



FKITMCMXIX

Sveučilište u Zagrebu
Fakultet kemijskog
inženjerstva i tehnologije



*Proizvodnja i razvoj kompostabilne ambalaže iz
otpadne biomase za pakiranje industrijski
prerađenih prehrambenih proizvoda*

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Svibanj 2025.




bioPHA-comFPack

Proizvodnja i razvoj kompostabilne ambalaže iz otpadne biomase za pakiranje industrijski prerađenih prehrambenih proizvoda

NPOO.C3.2.R3-II.04.0059

Nacionalni plan oporavka i otpornosti (NPOO)
Podrška transferu tehnologije

Prijavitelj projekta
Sveučilište u Zagrebu
Fakultet kemijskog inženjerstva i tehnologije
Trg Marka Marulića 19, 10 000 Zagreb

Voditelj projekta
Izv. prof. dr. sc. Dajana Kučić Grgić

Partneri projekta
Istraživačka organizacija:
Sveučilište Josipa Jurja Strossmayera u Osijeku
Prehrambeno-tehnološki fakultet Osijek
Franje Kuhaca 18, 31 000 Osijek

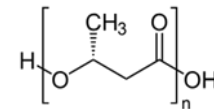
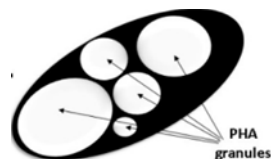
Poduzeća:
Podravka d.d.
Ante Starčevića 32, 48 000 Koprivnica
Rotoplast d.o.o.
Poduzetnička 7, Kerestinec, 10 431 Sveta Nedelja

Trajanje projekta: 1. 1. 2024. – 30. 6. 2026.

Ukupni prihvatljivi troškovi projekta: 1.628.689,99 €

Bespovratna sredstva: 1.488.082,51 €

www.fkit.unizg.hr
bio-pha-com-f-pack.eu





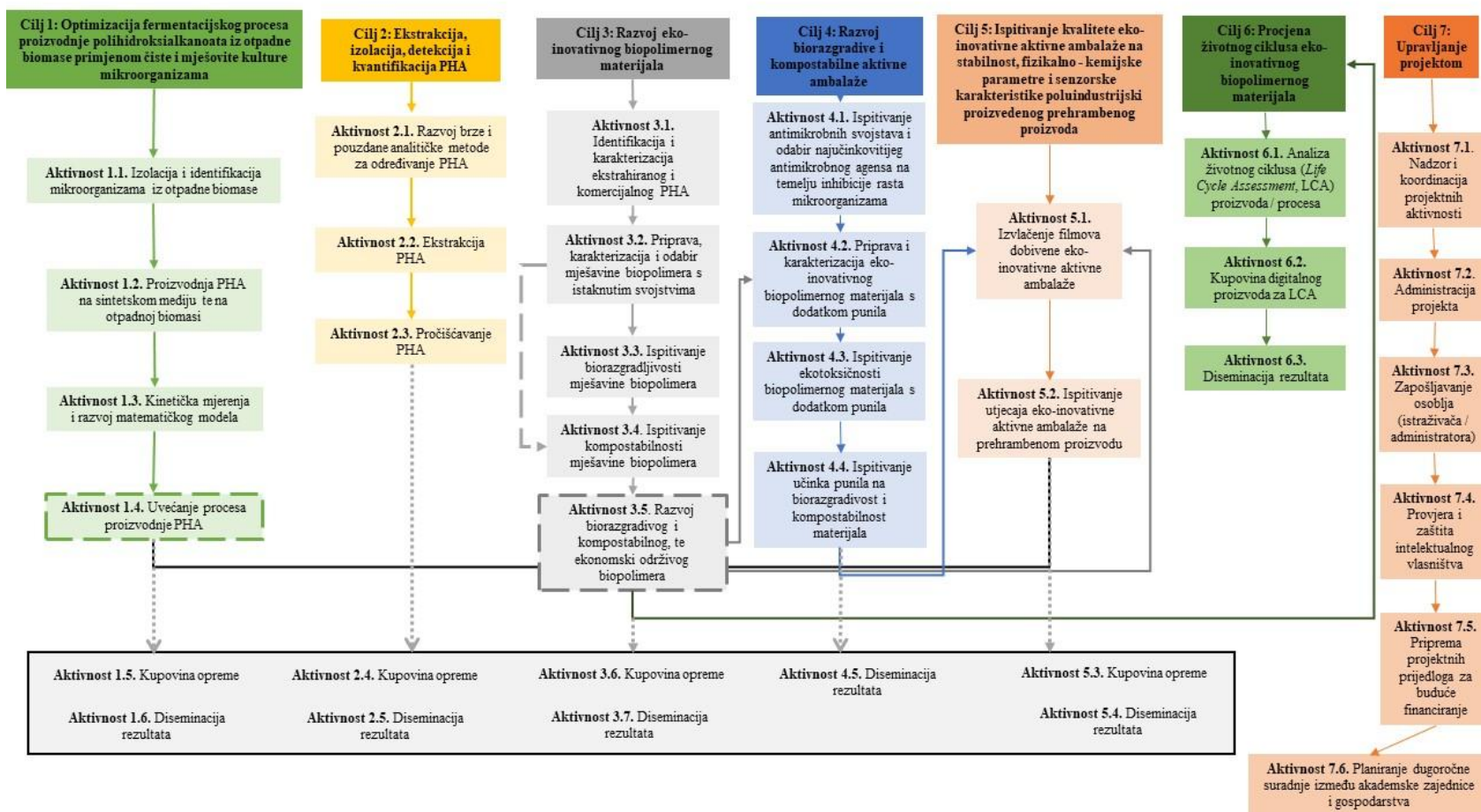
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Projektne aktivnosti



