a focus on the Brazilian Scenario. The main results obtained were an 83% reduction in emissions when biomethane is utilized to produce hydrogen. Furthermore, we achieve negative emissions results when this process is coupled with carbon capture (-41 gCO2 eq/MJ H2). This exercise and results will be helpful to evaluate the CH4/vinasse waste forecasted in our project.

PROGRESSION

I completed four disciplines (BI003, BI002, LBE5010, and PP590), a literature review, and the generation of the preliminary results described in this summary.

MAIN CHALLENGES

- Lack access to non-public databases (as Ecoinvent) and paid more advanced Life Cycle Analysis Tools.
- Development of skills to perform Technical Economical Analysis.

Ph.D. Student: Mayara Chagas de Ávila

PERSONAL INFORMATION

Supervisor: Prof. Letícia Maria Zanphorlin, Ph.D.
Co-Supervisor: Prof. Carlos Henrique Inacio Ramos, Ph.D.
Funding agency: FAPESP
Enrolment date: 03/2019
Conclusion (estimative): 03/2023
Lattes CV: http://lattes.cnpq.br/7998917024580751
LinkedIn: https://www.linkedin.com/in/mayara-chagas-de-%C3%A1vila-67aa63158/

PROJECT'S TITLE

Mechanism elucidation of not conventional peroxygenases applied on production of drop-in biofuels

SUMMARY

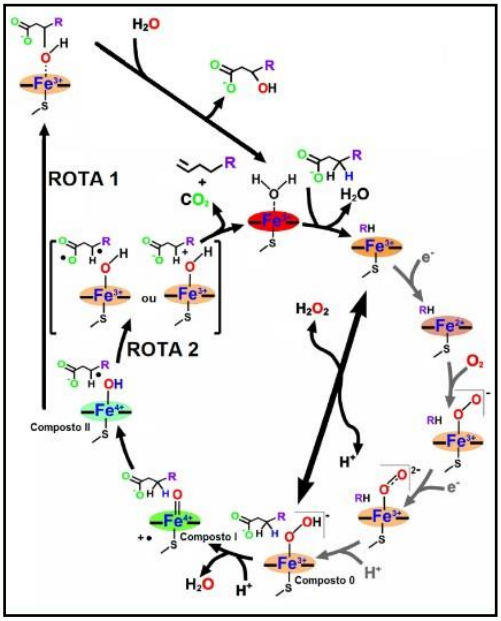


Figure 1: Canonical cycle of P450 enzymes

Biological strategies, through the discovery of new enzymes, added to microbial engineering to promote biomass use in advanced biofuel production and other bioproducts are certainly a more sustainable and promising way to complement the technologies based on petroleum. In addition to having a lower environmental impact, the biological approach allows the use of mild process conditions as temperature and pressure and less toxic chemical amounts. It also allows the use of enzymes that present higher specificity and conversion index in the bioprocess. In this sense, the discovery of the enzyme peroxygenase/decarboxylase CYP152 OleTJE made the scientific and technologic interesting in this enzyme family increase significantly because of the vast industry and economic appeal of the generated product, 1- alkene, which presents chemical composition and physical characteristic similar to the conventional petroleum fuels. The decarboxylation activity of the long-chain fatty acids (C12 – C20) promoted by this enzymatic family could solve one of the biggest hindrances of the drop-in biofuel production since it promotes the removal of the oxygen molecule of the chain. However, very little is known about peroxygenases from family 152. One of the significant challenges,

is obtaining enzymes that have preferential decarboxylation activity instead of hydroxylation, considering that CYP152 enzymes can catalyze both reactions. Recently, its notorious importance encouraged Wang and colleagues (2017) to publish the article "*Peroxygenases en route to becoming dream catalysts. What are the opportunities and challenges?*", which levers the use of peroxygenases in many biotechnology applications. Our research group, through bioinformatics strategies, identified innovative peroxygenases from two bacterias (32 and 73 % of identity with OleTJE), which were predicted with decarboxylation activityto a deep investigation of its molecular, functional, and structural mechanisms. Thus, this doctoral project aims to answer questions that together will support the use of peroxygenases to produce biofuels, as (i) the identified peroxygenases are hydroxylases or decarboxylases? (ii) What molecular components drive the formation of alkenes or not to be applied in the industry? (iii) Which is the specificity in terms of fatty acid size? (iv) If they are not decarboxylases, which mutations could we propose to transform them? A combination of structural, spectroscopic, and biochemical methods will be used to answer these questions,which are already widely applied in our laboratory. By the end of this doctoral project, we plan, beyond increasing the arsenal of peroxygenases with the decarboxylation of long-chain fatty acid, to propose a biological alternative to produce hydrocarbons, which are precursors to the biodegradable synthesis, for example, the green diesel and the aviation biokerosene.

HIGHLIGHTS

- Investigation of innovative P450 peroxygenases predicted with decarboxylation activity, involving amultidisciplinary approach
- A better understanding of how the decarboxylation activity works in terms of molecular, functional,and structural mechanisms
- Peroxygenase P450 enzymes can decarboxylate fatty acids producing alkenes, which areprecursors to produce drop-in biofuels.
- Propose a biological alternative to produce hydrocarbons, seeking an industrial application of drop-in biofuels.
- Drop-in biofuels production is a sustainable alternative to complement the technologies based onfossil fuels.

TIMELINE AND MAIN RESULTS

1s/2019

- Subject BI001 Fundamentals of Biomass Production
- Subject BI005 Advanced Topics in Processes
- Subject Biofuel Manufacturing
- Subject BI009 Special Topics in Bioenergy
- Subject NB515 Molecular Bases of Gene Expression
- Subject QP320 Biotechnology and Advanced Biochemistry

2s/2019

- Subject BI002 Biomass Transformation Processes in Biofuels
- Characterization techniques training at National Laboratory of Biorenewables (LNBR)

1s/2020

- Development of the tests regarding characterization of one of the peroxygenases targets

2s/2020

- Qualification of area (Work Plan) – Approved

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: To understand the mechanism of new peroxygenases/decarboxylases and their preferentialconditions/activity

Strategies: To use molecular, functional, and structural investigation through a multidisciplinary approach.

Challenge: To investigate and characterize enzymes with decarboxylation as preferential activity.
Strategies: Mutagenesis tests.

PhD. Candidate: Jorge Eduar Cardona Florez

PERSONAL INFORMATION

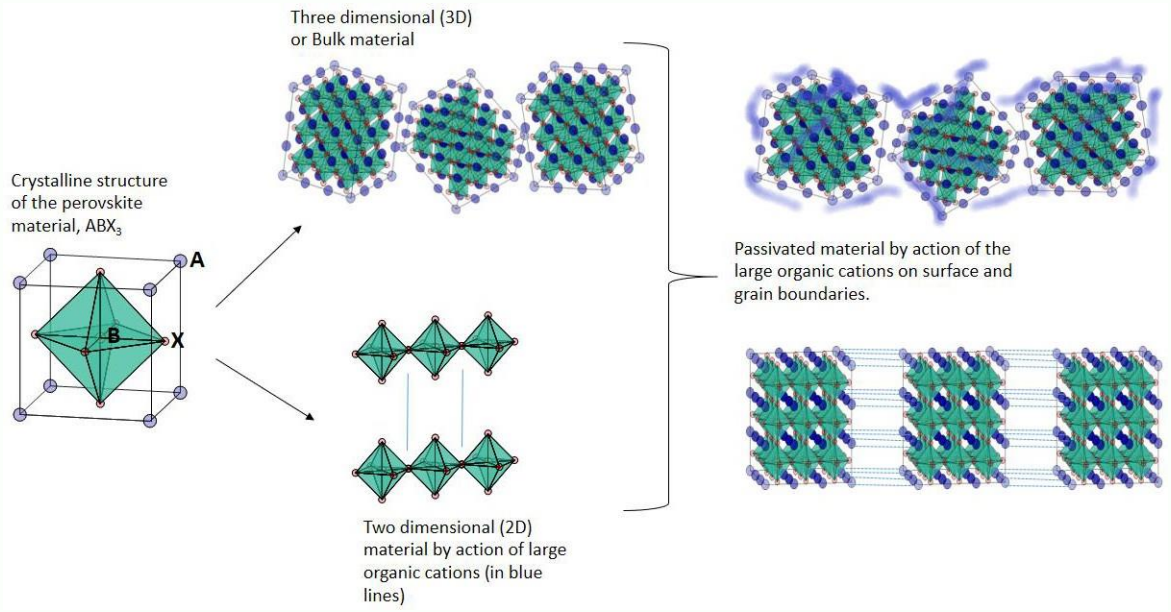
Supervisor: Ana Flávia Nogueira.
Nanotechnology and Solar Energy Laboratory (LNES). Institute of Chemistry (IQ). University of Campinas (UNICAMP)
Funding agency: CAPES
Enrolment date: March 2017
Conclusion (estimative): August 2022
Lattes CV: http://lattes.cnpq.br/0733107577093525
LinkedIn: https://www.linkedin.com/in/eduar-cardona-17b51a54/

PROJECT'S TITLE

Study on the organic-inorganic interface of two and three dimensional organoammonium lead iodide semiconductor for application in perovskite solar cells (PSCs)

SUMMARY

Methylammonium lead iodide (MAPI) is a kind of semiconductor, belonging to the family of perovskite materials, widely studied around the world with outstanding optoelectronic properties and high potential as light harvester for application in solar cells; however, despite its remarkably PCE (Power Conversion Efficiency), the material shows serious problems of degradation with sunlight, high temperature and moisture. Induce thermal decomposition in the absent of these external agents is fundamental to understand its degradation since its most viable application could be done under encapsulation. Thus, this is the case of the present work. On the one hand, defect-generation process located on surfaces and grain boundaries in the bulk material, seems to be an important source of the problem. On the other hand, taking in consideration the higher stability presented by 2D perovskite materials and evidences of passivation of bulk structures by mean of large organoammonium cations, herein is proposed a study on thermal degradation of MAPI material in both approaches, pure and passivated one. This research will aid to understand the process involved in the intrinsic degradation of the material as well as to propose an alternative passivated MAPI material looking for application in solar cells.



