THESSALONIKI2021

Influence of the products distribution and conversion technologies in the techno-economic performance of a biorefinery: The avocado case.

UNIVERSIDAD NACIONAL DE COLOMBIA SEDE MANIZALES

***J.C. Solarte-Toro**, J.A. Poveda-Giraldo, D.L. Restrepo-Serna, C.A. Cardona-Alzate**

Instituto de Biotecnología y Agroindustria, Departamento de Ingeniería Química, Universidad Nacional de Colombia, Manizales campus. Manizales - Colombia. Km 07 vía al Magdalena.

***Presenting author email: jcsolartet@unal.edu.co**

Introduction.

Colombia has been categorized as one of the most important producers of avocado in Latin America (544,933 tonnes in 2018). The Antillean race (***Persea americana var. Americana***) covers more than 75%. Nevertheless, more than 50% of this fruit does not fulfill the required specifications to be commercialized because plant diseases such as ***Phytophtora Cinnamomi.***

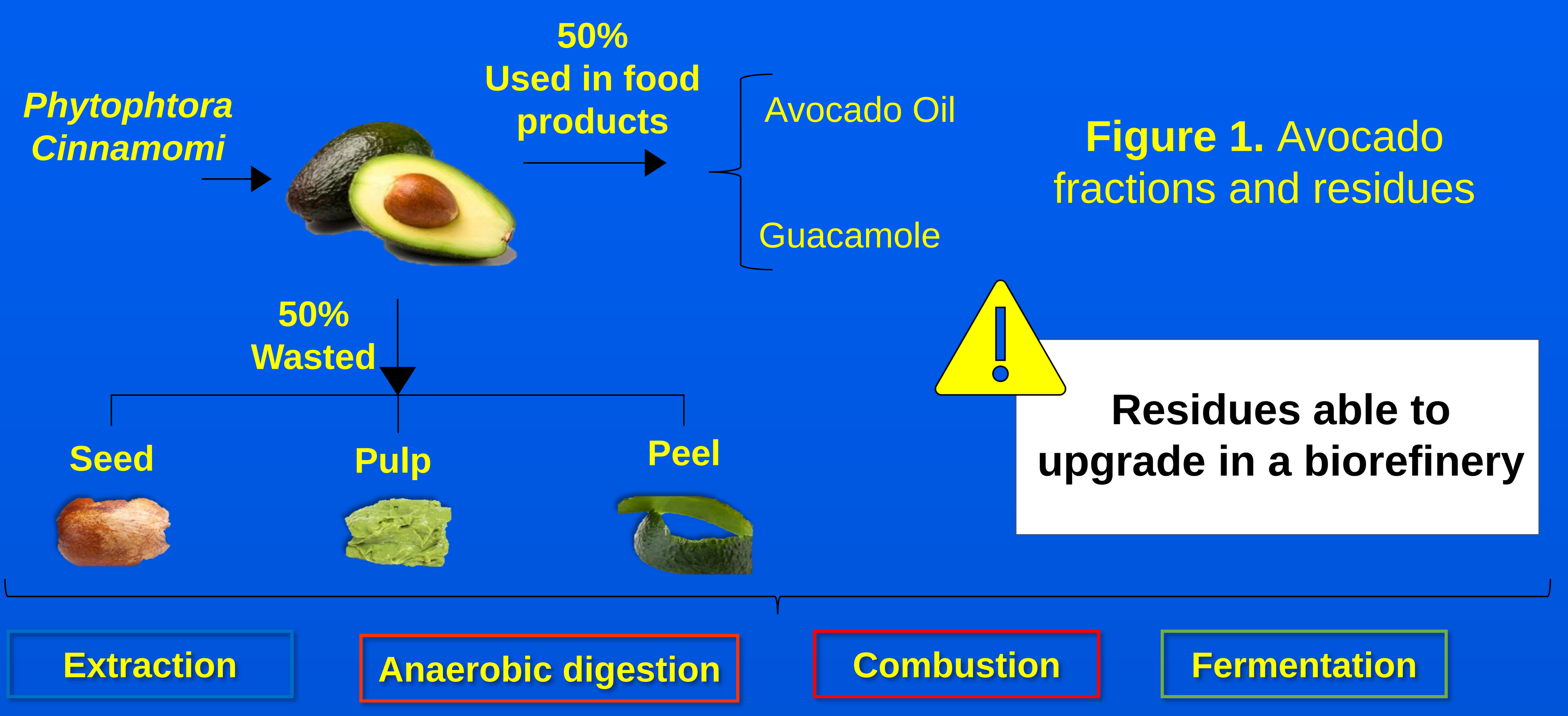


Figure 1. Avocado fractions and residues

Biorefineries are defined as a complex system where biomass is processed to obtain more than one product (e.g., bioenergy, chemicals). Nevertheless, products and technologies selection is done subjectively in most cases.

This work aims to shows the influence of varying the portfolio of products obtained in a biorefinery using avocado as raw material. This work also aims to elucidate how the products portfolio can affect technical and economic assessment of biorefineries

Methodology

01 Process design

