EVALUATION OF THE PHB PRODUCTION USING MILK WHEY AS FEEDSTOCK

Catalina Álvarez Campuzano, Juan Carlos Higuita V
Biotechnological and Agribusiness Institute, Chemical Engineering Department,
Universidad Nacional de Colombia at Manizales, Manizales-Colombia
caalvarezca@unal.edu.co, jchiguitav@unal.edu.co

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1. INTRODUCTION

PLASTICS

Oil has been considered as an essential raw material in many industrial processes. However, one of its derivatives, specifically synthetic plastics or polymers, presents serious pollution problems hence the necessity to find suitable and more environmentally friendly substitutes.


1. INTRODUCTION

BIOPOLYMERS

Biopolymers are presented as an attractive alternative, because of their similar properties to petroleum-based plastics, their biodegradability and ability to be obtained from renewable carbon sources.
1. INTRODUCTION

**PHB**

- First PHA discovered
- Similar to polypropylene
- Intracellular carbon reservoir
- Gram Positive and Gram negative Bacteria

PHB intracellular inclusion
1. INTRODUCTION

MILK WHEY

- Low costs
- High sugar content
- Bioremediation

<table>
<thead>
<tr>
<th>Component</th>
<th>Concentration (g/l)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Total Solids</td>
<td>63,0 – 70,0</td>
</tr>
<tr>
<td>Lactose</td>
<td>44,0 – 46,0</td>
</tr>
<tr>
<td>Protein</td>
<td>6,0 – 8,0</td>
</tr>
<tr>
<td>Calcium</td>
<td>1,2 – 1,6</td>
</tr>
<tr>
<td>Phosphates</td>
<td>2,0 – 4,5</td>
</tr>
<tr>
<td>Lactate</td>
<td>6,4</td>
</tr>
<tr>
<td>Chlorides</td>
<td>1,1</td>
</tr>
</tbody>
</table>

Milk whey composition
1. INTRODUCTION

Colombia produces 3,600 tonnes of milk whey per year\(^1\).


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**FINAL DISPOSAL**

Disposal in water sources: 45%

Dairy drinks: 30%

Whey powder: 17%

Food lactose: 8%
2. METHODOLOGY

Milk whey pre-treatment

Inoculum of the medium, using *B. megaterium*.

Thechno-Economic Evaluation using the comercial software Aspen Plus 8.0

PHB cuantification and extraction.
2. METHODOLOGY

Culture Conditions

• pH: 7
• Temperature: 32 °C
• Agitation: 200 rpm
• Aeration: 5 l/min

<table>
<thead>
<tr>
<th>Compound</th>
<th>Formula</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ammonium Sulfate</td>
<td>(NO₄)₂.SO₄</td>
</tr>
<tr>
<td>Acid sodium phosphate</td>
<td>Na₂HPO₄</td>
</tr>
<tr>
<td>Magnesium sulfate heptahydrate</td>
<td>MgSO₄.7H₂O</td>
</tr>
<tr>
<td>Potassium dihydrogen phosphate</td>
<td>KH₂PO₄</td>
</tr>
</tbody>
</table>

Nutrients added to the Bacillus megaterium growth medium
2. METHODOLOGY

ULTRAFILTRATION PRE-TREATMENT METHOD

- Fresh milk whey
- Sterilization 115°C 15 min
- Ultrafiltration
- Formulated medium addition
- Centrifugation 6000 rpm x 10 min
- pH 7 adjustment using NaOH 12 M
- Fermentation broth
2. METHODOLOGY

SIMULATION

- The experimental data was used for process simulation

Methodology

Mass and Energy Balances

- Using *Aspen Plus V 8.0* the mass and energy balances were generated

Economic Analysis

- For the Colombian conditions using *Aspen Plus economic analyzer*
2. METHODOLOGY

Technologies and conditions used in the techno-economic assessment of PHB production (100kg/h milk whey).

<table>
<thead>
<tr>
<th>Technology</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ultrafiltration</td>
<td>Cellulose- acetate membrane removing 96% of protein</td>
</tr>
<tr>
<td>Fermentation</td>
<td>Using <em>Bacillus megaterium</em> without genetic modification</td>
</tr>
<tr>
<td>Enzymatic</td>
<td>Enzymatic treatment using 2% w/w of <em>Burkholdeira sp</em></td>
</tr>
<tr>
<td>Digestion</td>
<td>PTV</td>
</tr>
<tr>
<td>Purification</td>
<td>Using H₂O₂ 1,2% v/v</td>
</tr>
</tbody>
</table>

PHB production process for the techno-economic evaluation.
3. RESULTS

Growth curve of *B. megaterium* using milk whey as substrate. Total Biomass, PHB concentration, Lactose concentration.
3. RESULTS

PHB PRODUCTION COST
4 USD/kg

PHB MARKET PRICE
3 USD/kg
4. CONCLUSION

It is possible to use different bio-residues to obtain PHB as an alternative to synthetic polymers (low cost and high pollution load).

The production of PHB using milk whey as raw material was demonstrated. Nevertheless, it is necessary to invest in new technologies for cheaper pre-treatment methods that would reduce the high production costs associated with this step and achieve a competitive level for this product.

PHB production could be assessed within a biorefinery scheme where other products are obtained, thereby reducing production costs and reaching similar values to synthetic polymers.
5. REFERENCES

6. ACKNOWLEDGMENTS

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JUAN CARLOS HIGUITA V, PhD

E-mail: jchiguitav@unal.edu.co