HIGHLIGHTS

- *Three different large organic cations, R, with different valence values were applied on MAPI material order to study their influence on the intrinsic stability of the semiconductor. Also pure two-dimensional layered perovskite materials were synthesized as well considering the same large organic cations as supporting information on the interaction of the R cations with the layers of inorganic octahedrons presented in both 2D and 3D approaches of the materials.*
- *Thermogravimetric analysis (TGA) under an inert atmosphere and Thermal diffusion spectrometry (TDS) under high vacuum were performed on all materials aiming to research their thermal degradation processes.*
- *Some R cations could mitigate the effects of degradation and vacuum conditions aiming to develop applications for encapsulated perovskite solar cells. Addition of the R cations in MAPI structures showed a general effect of diminishment of the mean size of the grain.*
- *Addition of benzylammonium iodide, a monovalent cation, presented a greater effect for the mean size of crystallite and was justly this cation that showed the best performance under thermal degradation; thus, it is likely that the smaller the grain size, the more stable the material.*
- *Although a smaller crystallite size could lead to a decrease in the photoelectronic properties, a satisfactory trade-off between stability and energy conversion efficiency could be considered.*

TIMELINE AND MAIN RESULTS

1s/2020:

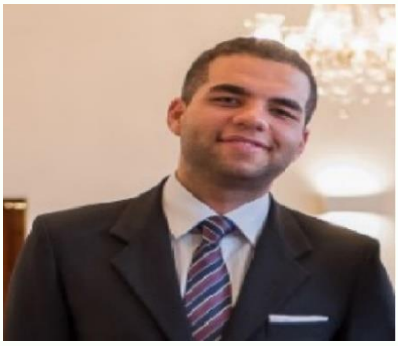
- Poster presentation under the name of “Synthesis and assessment of the thermal stability of MAPbI3 passivated with mono-, di- and tetravalent cations” at the second Workshop of Dense Energy Carriers(DEC) of Center for Innovation in New Energies (CINE).
- Development of activities in teaching internship (PED) on FA379 “Introdução à termodinâmica” at FEAGRI/Unicamp.
- Due to the beginning of the pandemic, the laboratories of the institute of chemistry and physics, where I carry out my research activities, stopped working and consequently my experimental research work was also suspended and my activities were focused on attending online congresses and seminars weekly.

2s/2020:

- My experimental research work continued to be suspended throughout the entire year 2020 and half of the year 2021 due to the prohibition of using the laboratories of the institutes where I do my doctoral work.
- I attended four more credits in the subject "introduction to quantum chemistry" from Institute of Chemistry, IQ/Unicamp.
- Activities focused on attending meetings, congresses and seminars weekly.
- Accomplishment of the second Qualification Exam of PhD Bioenergy Program.

CHALLENGES AND STRATEGIES TO OVERCOME THEM

In addition to being forced to change supervisor and research project almost halfway through the doctoral course, the arrival of the unexpected pandemic resulted in me being banned from using all the laboratories for approximately a year and a half, resuming activities only in the July 2021. My scholarship was closed in March 2021, so I am doing my best to be able to stay in the doctorate, finish the necessary experiments and defend my thesis only in the year 2022, hoping not to have more setbacks.



Ph.D. Student: Rafael Leonardo de Almeida

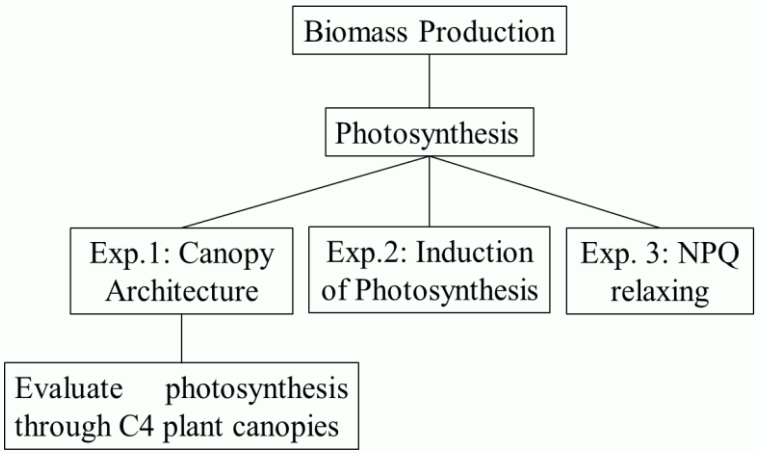
PERSONAL INFORMATION

Advisor: Prof. Dr. Rafael Vasconcelos Ribeiro
Funding agency: None
Entry: March 3rd 2020
Completion date: June 3rd 2025
Lattes: http://lattes.cnpq.br/5406860025431129
Linkedin: linkedin.com/in/rafael-leonardo-abb8121a9

PROJECT'S TITLE

Photosynthesis induction and photoprotection through the canopies of C4 species

SUMMARY



We will analyze photosynthetic induction, NPQ relaxation, light distribution and photosynthesis through plant canopy of genotypes of three C4 plant species: sorghum (*Sorghum bicolor* L.), maize (*Zea mays* L.) and sugarcane (*Saccharum* spp.). Three experimentswill be conducted.

EXPECTED RESULTS

Understanding the photosynthetic traits driving higher CO_2 assimilation by plant canopy, revealing their variation among genotypes. We expect that the fast induction of carboxylation kinetics and NPQ relaxation support higher photosynthesis and biomass production. Such finding would be relevant for breeding programs, selecting new cultivars for high photosynthesis and yield.

PROGRESSION

Minimum credit in course:

BI001 (4 credits) – Fundamentals for Biomass Production - A

BI002 (4 credits) – Processes for Biomass Transformation in Biofuels – A

BI011 (2 credits) – Bioenergy Seminars – Enrolled

AMG003 (8 credits) – Quantitative Genetics - A

Area Qualification:

Presented and approved.

Articles submitted (under review):

Rafael Leonardo de Almeida; Neidiquele Maria Silveira; Vinícius Sacramento Pacheco; Rafael Vasconcelos Ribeiro; Mauro Alexandre Xavier; Eduardo Caruso Machado. Variability and heritability of photosynthetic traits in *Saccharum* complex. Theoretical and Experimental Plant Physiology. March, 2021.

Rafael Leonardo de Almeida; Alan Valdir Saldanha; Bruno Luan Rosa; Elisa Monteze Bicalho; Eduardo Gusmão Pereira. Combined role of burying and fruit structures in maintenance of viability and vigor of macaúba palm seeds after fire. Acta Botanica Brasilica. March, 2021.

Neidiquele Maria Silveira; Paula Joyce Carenho Prataviera; Joana Claudio Pieretti; Amedea Barozzi Seabra; **Rafael Leonardo de Almeida**; Eduardo Caruso Machado; Rafael Vasconcelos Ribeiro. Chitosan-encapsulated nitric oxide donors enhance physiological recovery of sugarcane plants after drought stress. Environmental and Experimental Botany. March, 2021.

Larissa Prado da Cruz; Vinícius Sacramento Pacheco; Luciano de Melo Silva; **Rafael Leonardo de Almeida**; Marcela Trevenzoli Miranda; Maria Dolores Pissolato; Eduardo Caruso Machado; Rafael Vasconcelos Ribeiro. Morpho-physiological bases of biomass production by energy cane and sugarcane: a comparative study. Industrial Crops and Products. March, 2021.

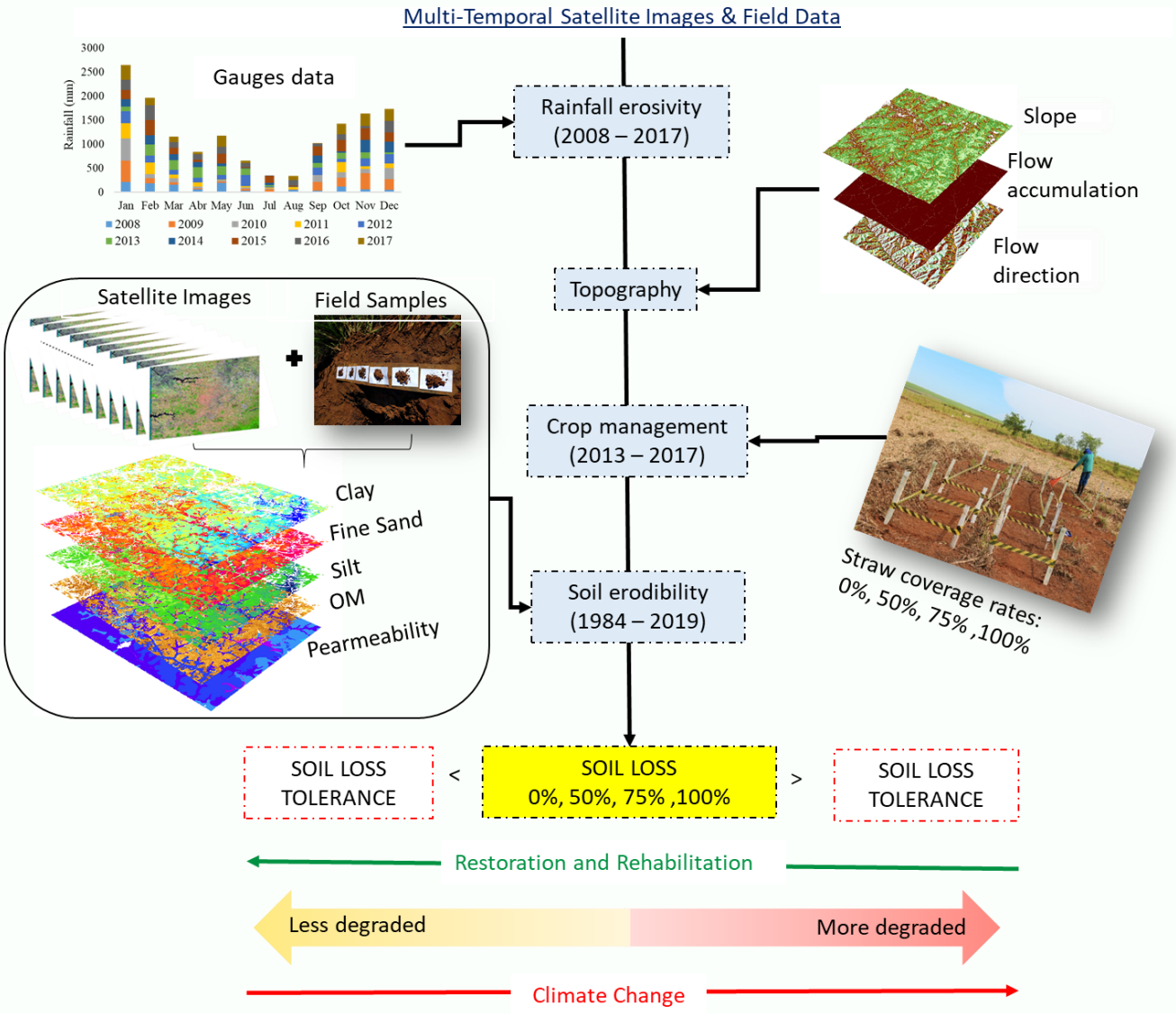
Ph.D. Candidate: Bruna Cristina Gallo

PERSONAL INFORMATION

Supervisor: Paulo Sergio Graziano Magalhaes
Funding agency: CAPES
Enrolment date: 03/2016
Conclusion:12/2021
Lattes CV:http://lattes.cnpq.br/5650464536525125
LinkedIn: www.linkedin.com/in/bruna-gallo-00044436

PROJECT'S TITLE

Soil erosion satellite-based estimation in cropland for soil conservation and bioenergysummary



Project flowchart to obtain soil loss and acess straw removal for bioenergy

HIGHLIGHTS

- This project incorporates crop management changes at farms' scale and the effects of different regional agroecological systems into an integrated model. These evaluations shed light on the impacts of straw removal on the next sugarcane cycle based on prior land use management information.