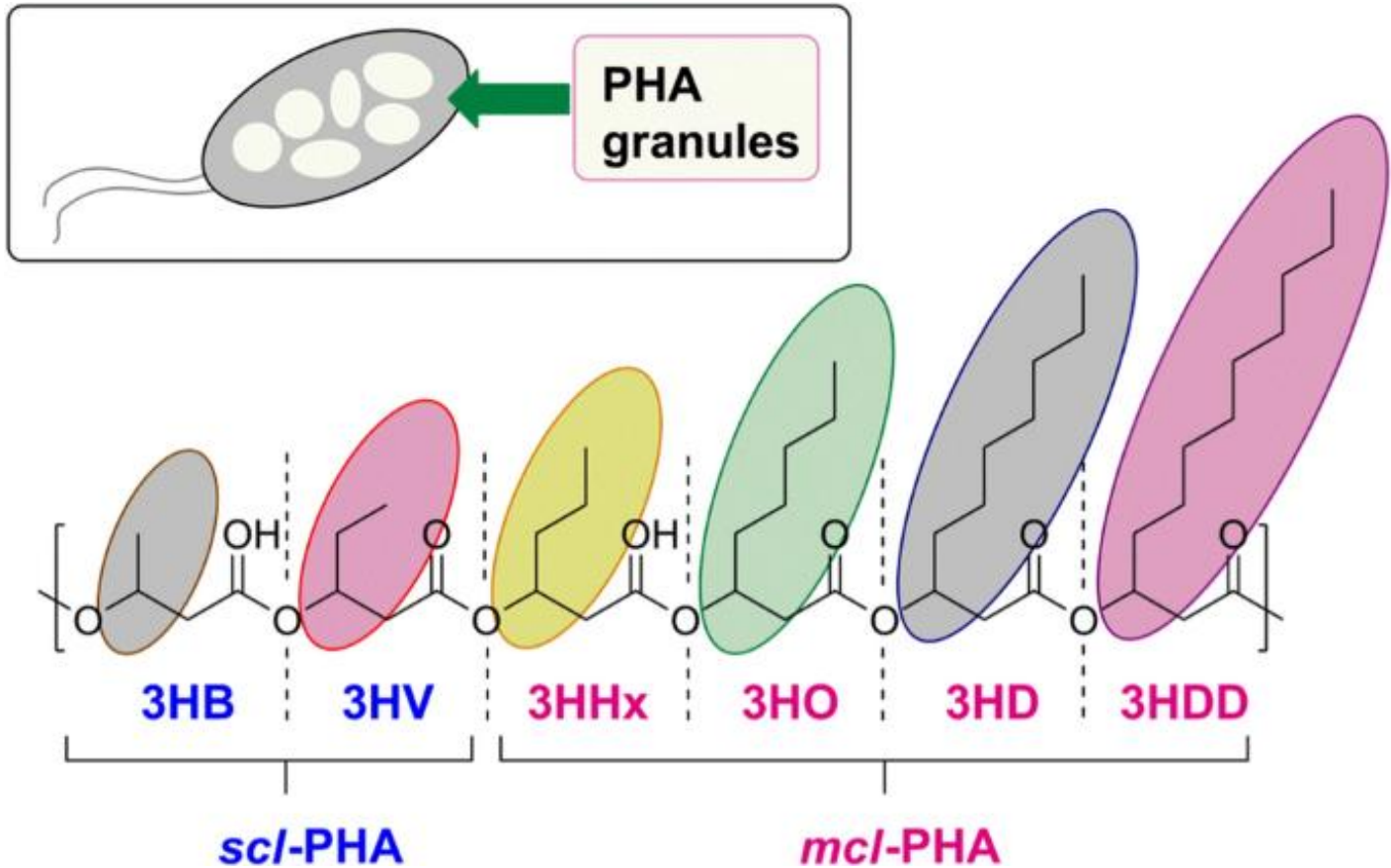
<https://bio-pha-com-f-pack.eu/>



Funded by
the European Union

This research was conducted as part of the project „Production and development of compostable packaging from waste biomass for the packaging of industrially processed food products” (NPOO.C3.2.R3-IL.04.0059) funded by National Recovery and Resilience Plan (funded by the European Union, Next Generation EU).

Polihidroksialkanoati



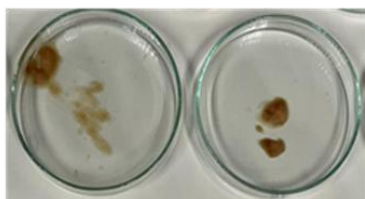
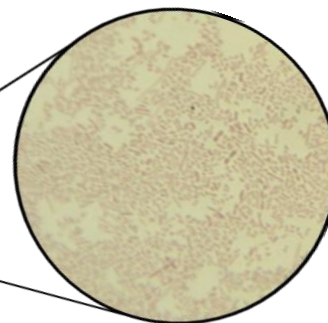
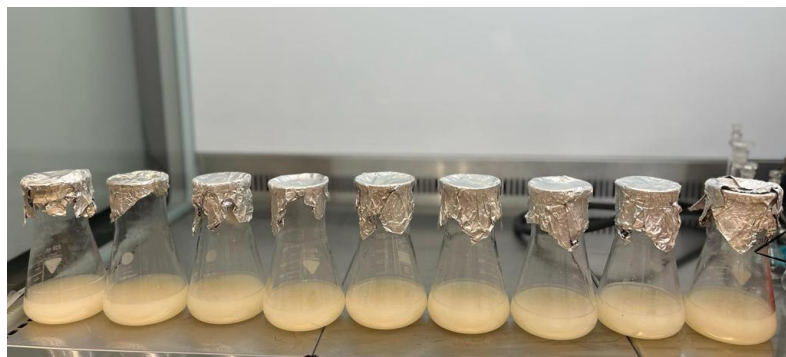
Proizvodnja bioplastike

<i>Proizvođač PLA</i>	<i>Proizvodnja (t/god)</i>	<i>% od globalne proizvodnje</i>
<i>NatureWorks LLC, SAD</i>	<i>150.000</i>	<i>40</i>
<i>Total Corbion PLA, Nizozemska</i>	<i>75.000</i>	<i>20</i>
<i>Sulzer Ltd, Švicarska</i>	<i>50.000</i>	<i>13</i>