Biorefinery I: Products distribution I	Biorefinery II: Products distribution II
Avocado oil → Avocado pulp	Biodiesel → Avocado pulp
Protein → Exhausted pulp	Phenolic compounds → Avocado seed
Phenolic compounds → Avocado seed	Sorbitol → Exhausted avocado seed
Bioethanol → Exhausted avocado seed	Pentane → Avocado peel
Xylitol → Avocado peel	Biogas → Solid residues
Electricity → Solid residues	

02 Process simulation

Aspen Plus and Aspen Energy Analyzer Simulation

- Mass Balances
- Energy Balances

Mass indicators

Product yield: $Y_P = \frac{\sum \dot{m}_{Product,\ i}}{\dot{m}_{Raw\ material}}$

Process mass intensity index: $PMI = \frac{\sum_{i=1}^{N} \dot{m}_i^{in}}{\sum \dot{m}_{Product,\ i}}$

Mass loss index: $MLI = \frac{\sum_{i=1}^{N} \dot{m}_i^{in} - \dot{m}_{Product}}{\sum \dot{m}_{Product,\ i}}$

Energy indicators

Overall energy efficiency: $\eta = \frac{\dot{m}_{Products} * LHV_{Products}}{(\dot{m}_{raw\ mat} * LHV_{raw\ mat}) + \dot{Q} + \dot{W}}$

Specific energy consumption: $S_{EC} = \frac{\dot{Q} + \dot{W}}{\dot{m}_{raw\ mat}}$

03 Economic assessment

Mass and Energy balances → **Sizing**: Aspen Process Economic Analyzer v.9.0. → **Costs estimation**: Input of raw materials, utilities, and labor costs → **Cash flow**: Estimation of economic metrics

Economic context

Depreciation method: Straight line
Tax rate: 28%
Interest rate: 1,64%
Project lifetime: 20 years.
Operator wage: 0,92 USD/h
Supervisor wage: 2,77 USD/h

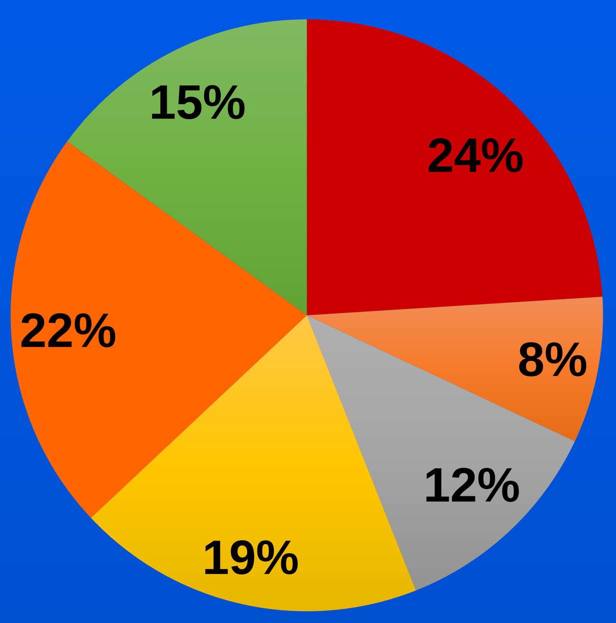
Figure 3. Methodology economic assessment.