- We found that approximately 70 % of the study site have the potential for sugarcane residue removal. The prospective to increase to about 80 % is expected if adopted sustainable straw removal in the subsequent cycles.
- The average regional soil loss and Soil Loss Tolerance (T) resulted in approximately 3.0 $Mg.ha^{-1}$ and 4.3 $Mg.ha^{-1}$ respectively. We can observe that soil loss occurs in 20% of the study area, even in sites with 100 % of straw coverage (baseline), indicating that straw has not been enough to protect the soil against erosion in this region.

TIMELINE AND MAIN RESULTS

1s/2019
Sandwich Doctoral Fellowship at Queen's University, Kingston, Ontario, Canada.

2s/2019
Published Paper

Impact factor: 4.85
MENDES, WANDERSON DE S.; MEDEIROS NETO, LUIZ G.; DEMATTÊ, JOSÉ A.M.; **GALLO, BRUNA C.**; RIZZO, RODNEI;
SAFANELLI, JOSÉ L.; FONGARO, CAIO T. Is it possible to map subsurface soil attributes by satellite spectral transfer models? GEODERMA., v.343, p.269 - 279, 2019.

Impact factor: 4.85
POPPIEL, RAÚL R.; LACERDA, MARILUSA P.C.; DEMATTÊ, JOSÉ A.M.; OLIVEIRA, MANUEL P.; **GALLO, BRUNA C.**;
SAFANELLI, JOSÉ L. Pedology and soil class mapping from proximal and remote sensed data. GEODERMA., v.348, p.189
- 206, 2019.

POPPIEL, RAÚL R.; LACERDA, MARILUSA P.C.; DEMATTÊ, JOSÉ A.M.; OLIVEIRA, MANUEL P.; **GALLO, BRUNA C.**;
SAFANELLI, JOSÉ L. Soil Class Map of the Rio Jardim Watershed in Central Brazil at 30-meter Spatial Resolution based on Proximal and Remote Sensed data and MESMA method. DATA IN BRIEF., v.348, p.104070 -, 2019.

1s/2020

Published Paper

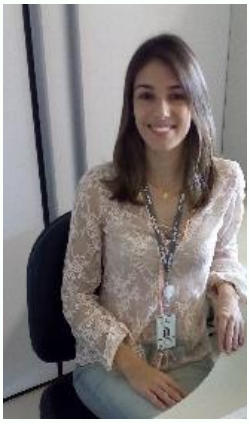
Impact factor: 4.0
DEMATTÊ, JOSÉ A. M. ; SAFANELLI, JOSÉ LUCAS ; POPPIEL, RAUL ROBERTO ; RIZZO, RODNEI ; SILVERO, NÉLIDA ELIZABET QUIÑONEZ ; MENDES, WANDERSON DE SOUSA ; BONFATTI, BENITO ROBERTO ; DOTTO, ANDRÉ CARNIELETTO ; SALAZAR, DIEGO FERNANDO URBINA ; MELLO, FELLIPE ALCÂNTARA DE OLIVEIRA ; PAIVA, ARIANE FRANCINE DA SILVEIRA ; SOUZA, ARNALDO BARROS ; SANTOS, NATASHA VALADARES DOS ; MARIA NASCIMENTO, CLÁUDIA ; MELLO, DANILO CESAR DE ; BELLINASO, HENRIQUE ; GONZAGA NETO, LUIZ ; AMORIM, MERILYN TAYNARA ACCORSI ; RESENDE, MARIA EDUARDA BISPO DE ; VIEIRA, JULIA DA SOUZA ; QUEIROZ, LOUISE GUNTER DE ; **GALLO, BRUNA CRISTINA** ;
SAYÃO, VERIDIANA MARIA ; LISBOA, CAROLINE JARDIM DA SILVA . Bare Earth's Surface Spectra as a Proxy for Soil Resource Monitoring. **Scientific Reports**, v. 10, p. 1-11, 2020.

2s/2020

Impact factor: 4.53
CERVI, WALTER ROSSI; LAMPARELLI, RUBENS AUGUSTO CAMARGO; **GALLO, BRUNA CRISTINA**; OLIVEIRA BORDONAL, RICARDO; SEABRA, JOAQUIM EUGÊNIO ABEL; JUNGINGER, MARTIN; HILST, FLOOR. Mapping the environmental and
techno-economic potential of biojet fuel production from biomass residues in Brazil. **Biofuels**

CHALLENGES AND STRATEGIES TO OVERCOME THEM

The pandemic situation caused by COVID-19 delayed the defense term due to the social isolation and instability access to the research institute. The extension period for defense firmed by the CCPG (Comissão Central de Pós-Graduação) has overcome this problem.



Ph.D. Candidate: Jéssica Marcon Bressanin

PERSONAL INFORMATION

Supervisor: Otavio Cavalett – NTNU
Co-supervisor: Edvaldo Rodrigo de Morais – LNBR/CNPEM
Funding agency: CAPES
Enrolment date: 03/2016
Conclusion (estimative): 07/2021
Lattes CV: http://lattes.cnpq.br/3367962943107778
LinkedIn: www.linkedin.com/in/jéssica-marcon-bressanin

PROJECT'S TITLE

Assessment and Optimization of Economic and Environmental Sustainability Impacts of Thermochemical Pathways Integrated to the Sugarcane Biorefinery

SUMMARY

Problem: Increasing environmental and energy concerns in face of climate change

Question: How can the implementation of the thermochemical route contribute to Brazil's compliance with the targets assumed at COP21?

Premise 1: The implementation of RenovaBio will influence the bioproduct market

Premise 2: Biomass alternatives in the sugarcane sector will be important for the implementation of thermochemical routes

Premise 3: Plant capacity will be relevant to select the best performance

Hypothesis: It is possible to contribute to the mitigation of Brazilian GHG emissions through gasification of lignocellulosic material followed by conversion of the synthesis gas via FT synthesis, and IGCC for electricity production, ensuring the economic viability of the process.

Prediction 1: It will be possible to identify the most attractive scenario in Brazil

Prediction 2: It will be possible to identify the most attractive mix of biomass and plant scale to meet the GHG mitigation targets, ensuring economic viability

MAIN RESULTS

- Optimized environmental and economic performance of thermochemical routes integrated to sugarcane production chain in Brazil
- The best alternatives to mitigate climate impacts ensuring economic profitability
- Thermochemical and biochemical processes representation using an assessment framework developed in Microsoft® Excel
- Metamodel obtainment to describe biorefinery processes

TIMELINE

1s/2016 Credits obtainment; Literature review and project elaboration

2s/2016 Credits obtainment; Program of internship teaching (PED) at Unicamp; Literature review and project elaboration

1s/2017	Qualification Exam; Credits obtainment
2s/2017	G-BiB Competition; Poster presentation at 14° Congresso Brasileiro de Polímeros in Águas de Lindóia (SP); Workshop on Second Generation Bioethanol and Biorefining at CTBE/CNPEM; Poster presentation at Bioenergy Symposium about the methodology of Ph.D. project; Research development
1s/2018	Program of internship teaching (PED) at Unicamp; Research development
2s/2018	Participation in “A Era da Bioenergia” in Campinas; Preparation of the general qualification exam
1s/2019	Qualification exam; Research development
2s/2019	Research development; Poster presentation at IX Encontro da Escola Brasileira de Química Verde in Uberlândia (MG);
1s/2020	Research development; Paper elaboration/submission
2s/2020	Paper published in the Journal Energies; Poster presentation at BBEST 2020-21 and BIOFUTURE SUMMIT II Virtual Conference
1s/2021	Papers elaboration/submission and preparation of Ph.D. thesis

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Among the difficulties faced, it is possible to mention obtaining in the literature and reconciling data of the considered industrial process, since the data are found for the sub-steps of the process separately or in works with different general configurations. There is still a need for adaptation to the Brazilian scenario, considering the different composition of the biomasses to be studied. In addition, the absence of estimates of the equipment costs for Brazil, generating a great uncertainty about investment in fixed capital. The difficulties related to the technical parameters of the process could be overcome through communication with specialists in the area. In the case of cost estimation, a methodology was adopted for the conversion of prices adopted in other countries through a specific location factor.

Ph.D. Candidate: Lauren Maine Santos Menandro

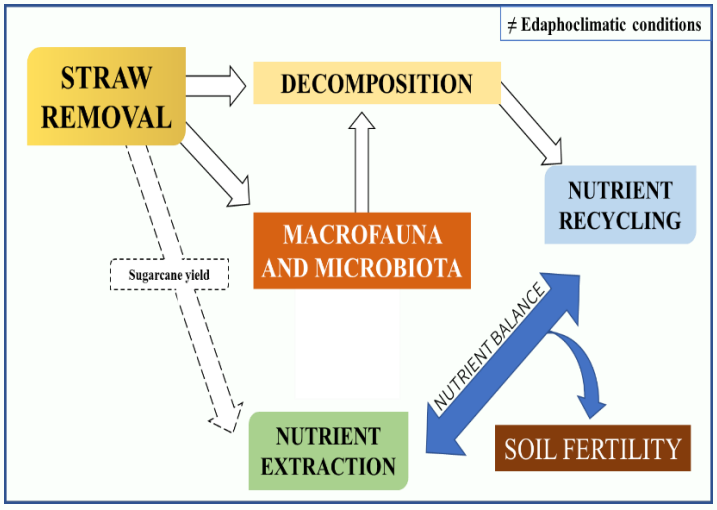
PERSONAL INFORMATION

Supervisor: João Luis Nunes Carvalho
Funding agency: Laboratório Nacional de Biorrenovaveis (LNBR/CNPEM)
Enrolment date: 03/16
Conclusion (estimative): 10/21
Lattes CV: : http://lattes.cnpq.br/3756691950300260
LinkedIn: https://www.linkedin.com/in/lauren-menandro-7b4b793b/
ResearchGate: https://www.researchgate.net/profile/Lauren_Menandro

PROJECT'S TITLE

Responses of biological and chemical soil attributes to sugarcane straw removal for bioenergy production

SUMMARY



In an increasingly resource limiting world, the search for alternative sources of energy production has focused attention on the use of agricultural residues. This is now driving increases in the removal of sugarcane straw for bioenergy. However, before this practice becomes even more widespread, it is necessary to obtain a better understanding about the consequences of straw removal in soil quality. In this context, the main hypothesis of this study is that indiscriminate sugarcane straw removal from field to bioenergy production results in degradation of the chemical and biological soil quality and this depends on the edaphoclimatic conditions. For that, field experiments were conducted with the general aim to evaluate the changes in biological and chemical attributes under sugarcane straw removal system across different edaphoclimatic conditions of south-central of Brazil

HIGHLIGHTS

- Integrated approaches with biological and chemical soil indicators should be adopted to better predict asugarcane straw removal management in Brazil.
- Total straw removal (TR) appears to impair the soil biological and chemical soil attributes.
- The partial straw removal can be viable to attend the energy demand without compromising the sugarcanefields.
- Clayey soils are more responsive to straw removal than sandy soils.