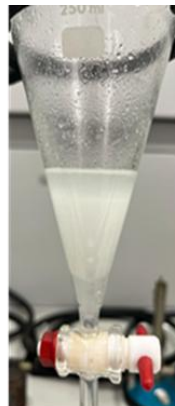
<i>Proizvođač PBS</i>	<i>Proizvodnja (t/god)</i>	<i>% od globalne proizvodnje</i>
<i>Metabolix (Yield10 Bioscience), SAD</i>	<i>5.000</i>	<i>30</i>
<i>Biomer, Njemačka</i>	<i>3,000</i>	<i>18</i>

<i>Proizvođač PHA</i>	<i>Proizvodnja (t/god)</i>	<i>% od globalne proizvodnje</i>
<i>Danimer Scientific, SAD</i>	<i>10000</i>	<i>25</i>
<i>Kaneka Corporation, Japan</i>	<i>8000</i>	<i>20</i>
<i>Bio-on SpA, Italija</i>	<i>5000</i>	<i>12</i>

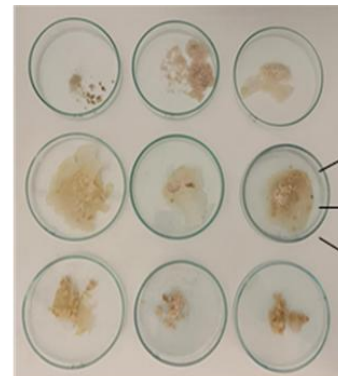
Dobivanje PHA sumberznom ferementacijom



Dry cell weight (DCW)
after centrifugation



Extraction with boiling chloroform
and 4% sodium hypochlorite
solution



Obtained PHA extracts
from chloroform phase

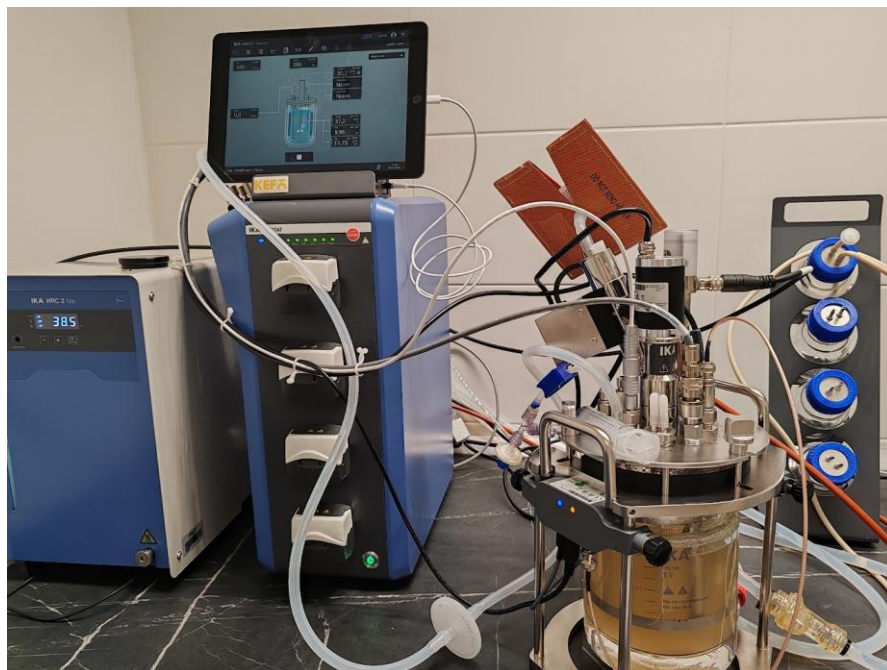
FTIR-ATR

TGA

DSC



Funded by
the European Union



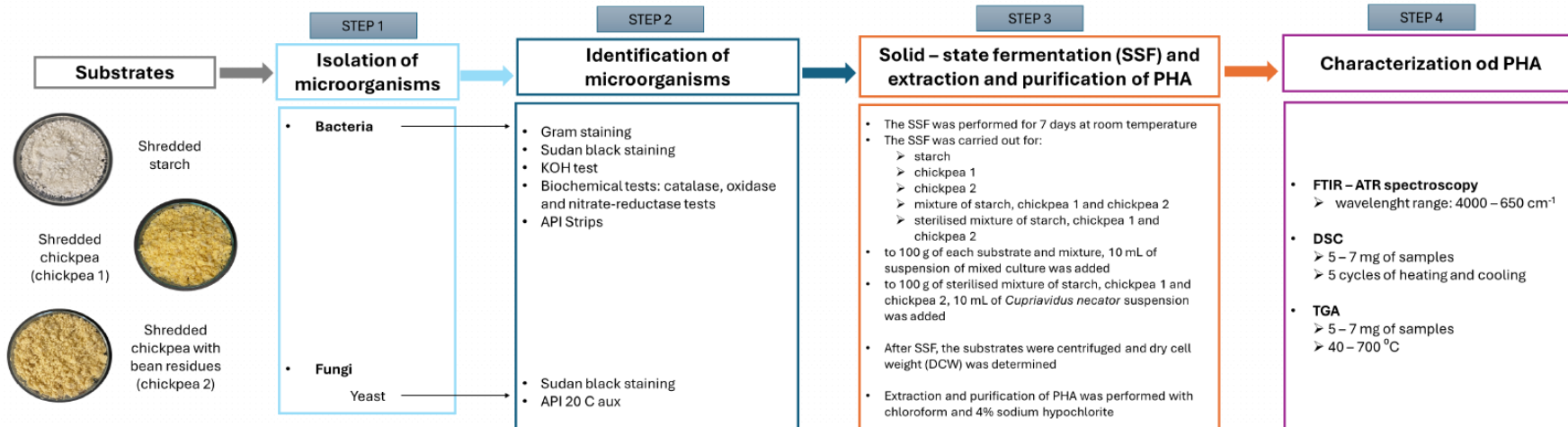
Dobivanja PHA sumberznom ferementacijom



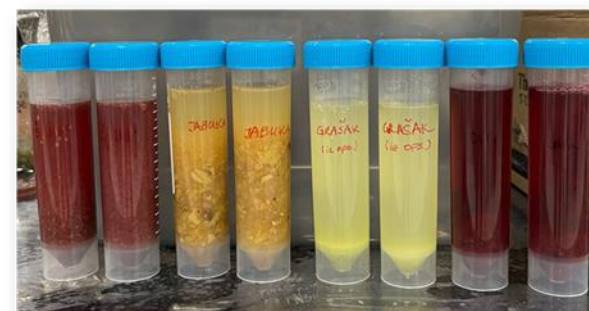
Liofilizator

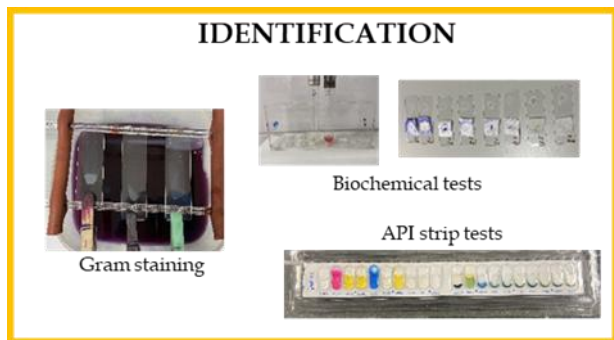
*Dobivanje PHB, 67 %
iskorištenja, čistoće > 98%*





Agroindustrial waste





Substrate	Identified Microorganism	Morphology
Chickpea 1	<i>Brevibacillus</i> sp.	Transparent with flat elevation, and regular round configuration, rod shaped
	<i>Empedobacter brevis</i>	Orange with flat elevation, and regular round configuration, rod shaped
	<i>Aneurinibacillus aneurinilyticus</i>	Brownish with raised elevation, and regular round configuration, rod shaped
Chickpea 2	<i>Micrococcus</i> spp.	Orange with flat elevation, and regular round configuration, round shaped (cocci)
	<i>Trichosporon asahii</i>	White and cracked in the middle with smooth and shiny edges
	<i>Leucomotoc</i> sp.	White with flat elevation, and regular round configuration, cocci/coccobacilli