Results.

Table 1. Mass and energy indicators of each biorefinery.

Indicator	Biorefinery 1	Biorefinery 2
Overall product yield	125.45	198.23
Process mass index	53.23	32.98
Mass loss index	21.58	17.32
Overall energy efficiency	16%	24%
Specific energy consumption	548.65	613.28

Biorefinery 1: Non-catalytic upgrading and products distribution I



Acceptable energy consumption

Low raw material conversion

Biorefinery 2: Catalytic upgrading and products distribution II

High raw material conversion

High energy consumption

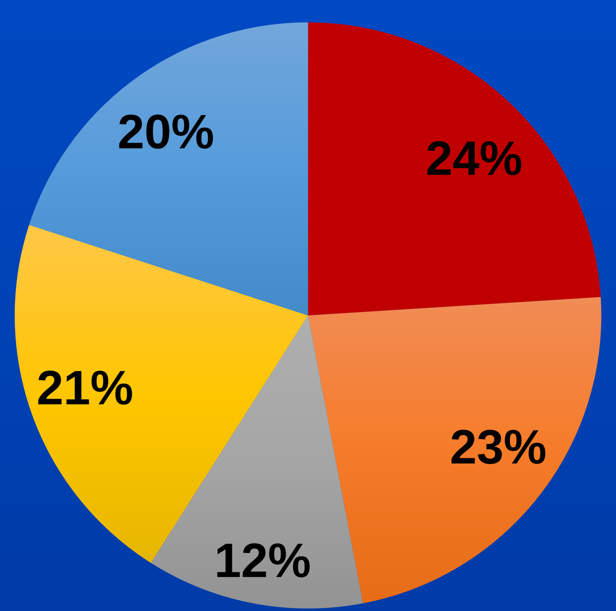


Figure 4. Cost distribution of each biorefinery

Table 2. Economic metrics of each biorefinery configuration.

Economic metric	Biorefinery 1	Biorefinery 2
Processing scale	420 ton/year	420 ton/year
Net present value	0.92 M.USD	0.68 M.USD.
Payback period	16.53 years	18.44 years
CapEx	889,526 USD	1'080,000 USD
OpeEx	79,097 USD/year	130,960 USD/year

Conclusions.

The avocado biorefineries evaluated in this work reflects that biotechnological and physical conversion processes can give a more economic feasible biorefinery. Nevertheless, issues related to solid and liquid waste generation will be higher. Consequently, the implementation of catalytic conversion processes can increase biomass valorization since a complete upgrading of biomass components can be achieved. From this results, catalytic biomass upgrading can boost biomass valorization in a initial stage because most conversion technologies have reached the highest technological readiness level.

Other aspects related to (i) the industrialization level, (ii) socio-economic context, (iii) strengths and weaknesses in the market, (iv) match between raw materials and products (i.e., Although all biomass has cellulose, hemicellulose, and lignin, it does not mean that all biomass can be upgraded in all conversion processes) are necessary before to decide how to valorize any biomass source.

Acknowledgements.

This work is the result of the research developed through the program: PROGRAMA DE INVESTIGACIÓN RECONSTRUCCIÓN DEL TEJIDO SOCIAL EN ZONAS DE POS-CONFLICTO EN COLOMBIA SIGP Code: 57579 within the research project "COMPETENCIAS EMPRESARIALES Y DE INNOVACIÓN PARA EL DESARROLLO ECONÓMICO Y LA INCLUSIÓN PRODUCTIVA DE LAS REGIONES AFECTADAS POR EL CONFLICTO COLOMBIANO" SIGP Code: 58907. Funded within the framework of Colombia Científica, Contract No FP44842-213-2018.