TIMELINE AND MAIN RESULTS

1s/2016

- Start in Ph.D. in Bioenergy.
- Monitoring and conduction of Ph.D. experiments

2s/2016

- Monitoring and conduction of Ph.D. experiments

1s/2017

- Qualification of PhD. Thesis project
- Monitoring and conduction of Ph.D. experiments
- 11 credits in Ph.D courses
- Speaker at VIII Simpósio Tecnologia de Produção de Cana-de-açúcar, Piracicaba, São Paulo MENANDRO, L. M. S. Estratégias para remoção de palha de cana-de-açúcar para bioenergia.
- Publication of two manuscript in the Ph.D. study area:
  - Menandro et al., Comprehensive assessment of sugarcane straw: implications for biomass and bioenergyproduction. Biofuels Bioproducts & Biorefining-Biofpr, v. 11, p. 488-504, 2017.
  - Carvalho et al., Agronomic and environmental implications of sugarcane straw removal: a major review. GlobalChange Biology Bioenergy, v. 9, p. 1181-1195, 2017.

2s/2017

- Monitoring and conduction of Ph.D. experiments
- 4 credits in Ph.D courses
- Poster presentation at I Bioenergy Symposium. Optimizing amount of sugarcane straw in the field to supllybioenergy feedstock preserving soil quality and sugarcane yields.

1s/2018

- 2 credits in Ph.D courses
- Monitoring and conduction of Ph.D. experiments.

2s/2018

- 8 credits in Ph.D courses. Completion of the courses.
- Speaker at Workshop de Remoção de Palha: implicações na qualidade do solo, nas emissões de GEE e na produção de cana-de-açúcar. Projeto SUCRE, with two presentation including Ph.D results:
  "Respostas dos organismos do solo à remoção de palha de cana-de-açúcar" "Remoção de palha: implicações na reciclagem de nutrientes e fertilidade do solo"
- Publication of two manuscript in the Ph.D. study area. The first presents some Ph.D. results:
  - Castioni et al., Soil physical quality response to sugarcane straw removal in Brazil: A multi-approach assessment.Soil & Tillage Research, v. 184, p. 301-309, 2018.
  - Bordonal et al., Sugarcane yield and soil carbon response to straw removal in south-central Brazil. Geoderma,v. 328, p. 79-90, 2018.
- Poster presentation at:
  - A Era da Bioenergia. Relação da remoção de palha da cana-de-açúcar para bioenergia e os atributos químicose biológicos do solo.
  - 21st World Congress of Soil Science (WCSS). Sugarcane straw decomposition as a function of quality andquantity of green tops and dry leaves associated with climate conditions.

1s/2019

- Publication of the first chapter of the thesis and five more manuscript as co-author:
  - Menandro et al., Soil Macrofauna Responses to Sugarcane Straw Removal for Bioenergy Production. BioEnergyResearch, v. N/N, p. N/N, 2019.
  - Ruiz Corrêa et al., 2019. Straw Removal Effects on Soil Water Dynamics, Soil Temperature, and Sugarcane Yieldin South-Central Brazil. BioEnergy Research, p. 264?276, 2019.
  - Carvalho et al., Multilocation Straw Removal Effects on Sugarcane Yield in South-Central Brazil. BioEnergyResearch, v. N/N, p. N/N, 2019.
  - Castro et al., 2019. Changes in Soil Pest Populations Caused by Sugarcane Straw Removal in Brazil. BioEnergyResearch, v. N/N, p. N/N, 2019.
  - Castioni et al., 2019. Straw Removal Affects Soil Physical Quality and Sugarcane Yield in Brazil. BioEnergyResearch, v. N/N, p. N/N, 2019.

2s/2019

- Awarded in the 10 Best finalist of the Rising Soil Stars Science Communication Competition, Wageningen Research& University. Wageningen. Netherlands
- Speaker at Wageningen Soil Conference: Exploring soil macrofauna as an indicator of sugarcane straw removal effects on soil quality. Wageningen. Netherlands

1s/2020

- Recognition of the most remarkable and outstanding research work in the field of Biomass on the occasion of EUBCE - Europe Biomass Conference & Exhibition 2020. Studant Awards. “Guidelines for sugarcane straw removal: a decision-making tool for assessing the potential and availability of biomass” and speaker presentationof the same work.

2s/2020

- Elaboration of the these in papers and change the job. TIMAC AGRO Fertilizers

CHALLENGES AND STRATEGIES TO OVERCOME THEM

The biggest challenge at this point is to finish the Ph.D, reconciling with work in the commercial area and people management. Last year I took over as Regional Sales Supervisor at a multinacional TIMAC AGRO Fertilizantes. At the moment, I plan to take a vacation in June/2021 to dedicate to finish my PhD, as the remaining chapters are already well advanced.

Ph.D. Candidate: Nariê Rinke Dias de Souza

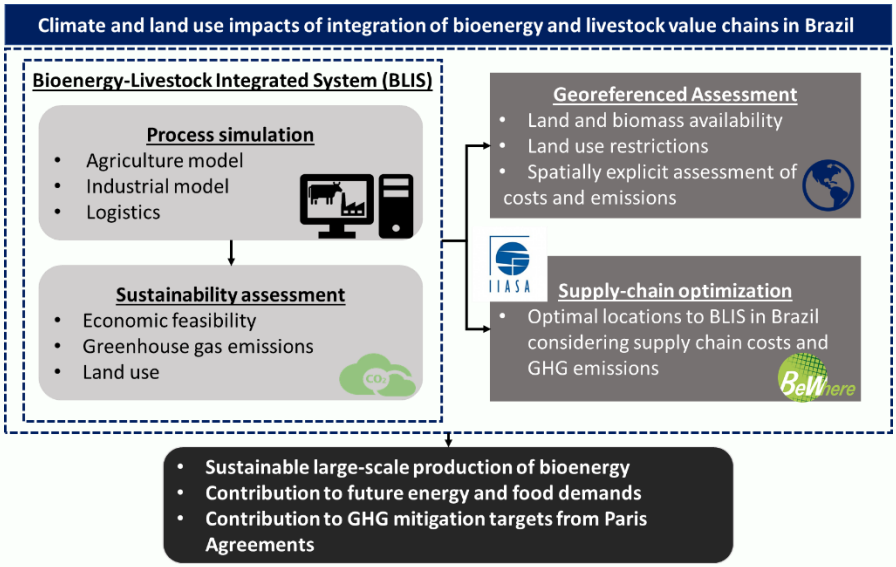
PERSONAL INFORMATION

Supervisor: Otávio Cavalett – NTNU
Co-supervisor: Tassia L. Junqueira – LNBR/CNPEM
Funding agency: -
Enrolment date: February 2018
Conclusion (estimative): February 2023
Lattes CV: http://buscatextual.cnpq.br/buscatextual/visualizacv.do?id=K8499277E3
LinkedIn: https://www.linkedin.com/in/nari%C3%AA-rinke-d-de-souza-18404a84/

PROJECT'S TITLE

Climate and land use impacts of integration of bioenergy and livestock value chains in Brazil

SUMMARY



This project aims to understand how bioenergy-livestock integrated systems can contribute to climate mitigation in Brazil, while attending energy and food demands from our society.
The project is divided in 5 main steps:
(1) Understanding land and biomass availability to meet future demands of energy and food: availability of land for bioenergy purposes considers current pasture areas inside Sugarcane Agroecological Zoning (SAEZ). Biomass availability considers current production and potential production using crop yield estimation tools from LNBR/CNPEM. Demands are derived from the Shared Socioeconomic Pathways (SSPs) for Brazil and other official national estimates.
(2) Modelling Bioenergy-Livestock Integrated Systems (BLIS): the alternatives are simulated using and adapting the existing models in the Virtual Biorefinery platform from LNBR/CNPEM based on agricultural and industrial yields and operational parameters from literature and real cases.
(3) Spatially explicit assessment of greenhouse gas (GHG) emissions and costs of BLIS: Life Cycle Assessment (LCA) and techno-economic assessment (TEA) are performed considering site-specific parameters, such as yields, transportation distances, land availability and others.
(4) Brazilian potential to mitigate GHG emissions while meeting future energy and food demands: the expansion of BLIS is considered in pasture areas inside SAEZ, taking into account the site-specific conditions from step 3.
(5) Best locations to apply BLIS systems: The optimal location of BLIS in Brazil is performed minimizing supply- chain costs and emissions. This part of the PhD is performed with the participation on Young Scientists Summer Program (YSSP) from the International Institute for Applied Systems Analysis (IIASA), using BeWhere model.

HIGHLIGHTS

- Pastureland intensification may release a substantial area to bioenergy production.

- Address the potentials of bioenergy by-products as animal feed and manure for bioenergy productionstimulating a circular economy perspective
- Potentials of bioenergy-livestock integrated system to mitigate GHG emissions while attending future energyand food demands.
- Identification of synergies and tradeoffs among meeting energy demands and GHG mitigation targets.
- Optimal location of bioenergy-livestock integrated systems in Brazil minimizing supply-chain costs and GHGemissions.