Starch	<i>Bacillus licheniformis</i>	White with raised elevation, wavy and smooth edges, rod shaped
	<i>Staphylococcus lentus</i>	Transparent with raised elevation, and regular round configuration, round shaped (cocci)
	<i>Citrobacter freundii</i>	Transparent with raised elevation, irregular shape with twisted edges, rod shaped
	<i>Cryptococcus humicola</i>	Yellowish with raised elevation, round shape with jagged edges
	<i>Geotrichum klebahnii</i>	White with flat elevation, filamentous shape with jagged edges
	<i>Candida krusei</i>	White with raised elevation, and regular round configuration

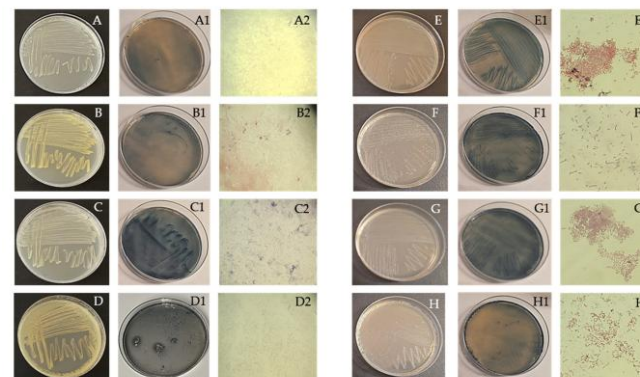


Figure 2. Obtained pure cultures by streaking method, cultures stained with Sudan Black dye, and microphotographs of Gram staining of bacteria isolates *Brevibacillus* sp. (A,A1,A2), *Empedobacter brevis* (B,B1,B2), *Aneurinibacillus aneurinilyticus* (C,C1,C2), *Micrococcus* spp. (D,D1,D2), *Leucomotoc* sp. (E,E1,E2), *Bacillus licheniformis* (F,F1,F2), *Staphylococcus lentus* (G,G1,G2), *Citrobacter freundii* (H,H1,H2), M = 1000x.

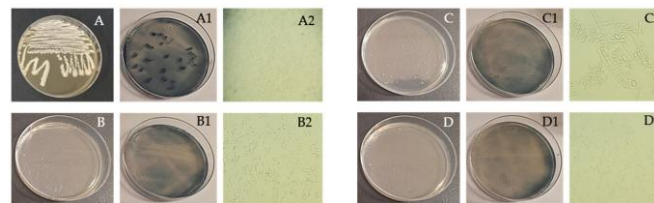


Figure 3. Obtained pure cultures by streaking method, cultures stained with Sudan Black dye, and microphotographs of yeast isolates *Trichosporon asahii* (A,A1,A2), *Cryptococcus humicola* (B,B1,B2), *Geotrichum klebahnii* (C,C1,C2), *Candida krusei* (D,D1,D2), M = 400x.

Identified Bacteria	Gram Staining	KOH Test	Oxidase	Catalase	Nitrate-Reductase
<i>Brevibacillus</i> sp.	+ve	+	+	+	+
<i>Empedobacter brevis</i>	-ve	+	+	+	-
<i>Aneurinibacillus aneurinilyticus</i>	+ve	+	+	+	-
<i>Micrococcus</i> spp.	+ve	+	+	+	+
<i>Leucomotoc</i> sp.	+ve	-	-	-	-
<i>Bacillus licheniformis</i>	+ve	-	-	+	+
<i>Staphylococcus lentus</i>	+ve	-	-	+	+
<i>Citrobacter freundii</i>	-ve	-	-	+	+

Otpad od rajčice – sterilni i nesterilni otpad



Otpad od rajčice + *C. necator*

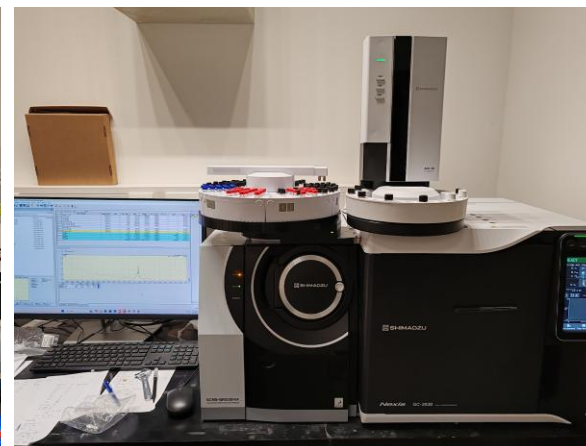
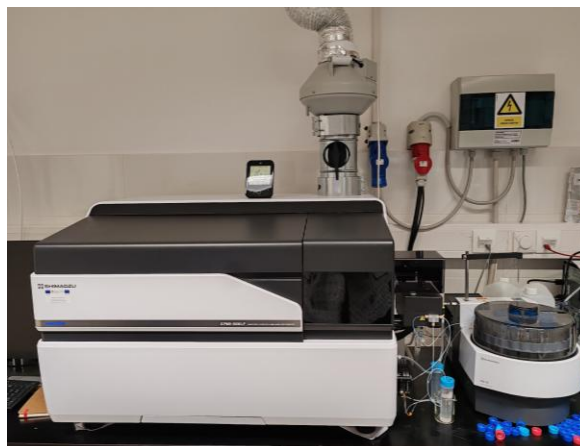
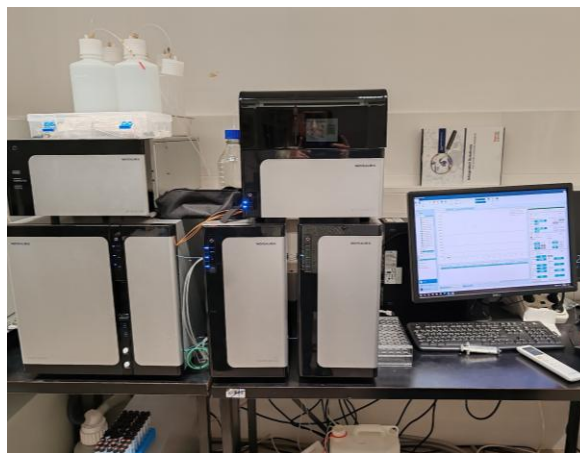
Otpad od jabuke + *C. necator*

Parameter	Sterile	Non-sterile	Sterile	Non-sterile
Moisture content [%]	4.40 ± 0.10	5.66 ± 0.15	4.38 ± 0.09	4.95 ± 0.07
Protein content [%]	25.71 ± 7.57	16.43 ± 0.34	13.50 ± 7.00	12.09 ± 0.23
Free lipid content [%]	9.31 ± 0.17	3.21 ± 0.06	3.46 ± 0.05	3.70 ± 0.03
PHA content [%]	9.23 ± 0.37	5.98 ± 0.50	7.54 ± 0.14	9.71 ± 0.12

Otpad od jabuke – sterilni i nesterilni otpad

EQUIPMENT

- Ion chromatography (IC) instrument
- Orbitrap
- GC-MS
- ICP-MS



EQUIPMENT

- TOC – liquid and solid sample
- Lyophilizer
- Determination of minimal inhibitory concentration (MIC test) - photometer



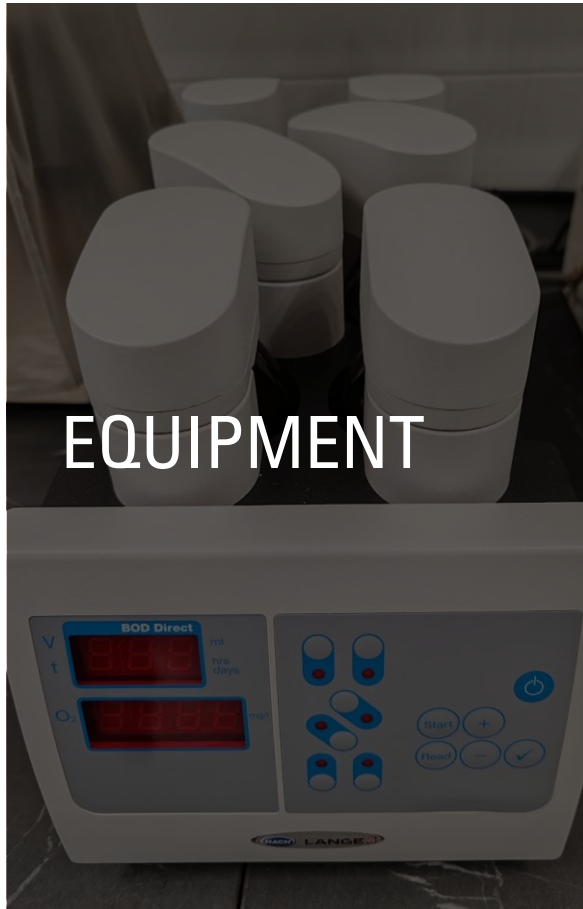


EQUIPMENT

- FTIR-ATR with microscope
- UV-VIS spectrophotometer
- Kjeltec – determination of total N
- Blender



EQUIPMENT



Proizvodnja biorazgradive i kompostabilne ambalaže

PHA



PLA



TPS



Films, 100 μ m



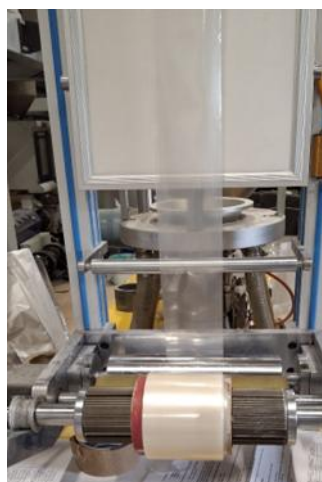
Dodatak kompostabilnih premaza

Proizvodnja biorazgradive i kompostabilne ambalaže

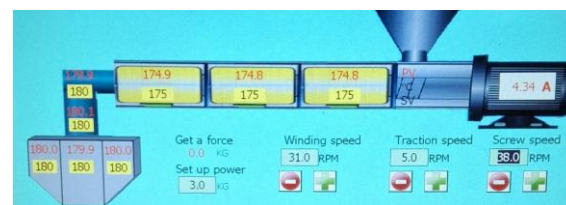
Vanjska usluga – Bio-Mi – izvučeni filmovi na pilot skali