TIMELINE AND MAIN

RESULTS2018

- Bi001 course - Fundamentals of Biomass Production; PE131 course – Renewable Sources of Energy; ESALQ
  course – Biomass, Energy and Environmental Sustainability
- BBW ForWerts Summer School "Visions in Bioeconomy - Bioeconomy Strategies: Learning from the best?" –
  Bioeconomy Research Program Baden-Württemberg
- BECY summer school on Bioeconomy - Euroleague of Life Sciences (ELLS) and Strategic Network Bioeconomy(BECY), University Hohenheim
- Poster presentation at FOOD 2030 congress: "Food-bioenergy integration in Brazil: towards sustainable land
  use intensification" – University of Hohenheim
- Admission as Analyst at LNBR/CNPEM
- Application for the Fulbright scholarship – University of Nebraska – *waiting list*

2019

- Paper published - Biomass & Bioenergy scientific journal: "Sugarcane ethanol and beef cattle integration inBrazil"
- Approved in the 1st PhD qualification exam
- CD-LINKS Summer School On Integrated Assessment Models: A Tool For Science-Based Policy Making - CMCCand IIASA

2020

- Approval on YSSP 2020 – *didn't participate due to COVID-19 pandemic.*
- Poster presentation on BBEST 2020: "*The role of livestock and bioenergy integration for the Brazilian sustainable future*"
- Scenario's simulation

1s/2021

- Techno Economic Assessment (TEA) and Life Cycle Assessment (LCA) of simulated scenarios
- Approval on YSSP 2021. Project: "*Valorization of ecosystem services through location optimization ofintegrated value chains for biofuel and livestock production in Brazil*"
- Paper submission on Industrial Crops and Products scientific journal: "*Opportunities of bioenergy-livestockintegrated systems to meet future demands of food and energy in Brazil*"

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: Georeferenced information of land availability and restrictions, biomass availability, and supply-chain costs andemissions

Strategies: Improving abilities on GIS platforms, support from LNBR staff Challenge: Integration of BLIS with BeWhere model

Strategies: Discussions and meetings with IIASA supervisors Challenge: Optimization of supply-chain

Strategie: Support from IIASA supervisors

Ph.D. Student: Rafael Boni

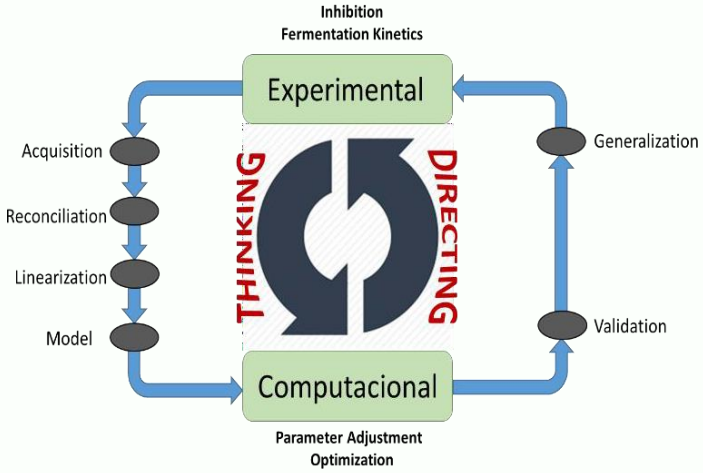
PERSONAL INFORMATION

Supervisor: Prof. Edvaldo Rodrigo de Morais, Ph.D. **Co-Supervisor:** Prof. Adriano Mariano Pinto, Ph.D. **Funding agency:** FAPESP
Enrolment date: 03/2019
Conclusion (estimative): 1st semester/2023
Lattes CV: http://lattes.cnpq.br/2722171529819752
LinkedIn: https://www.linkedin.com/in/rafael-boni/

PROJECT'S TITLE

Kinetic Modeling of Pentose Fermentation: Understanding the synergistic behavior of lignocellulosic inhibitorsin the metabolism of genetically modified *S. cerevisiae*.

SUMMARY



The objective of this project is to perform a mathematical and kinetic modeling of the fermentation process of pentose using *S. cerevisiae* G.M.O. containing the enzyme xylose isomerase to evaluate and understand the influence of synergistic profiles of inhibitors in the production of second-generation ethanol. Experimentally is expected to identify the concentrations of the inhibitors, separately and in combination, which affect the fermentation of pentose, while computationally is expected to have a model that adequately represents the reaction mechanism and the different types of inhibition.

HIGHLIGHTS

- Extracted and identified a solid containing 36 phenolic compounds from hemicellulosic hydrolysate;
- Phenolic Compounds (solid) applied in different proportions in nanocellulose films;
- Introduction to optimization techniques in Python to evaluate test function for future application in kineticmodeling functions.

TIMELINE AND MAIN RESULTS

1s/2019

- Subject BI001 – Fundamentals of Biomass Production
- Subject BI001 – Social, Economic and Environmental
- SustainabilitySubject IQ350 – Design of Experiments
- Online Course: Industrial Biotechnology – TU Delft

2s/2019

- Subject IA015 – Computation Data
- Modeling Subject IA543 – Non-linear Optimization

1s/2020

- Obtained solid from hemicellulosic hydrolysate as phenolic compounds
- Nuclear magnetic resonance (NMR), Liquid Chromatography Mass Spectrometry (LCMS) and GasChromatography Mass Spectrometry: techniques used to identify compounds present in the solid
- Identified 36 phenolic compounds from solid extracted

2s/2020

- Newton, Nelder-Mead, Particle Swarm Optimization and Differential Evolution: optimization techniquesapplied in test functions to evaluate its methods step by step in Python
- Introduction to Distributed Evolutionary Algorithm in Python (DEAP) a specific framework to developevolutionary algorithms
- Application of phenolic compounds (solid) in nanocellulose films to evaluate its improvement in UVprotection.
- Qualification of area

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: Identification of new compounds from solid extracted.
Strategies: Understanding and integrating the techniques (NMR, LCMS and GCMS) was important toidentify a large number of compounds.
Challenge: Python Programming
Strategies: It was necessary an introduction to paradigms of programming, acknowledgment of differentlibraries and build-in function before evaluate test functions in optimization techniques in Python **Challenge:** Applying phenolic compounds extracted into nanocellulose films
Strategies: Partnership with the National Nanotechnology Laboratory (LNNano) for the production of nanocellulose films and subsequent application of phenolic compounds to UV absorption property of thefilms produced.

Ph.D. Candidate: Raquel de Souza

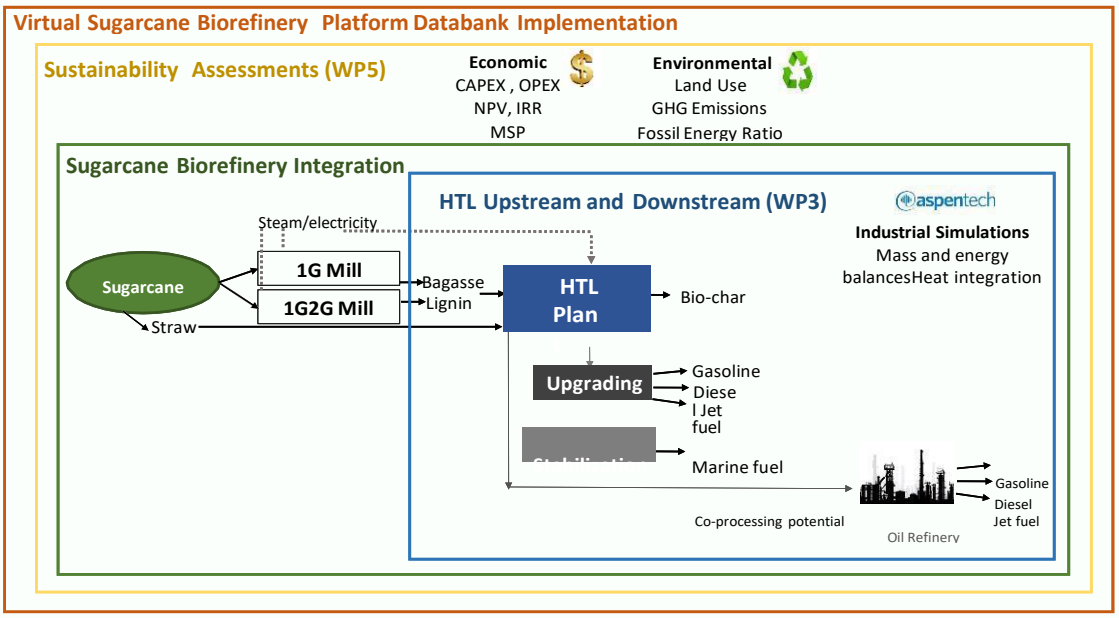
PERSONAL INFORMATION

Supervisor: Marcos Djun Barbosa Watanabe
Co-supervisor: Leonardo Vasconcelos Fregolente
Funding agency: CAPES
Enrollment date: 02/2018
Conclusion (estimative): 05/2022
Lattes CV: http://lattes.cnpq.br/7429486815296607
LinkedIn: https://www.linkedin.com/in/raquel-de-souza-b42448b0

PROJECT'S TITLE

Hydrothermal Liquefaction of Agricultural Residues to Produce Advanced Fuels: Techno-Economic and Environmental Assessments

SUMMARY



The present project consists in a comprehensive feasibility analysis of producing advanced fuels from lignocellulosic biomass through hydrothermal liquefaction. Hydrothermal liquefaction (HTL) is a thermochemical process that converts wet biomass into bio-crude oil and other by-products. HTL is an emergent technology that is receiving increased attention from research groups around the world but is yet to be deeply investigated in Brazil. HTL may be a promising alternative to increment the participation of renewable fuels in the Brazilian energy matrix. A desired biofuel technology needs to be efficient in terms of net lifecycle greenhouse gas (GHG) emission reduction and satisfactorily meets environmental and social sustainability standards. For this purpose, an integrated assessment will be carried out in order to assess the technical, environmental and economic performance of all the stages of the HTL process, using a methodology that comprises process modelling and simulation of both agricultural and industrial stages involving biofuel production. The work will include the evaluation of: (a) the conversion of sugarcane residues (straw, bagasse and lignin-rich streams from 2nd generation ethanol plants) into bio-crude oil through HTL; (b) the upgrading of the HTL bio-crudes into liquid fuels in the range of gasoline, diesel and jet fuel equivalent (c) the HTL bio- crudes stabilization for marine fuel applications (d) the HTL process at different greenfield biorefinery configurations, including strategies such as co-location with 1G and 1G2G plants. Based on the results of the environmental and techno-economic assessments, the best scenario will be selected considering all the studied configurations.

HIGHLIGHTS

- First study on hydrothermal liquefaction of lignocellulosic biomass in Brazil;
- Study of the co-processing potential of biocrude with petroleum in oil refineries;
- Data generated from this project will implement the Virtual Sugarcane Biorefinery;
- This research on HTL technology will be pioneer in Brazil and its results may help on the decision for itsimplementation in the Brazilian energy matrix.