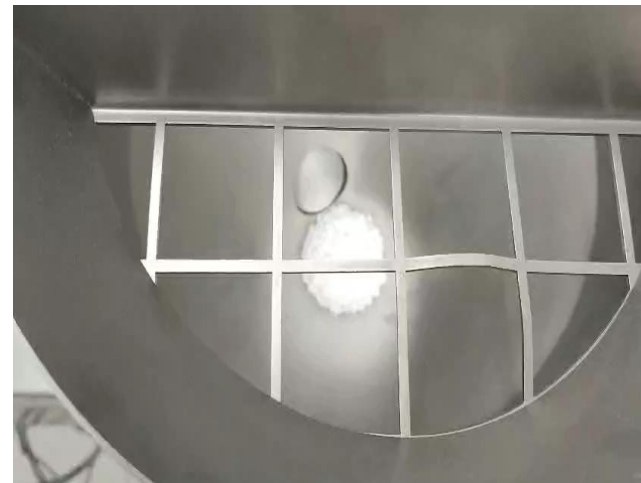
Ekstruzija puhanjem



Ekstruzija lijevanjem



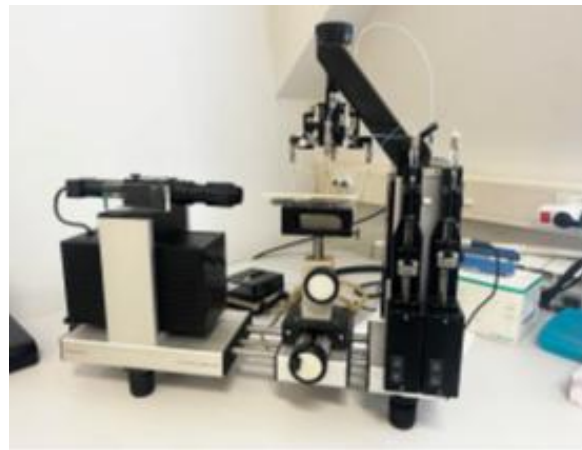
Dobivanje filmova – PTF Osijek



The Brabender Univex is a universally applicable downstream device for draw-off, cooling and winding of flat films with film speeds up to 30 m/min.

- VAC-V2 Gas Permeability Tester, Gas Transmission Rate (GTR) Tester (Labthink)
- Standards ISO 15105-1, ISO 2556, GB/T 1038-2000, ASTM D1434, JIS K7126-1, YBB 00082003





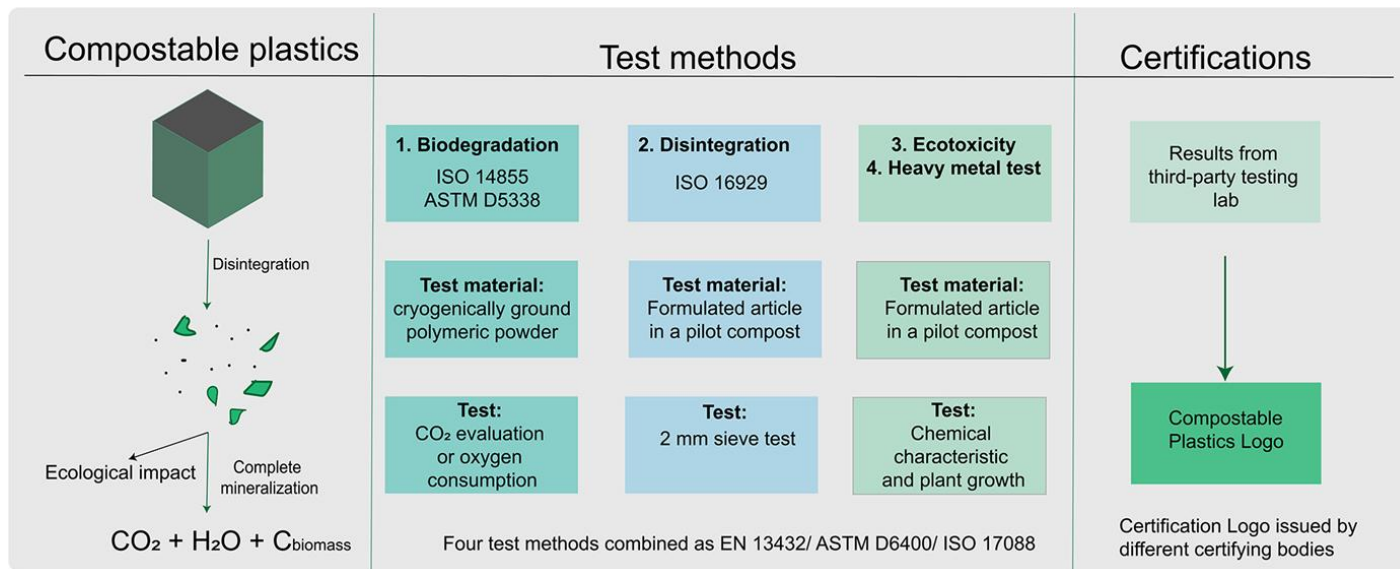
CHARACTERIZATION OF BIOPOLYMER BLENDS

- Contact angle
- Tensile test
- SEM



CHARACTERIZATION OF BIOPOLYMER BLENDS

- Determination of thermal properties using differential scanning calorimetry (DSC);
- Determination of thermal stability using thermogravimetric analysis (TGA);
- Insight into the viscoelastic properties of materials using a dynamic mechanical analyzer (DMA);
- Rheological properties of polymer materials, including viscosity, elasticity, and flow behavior (Rheometer HR 30 TA Instruments)



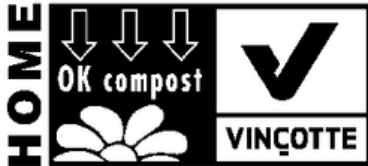
ISO 17556:2019

Plastics — Determination of the ultimate aerobic biodegradability of plastic materials in soil by measuring the oxygen demand in a respirometer or the amount of carbon dioxide evolved

ISO 14852:2021

Determination of the ultimate aerobic biodegradability of plastic materials in an aqueous medium — Method by analysis of evolved carbon dioxide

Kućno kompostiranje vs. industrijsko kompostiranje

	Industrial composting (EN13432)	Home composting (Vincotte certification)
Biodegradation	Test at 58°C in 180 days Biodegradation min. 90%	Test at 20–30°C in 365 days Biodegradation min. 90%
Disintegration	Test at 58°C in 90 days Sieve 2 mm mesh Disintegration > 90% Max 10% of dry weight allowed to be retained by 2 mm sieve	Test at 20–30°C in 180 days Sieve 2 mm mesh Disintegration > 90% Max 10% of dry weight allowed to be retained by 2 mm sieve
Certification	Din Certco/OK Compost	OK Home
		

Source: Song *et al.* 2009. The seedling logo and the OK Home Compost logo illustrated in the Table are shown by courtesy, respectively, of the European Bioplastics Association and Vincotte.

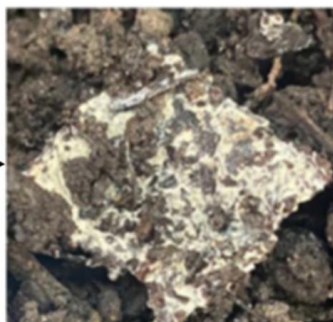


Biorazgradnja bioplastike

Regular edges

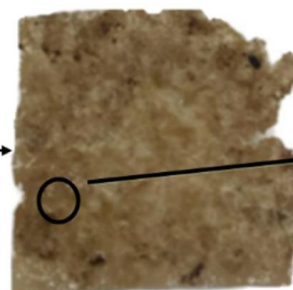


Before biodegradation
TPS_SL/PLA 60/40



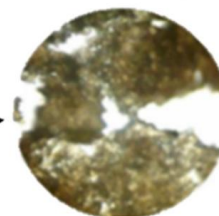
After 7 days of biodegradation
in soil
TPS_SL/PLA 60/40

The edges of the material have
been degraded by microorganisms.



After 7 days of biodegradation
– wahed with water and 70% of
ethanol

Visible cracks are
discernible within the
film.



Microphotograph - polarazing
optical microscope 400 x



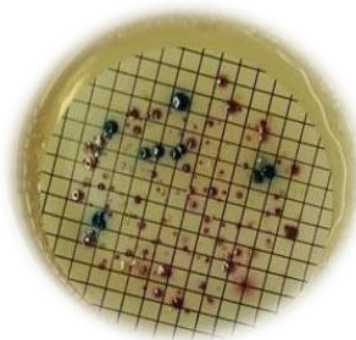
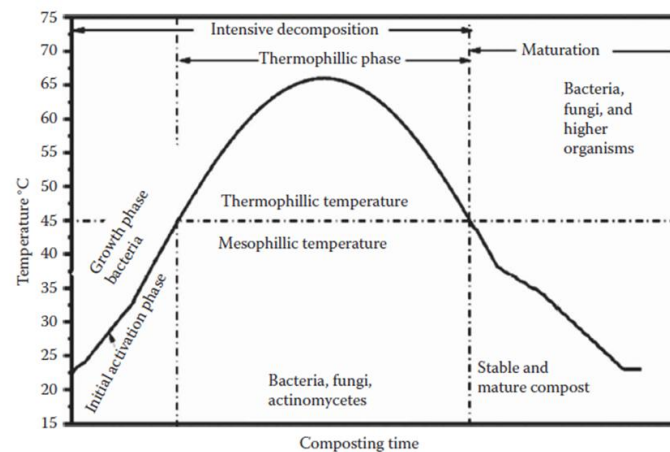
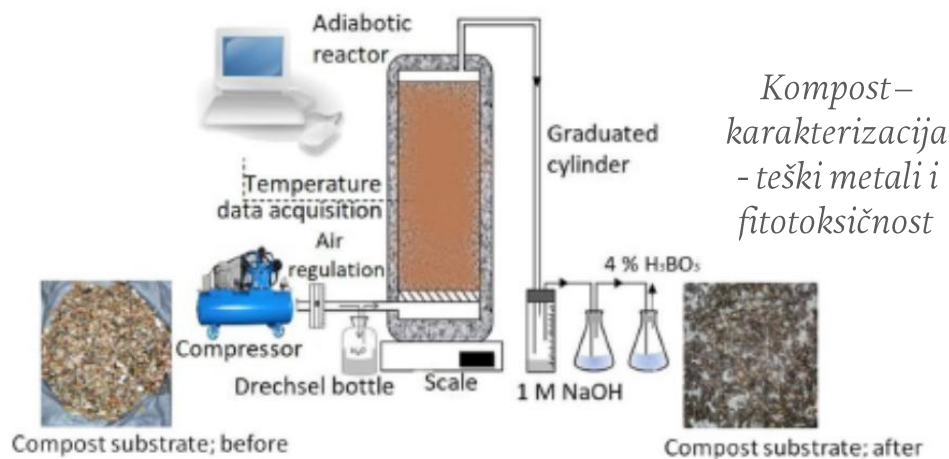
Polarazing optical microscope



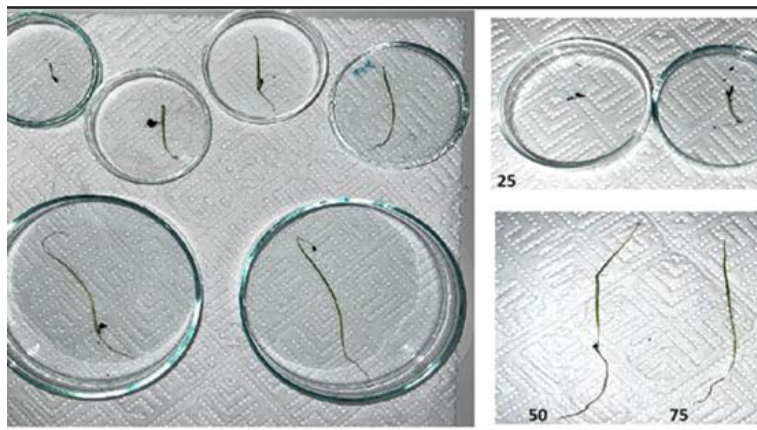
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Ispitivanje kompostabilnosti materijala