TIMELINE AND MAIN RESULTS

1S/2018
Partial fulfillment of required credits.
Bibliographic review.
FAPESP project elaboration & submission.

2S/2018
Partial fulfillment of required credits.
Bibliographic review.
Qualifying examination.

1S/2019
Fulfillment of the required credits.
PED (Estágio docência).
Extensive bibliographic review.
Data collection (HTL technical parameters).
Aspen simulations for HTL process.
Experimental design elaboration on HTL experiments for the BioValue Project partners.

2S/2019
VSB platform training.
Preliminary economic case study for HTL biorefinery in Brazil.
Participation at IX Encontro da Escola Brasileira de Química.
Poster and oral presentation at CEC- Congresso de Estudantes do CNPEM.
Participation at the International meeting of the BioValue & Becool Project to discuss the progression of the project.

1S/2020
Identification and compilation of the composition of HTL bio-crude available in the literature (by functional groups and chemical species).
Proposition of a simplified composition by using model compounds.
Assessment of the existing data on HTL upgrading and coprocessing with respective gaps and opportunities.
Industrial simulations and study of co-processing potential of HTL bio-crudes in petroleum refineries.

2S/2020
Poster presentation at BBEST Conference.
Techno-economic evaluation of a standalone HTL biorefinery.
Manuscript preparation.

CHALLENGES AND STRATEGIES TO OVERCOME THEM

The interruption of presential activities at the laboratory, loosing therefore the access to some of the softwares that are an instrument for my project, together with the laboratory structure itself was the most significant challenge for my research during the last year. I decided to use other strategies, such as using excel spreadsheetsfor the calculation of mass and energy balances instead of Aspen and partnering with another student who had access to some of the necessary tools. Another challenge I encountered during the last year was regarding the lack of experimental data, since the experimental activities of the project that I am a participant were interrupted. Iused all the literature data available and made adjustments to fit on my project.

Thaynara Késsia Espíndola Pereira

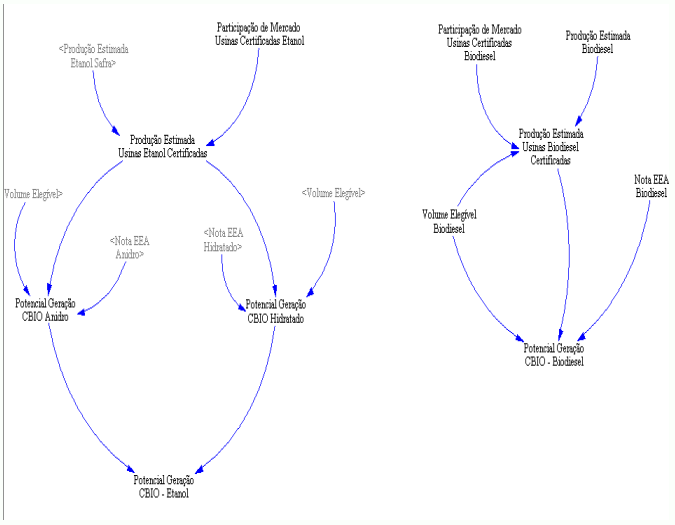
PERSONAL INFORMATIONS

Advisor: Dr. Marcelo Falsarella Carazzolle
Funding Source: Scholarship Research Company – COPERSUCAR S.A.
Admission: 02/2019
Probable Conclusion Date: 02/2021
Lattes: http://lattes.cnpq.br/0546300627793277
LinkedIn: https://www.linkedin.com/in/thaynara-espíndola-a0157016b/

TITLE OF PROJECT

Modeling in dynamic systems the decarbonization goal of the Brazilian energy matrixassociated with the national biofuel policy.

PROJECT SUMMARY



The thesis intended to determine the target of decarbonization of the Brazilian energy matrix using the modeling methodology by dynamic systems, in order to predict the same for each year of activity of the policy, so that its determination is assertive under the influence of the most diverse variables related to the manufacture, distribution and commercialization of ethanol and to determine variables of interest in the interaction between the national biofuel policy and the energy sector, assessing impacts on the prices of sugar, ethanol and other products in the basket.

MAIN RESULTS

- A model in dynamic systems that determines the decarbonization goal of the Brazilian energymatrix for each year of operation of the national biofuel policy;
- CBIOS offer potential model for each year of the policy's performance;
- Model of the potential for expanding the CBIO offer during the performance of the policy on the following axes: potential for expansion of the certified volume, potential for improving the grades of environmental energy efficiency, increase in certified production units, potential increase in the volume of biofuels produced in the country;
- A model in dynamic systems for the demand for biofuels considering the Brazilian market andexport potential in the 2021 - 2030 time axis;

- Discussions about the effects of the Renovabio implementation on the expansion of biofuel production plants and the consequences for improving production efficiency;
- Discussions about the economic influences of Renovabio and their influence on the carbon markets, correlating mechanisms for carbon capture and storage, nationally and internationally; - Information that can be used by government officials as a guide for making strategic decisions about the goal of decarbonizing the Brazilian energy matrix;
- Discussions about approaches that can be used for the internationalization of Renovabio;
- A responsive model where information about the influence of CBIO in the various variables of the sugar and energy sector and transport can be obtained;
- Discussions about aspects of marketing and exporting ethanol and sugar under the influence of CBIO and correlating them with the decarbonization target;
- A solid modeling that follows the temporal evolution of Renovabio and its interactions throughout the life cycle of biofuels - from the agricultural phase of biomass cultivation, through the industrial phase of biofuel production, distribution, transport, marketing to the final consumer.

PROGRESSION

1º SEM Delimitation of the research project; Writing the research project along the lines of FAPESP; Take courses.
2º SEM Research methodology design; Bibliographic research on the topic; Simulations in dynamic systems; Rewriting the research project along the lines of FAPESP; Take courses.
3º SEM Delimitation of the scope of the simulation; Simulations in dynamic systems.

DIFFICULTIES FOUND AND PROPOSALS FOR SOLUTIONS

The main challenge encountered was made simulations in the context of forecasts at an atypical time for the sector due to the recent global pandemic, in addition to the fact that the implementation of the national biofuels policy occurred only during this atypical period, so there are no real data on the implementation of this policy in a context of normality in the sector. In order to solve it, it was necessary to consider which historical data were representative for the sector's behavior and to standardize variables when necessary to make considerations that are as representative as possible, as they will culminate in a more robust and assertive model.

Ph.D. Student: Sarah Tenelli

PERSONAL INFORMATION

Supervisor: João Luís Nunes Carvalho
Co-supervisor: Ricardo de Oliveira Bordonal
Funding agency: CAPES (via Bioenergy Program - grant 88882.435528/2019-01)
Enrolment date: March 2017
Conclusion (estimative): October 2021
Lattes CV: http://lattes.cnpq.br/1343928140917943

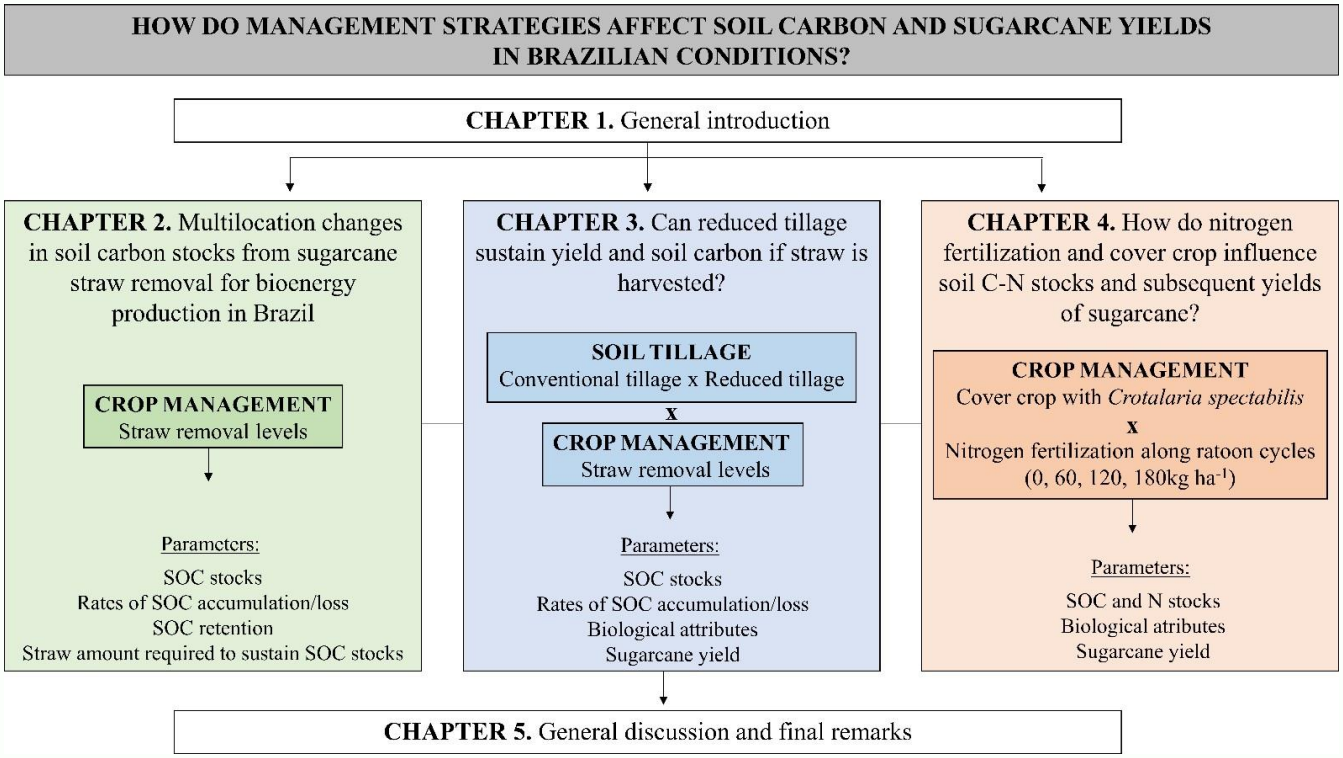
PROJECT'S TITLE

How do management strategies affect soil carbon and sugarcane yields in brazilian conditions?