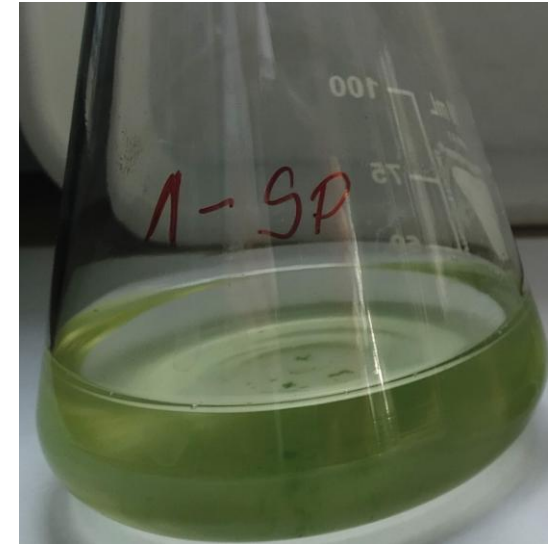
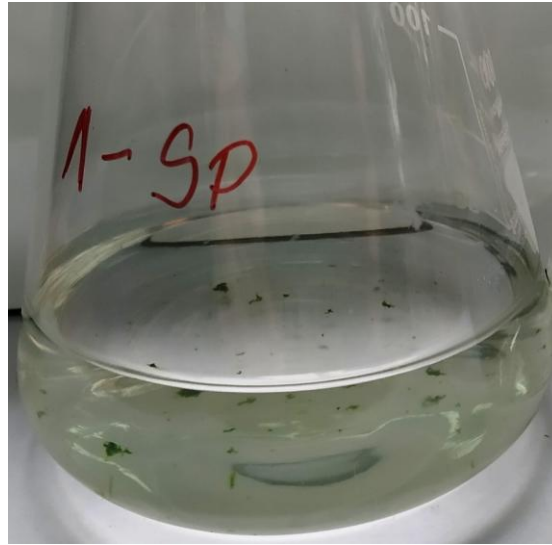
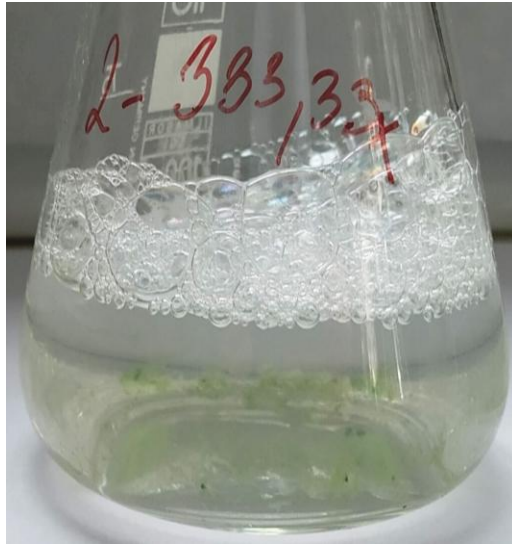


Fitotoksičnost

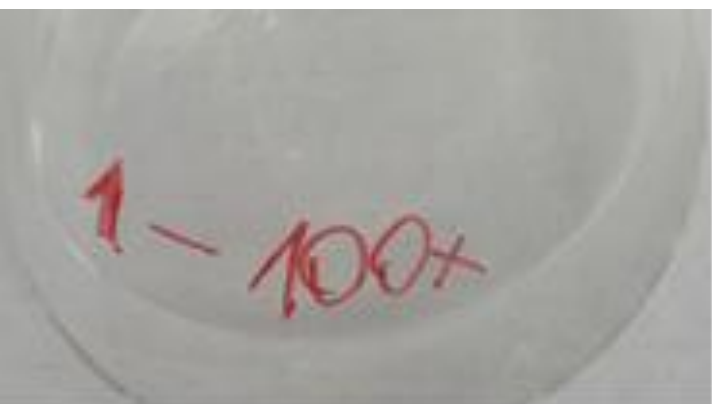
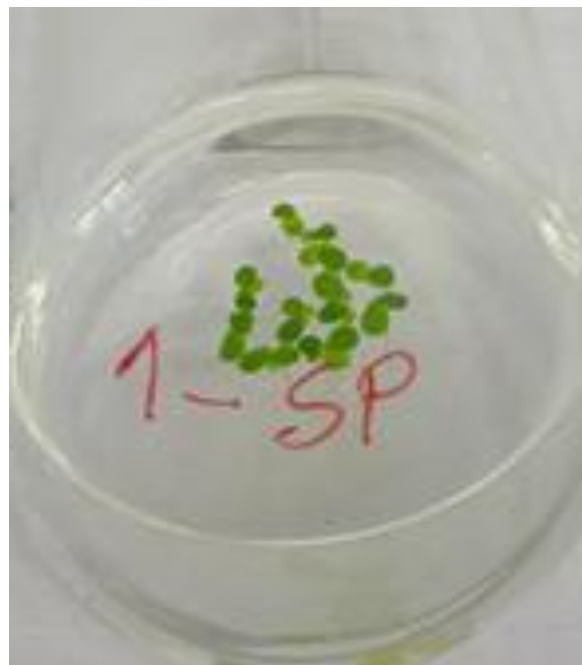


*% Germination = number of
germinated seeds in
contaminated test soil / number of
germinated
seeds in control 100*

*ISO 18763:2016 Soil quality — Determination of the toxic effects of pollutants on
germination and early growth of higher plants*



RESEARCH – ECOTOXICOLOGY - DETERMINATION OF THE
ECOTOXICITY OF THE ADDITIVES



RESEARCH – ECOTOXICOLOGY - DETERMINATION OF
THE ECOTOXICITY OF THE ADDITIVES ON THE
AQUATIC ECOSYSTEM – *Lemna minor*

Thank you
for your
attention