SUMMARY

Over the past few years, the sugarcane straw deposited on soil surface by the mechanized harvesting system has shown agronomic and industrial benefits, as well as caused a series of changes in the soil and crop management practices. Consequently, these management changes can have a strong influence on soil organic carbon (SOC) storage and sugarcane yield. For example, the sugarcane straw on soil surface is the main input of C to soil and its removal for bioenergy purposes has potential to decrease SOC stocks. Whereas the consecutive application of nitrogen (N) fertilizer under areas previously cultivated with legume cover crop has no clear effect on SOC-N stocks and potential reduction in synthetic N fertilizer rates over the sequential ratoon crop cycles. The objectives of this study were to: (i) evaluate the SOC stocks changes induced by sugarcane straw removal management; (ii) identify alternative management strategies that minimize the impacts of straw removal on SOC stocks and crop yield; and (iii) assess how N fertilization and the cultivation of crotalaria cover crop affect SOC and N stocks, and sugarcane yields. A group of experiments was conducted under contrasting climate and soil conditions in south-central Brazil containing the following treatments: rates of straw removal, conventional and reduced soil tillage, and rates of N fertilizer under previous cultivation of crotalaria cover crop and fallow during the sugarcane replanting period.

Seeking a better comprehension of the management changes on SOC stocks in this new scenario of sugarcane production system in Brazil, this thesis was organized into five chapters:



HIGHLIGHTS

- About 19% and 25% of the C are incorporated into SOC stocks in sandy and clayey soils for each Mg of dry sugarcane straw maintained in the field.
- The sugarcane straw is not sufficient to sustain SOC stocks in sandy soils, and its removal showed to be less deleterious to SOC stocks in clayey soils.
- The adoption of reduced tillage attenuates the adverse impacts of straw removal on SOC stocks, while presents potential gains in sugarcane yields of 7 Mg ha^{-1}. Therefore, reduced tillage can be a feasible strategy for sustainable straw-based bioenergy production;
- N fertilization in sugarcane ratoon cycles causes small changes in SOC and N stocks;
- The previous cultivation of crotalaria cover crop causes small changes in SOC stocks, increases soil N stocks by 50- 80 kg N ha^{-1}, increases the average sugarcane yields by 9 to 15% without additional N, while reduces sugarcane response to synthetic N fertilization over sugarcane cycles.

TIMELINE AND MAIN RESULTS

2s/2019 - Attainment a teaching internship (PED) on TA322 at FEA/Unicamp

- Finalization and submission of the chapter IV as a paper at Soil Tillage Research
- Presentation of the partial results of the thesis at the LNBR/CNPEM Scientific Forum internal seminar with the title "It is possible to remove straw and maintain soil carbon stocks" in Nov 2019
- Publication of chapter III as a paper at Bioenergy Research Journal with the title "Can reduced tillage sustain sugarcane yield and soil carbon if straw is removed?", also a paper from my master degree (doi.org/10.1007/s10705- 019-09979-y) and other four papers as a co-author (doi.org/10.1016/j.still.2019.104383; doi.org/10.1007/s12155-019- 10007-8; doi.org/10.1590/1678-992x-2017-0147; doi.org/10.1590/1678-992x-2017-0295)

1s/2020 - Attainment a teaching internship (PED) on TA322 at FEA/Unicamp

- Finalization and submission of the chapter II as a paper at Global Change Biology and Bioenergy
- Presentation of partial results of the thesis at the CNPEM Student Congress in Jan 2020

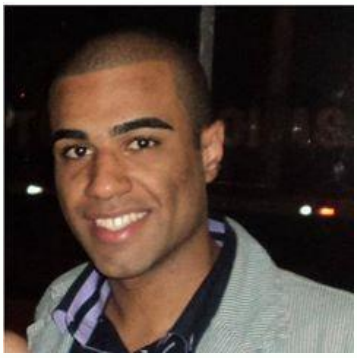
2s/2020 - Accomplishment of the second Qualification Exam of PhD. Bioenergy Program

- Revision of the papers from chapters II and IV that came back from the Journals with major revision
- Presentation of partial results of the thesis in an internal meeting of Biotechnology for Agriculture from LNBR/CNPEM with the title "Temporal changes of soil carbon stocks driven by sugarcane straw removal" in Oct 2020

-Publication of two papers as a co-author (doi.org/10.1016/j.indcrop.2020.112853, doi.org/10.1016/j.biombioe.2020.105889)

CHALLENGES AND STRATEGIES TO OVERCOME THEM

The difficulty I encountered during this period was to carry out the teaching internship (PED) remotely in the first semester of 2020 due to the pandemic situation. It was very challenging to support teachers and students during the semester, but with the collaboration and willpower of all students, PADs and other PEDs, we managed to perform well using Unicamp's virtual tools and constant virtual meetings.



Ph.D. Candidate: Leandro Carolino Gonzaga

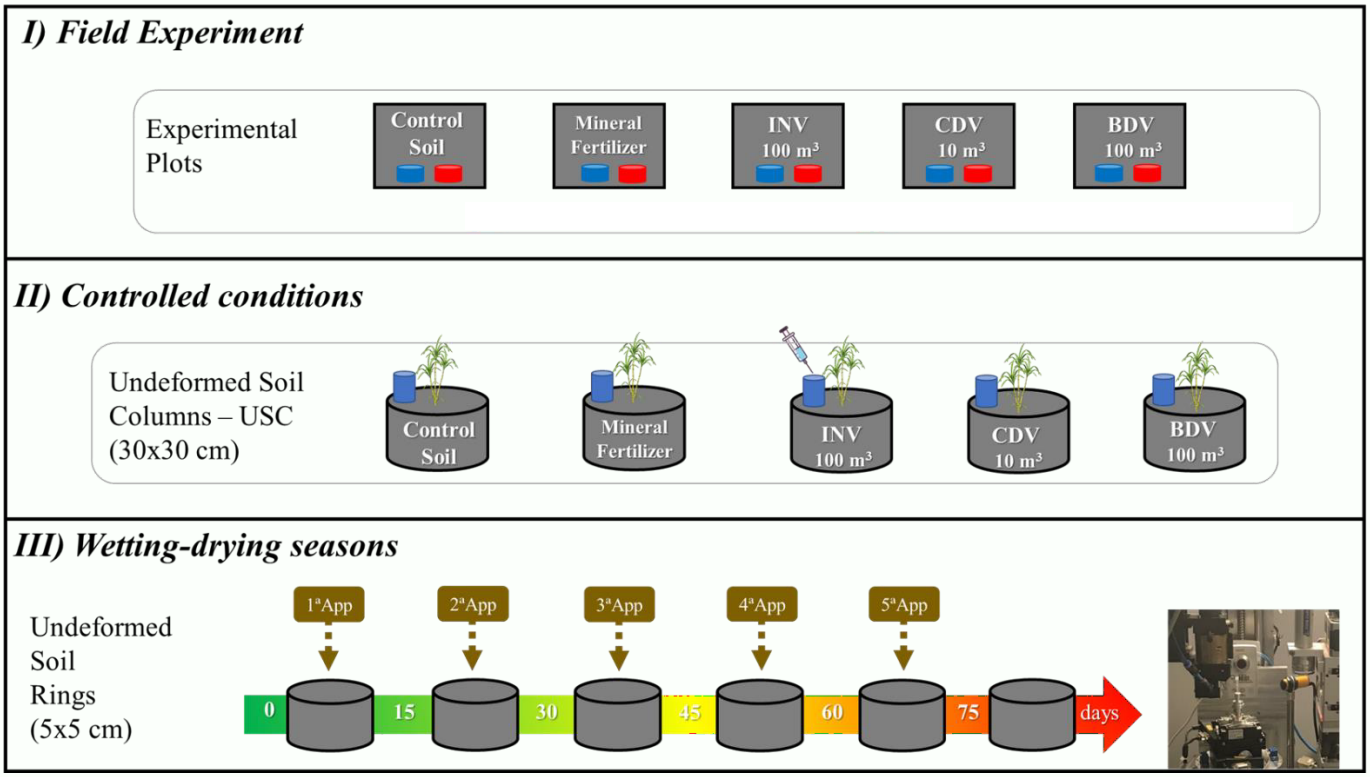
PERSONAL INFORMATION

Supervisor: João Luís Nunes Carvalho (LNBR/CNPEM)
Funding agency: None
Enrolment date: 03/2019 **Conclusion (estimative):** 03/2022
Lattes CV: http://lattes.cnpq.br/0474118610423902
LinkedIn: https://www.linkedin.com/in/leandro-carolino-gonzaga-78683a52

PROJECT'S TITLE

Understanding the effects of vinasse application on soil greenhouse gas emissions and its relationship withsoil physical changes

SUMMARY



Vinasse is the main agro-industrial residue produced by the sugarcane mills and, depending on the disposal mode, it can lead to environmental benefits or problems. Most of the vinasse produced in Brazil is applied to sugarcane by fertirrigation and the implications of this practice on soil and sugarcane yield still need to be better understood. Currently, new types of vinasse (e.g., concentrated and biodigested) are rising in Brazil, and the agricultural and environmental implications of these alternatives are unknown. The objective of this project is to assess the impacts of fertirrigation with fresh vinasse and understand how different types of vinasse can affect greenhouse gas emissions - especially for nitrous oxide and if changes in pore structure and aggregation influence N_2O emissions. The results of this project will be useful in determining the best strategies for vinasse disposal, helping to improve the sustainabilityof the sugar-energy sector in Brazil.

HIGHLIGHTS

- Assess the effects of the application of different types of vinasse on soil N_2O emissions.

- Evaluate the modifications caused by different vinasse in soil aggregation and how they correlate with N_2O emissions.
- Determine how successive vinasse applications affect soil microstructure and impact N_2O emissions.

TIMELINE AND MAIN RESULTS

1s/2019	To take the obligatory credits of the program – on going Submission of articles to a scientific journal, entitles: "Multilocation straw removal effects on sugarcane yield in south-central Brazil" and "Implications of sugarcane straw removal for soil greenhouse gas emissions in São Paulo state, Brazil" Finish work planning
2s/2019	Deliver an English proficiency test Start the data collection (second step)
1s/2020	Finish the obligatory credits of the program Other activities affected by the pandemic
2s/2020	First experiment to evaluate the impacts of new types of vinasse
1s/2021	Second experiment to evaluate the impacts of new types of vinasse First Qualifying Exam
2s/2021	Third experiment to evaluate the impacts of new types of vinasse Submission of an article to a scientific journal
1s/2022	Submission of an article to a scientific journal Second Qualifying Exam
2s/2022	Thesis defense

CHALLENGES AND STRATEGIES TO OVERCOME THEM

To discover the best way to reuse vinasse in order to improve the sustainability of the sucroenergy sector	Quantify the impact of the application of different types of vinasse on soil N_2O emissions
	Evaluate the effects of vinasse application on soil pore structure and aggregation and correlate the changes on soil physical properties with N_2O emissions.

HIGHLIGHTS OF THE STUDY ALREADY DONE

The first experiment was installed in October 2020 and conducted by 60 days under controlled conditions, where N_2O emissions were assessed and the sugarcane yield. We tested three types of vinasse: fresh, concentrated and biodigested, all types associated with nitrogen fertilizer. Based on

preliminary data, it is concluded that, under the conditions studied, the use of vinasse increases N_2O emissions when compared to mineral fertilizer but maintains the productivity of sugarcane biomass at levels like that of mineral fertilizer. In turn, the biodigested and concentrated vinasse, reduce N_2O emissions and maintain sugarcane yield, and can serve as a strategy to reduce emissions and improve sugarcane sustainability indicators. These results are important to help in the search for better strategies forthe management of organic residues from the production of bioethanol.

Ph.D. Student: Marcelo Antunes Gauto

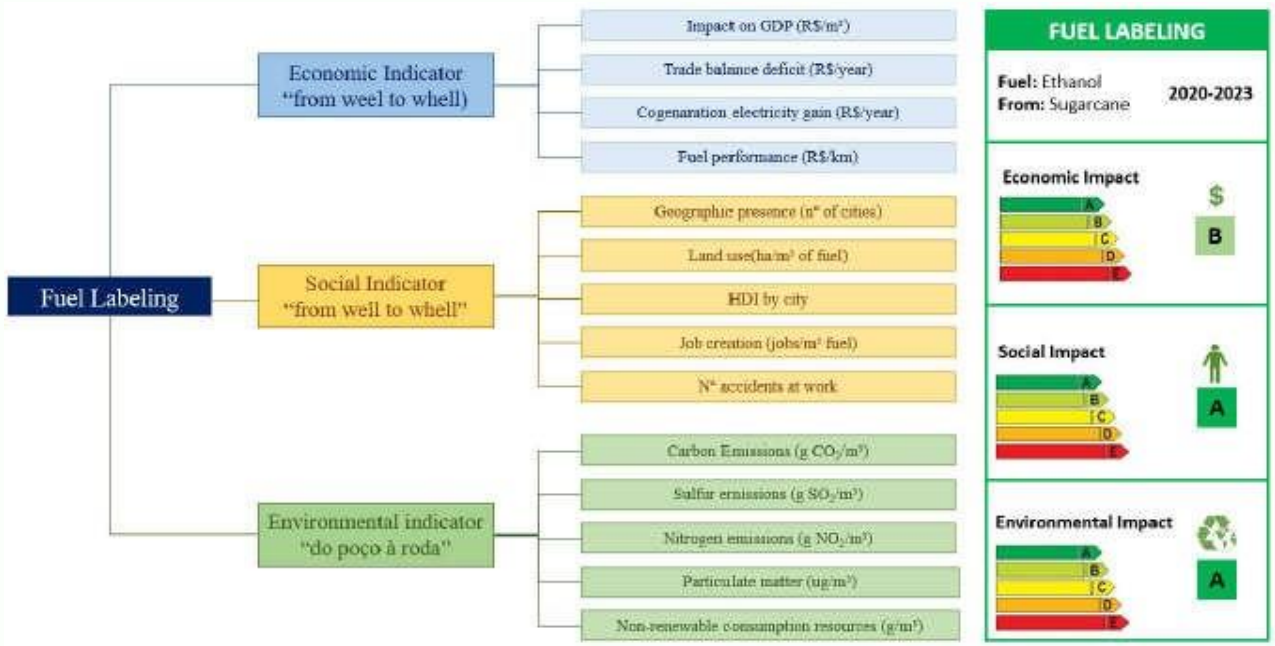
PERSONAL INFORMATION

Supervisor: Prof. Gonçalo Amarante Guimarães Pereira, Ph.D. **Co-Supervisor:** -
Funding agency: not applied. I work at Petrobras **Enrolment date:** 03/05/2021
Conclusion (estimative): 03/2025
Lattes CV: lattes.cnpq.br/9809120691290002
LinkedIn: linkedin.com/in/quimicogauto

PROJECT'S TITLE

Socioeconomic Fuel Labeling in Brazil

SUMMARY



The aim of this project is to compare the life cycle of distinct types of fuel employed in light vehicles, using economic, social, and environmental indicators, and to propose the creation of a labeling program for biofuels in Brazil. This tool may contribute to the discussion about value generation from biofuel and its role in the current energy transition.

HIGHLIGHTS

- Define and quantify, through Life Cycle Assessment (LCA), economic, social and environmental indicators considered relevant for consumers, for maximize the value of biofuel for them and for the country.
- Show the benefits of ethanol compared to gasoline and CNG in Brazil, considering aspects such as job creation, currency evasion, energy independence, water and air pollution, and health damage, among others.
- Influence and guide consumers to consider other characteristics of fuels besides cost per unit of volume when filling the tank of their vehicles.
- Create the socioeconomic fuel labeling to communicate efficiently mode the benefits of biofuel for society.

TIMELINE AND MAIN RESULTS

1s/2021

□ Subject BI001 – Fundamentals of biomass production: 4 credits

□ Subject BI011 – Bioenergy Seminars': 2 credits

□ Subject BI003 – Social, Economic and Environmental Sustainability: 4 credits

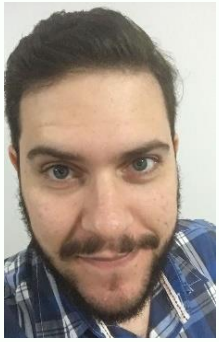
□ Presentation Seminar "The directions of the O&G and biofuels industry in Brazil" (04/08/2021)

CHALLENGES AND STRATEGIES TO OVERCOME THEM

Challenge: define the main indicators which serve as a basis for the study
Strategies: compile from literature the many indicators existing and choice through the multicriteria analysis which them are the better to execute the quantify.

Challenge: Quantify the social, economic and environmental indicators defined in the first step at the workplan.
Strategies: use national and international public databases how scientific articles, sectorial reports,governmental, of the research institutes, among others, considering the LCA.

Challenge: build the labels fuels with indicators quantified
Strategies: research on existing labeling programs in some countries for fuel label modeling anddevelopment of its own method to use all chosen indicators in the composition of the labe.



Ph.D. Candidate: Henrique Real Guimarães

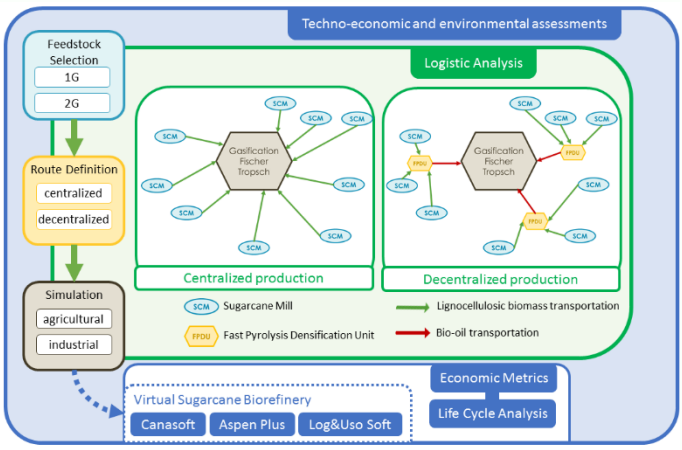
PERSONAL INFORMATION

Supervisor: Marcos Djun Barbosa Watanabe
Funding agency: CAPES
Enrolment date: 02/2018
Conclusion (estimative): 12/2021
Lattes CV: http://lattes.cnpq.br/1446926780517383
LinkedIn: https://www.linkedin.com/in/henrique-guimarães-840790120

PROJECT'S TITLE

Techno-economic and environmental assessments of thermochemical routes integrated to the Brazilian sugarcane sector: decentralized biomass valorization to renewable jet fuel

SUMMARY



In recent years, environmental agreements and international concerns on greenhouse gas emission reduction policies have pushed different segments of the economy to search for renewable alternatives to decrease greenhouse gas emissions with economically viable technologies. This scenario led to an increase on studies regarding biomass conversion into biofuels either from biochemical or thermochemical routes. This is the case for jet fuels, whose demand from the international flight sector is considering decreasing fossil fuel-based CO2 emissions. One of the possible solutions is the renewable jet fuel obtained from the gasification of lignocellulosic biomass, followed by catalytic conversion (Fischer-Tropsch reactions) into the desired biofuel. However, this process presents its own setbacks mainly related to the dependence on large scale plants that raise the investment and costs associated with biomass transportation to the plant. A hypothesis is that the implementation of intermediate-scale fast pyrolysis units near the biomass production sites could supply the production chain with bio-oil at an economically feasible condition, with a liquid intermediate that would lower transportation costs and make the production of jet fuel feasible. Thus, with the assistance of techno-economic and environmental assessments considering logistics aspects, the present project aims to evaluate the best technological routes to implement fast pyrolysis units into the biojet fuel production chain through gasification/catalytic conversion technologies, integrating this route to the biochemical conversion technologies of sugarcane industry in Brazil.

HIGHLIGHTS

- Study of biomass gasification and Fischer Tropsch conversion to produce advanced biofuels (biokerosene)
- techno-economic and environmental analysis of a thermochemical process on the Brazilian Scenario
- study of the influence of decentralizing the large scale production chain with smaller scale densification units (through fast pyrolysis)
- preliminary studies of the base scenario (integrated to 1G mill) already shows promising results;
- a stand alone thermochemical plant needs to be of higher capacities to become more viable than an integrated, thus biomass costs and transportation have significant influence on economic perfomance

TIMELINE AND MAIN RESULTS

1s/2018	Fulfillment of required credits
	Bibliographic review
	Project Elaboration
2s/2018	Fulfillment of required credits
	Bibliographic review
	Scholarship project submission
1s/2019	Bibliographic review
	Simulation and scenarios definition
2s/2019	Bibliographic review
	Simulation elaboration (base case)
1s/2020	Obligatory instructor internship (PED program)
	Paper elaboration
	Techno-economic assessment
2s/2020	Paper elaboration
	Simulation elaboration (base case) + Techno-economic assessment
	Simulation elaboration (alternative case)

CHALLENGES AND STRATEGIES TO OVERCOME THEM

The elaboration of a project for a FAPESP scholarship still was a challenge during the second year of the project (2019). However, I have managed to acquire a CAPES scholarship and was able to dedicate fully to the project. This made it possible to develop a large part of the necessary simulation for the project. However, during the pandemic (early 2020) I wasn't able to access my work computer, and the simulation elaboration was halted. During this period, effort was made to utilize the already available data from the initial simulations in order to elaborate a paper. During the second semester of 2020, I have gained access to the computer, and was able to resume the simulations and correct some flaws and mistakes on the initial simulation. The resulting paper is in the process of submission, and the project is continuing.