From waste to functional materials:

Biopolymer materials synthesis in the framework of a circular economy

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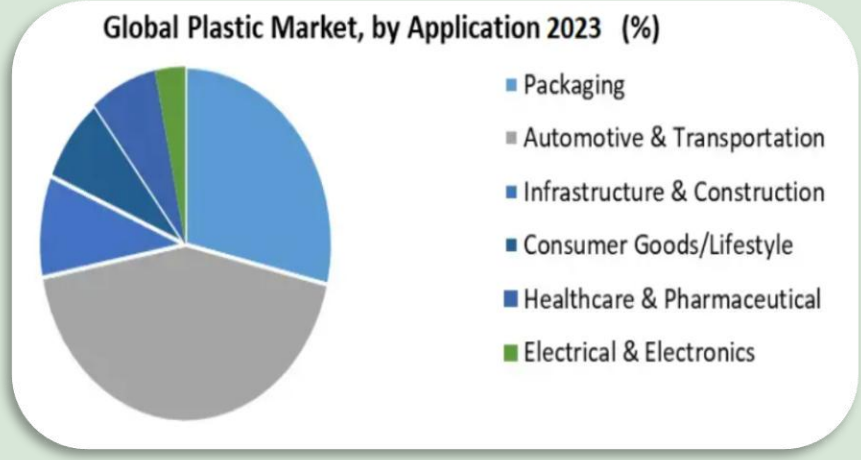
Introduction

- One third of all produced plastic is dedicated to packaging materials.
- Mostly one time used items that are immediately discarded after consumption.



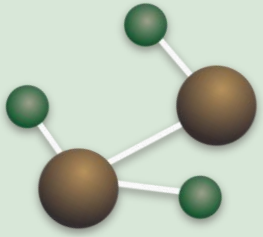
It is mandatory to minimze…

Harmful effects in ecosystem: “plastic“ oceans and rivers, landfills, wildlife…

What are solutions?

Biopolymers – materials of green era

- Biodegradable
- Sustainable
- Renewable
- Environmentally friendly
- Non-toxic
- Cost-effective



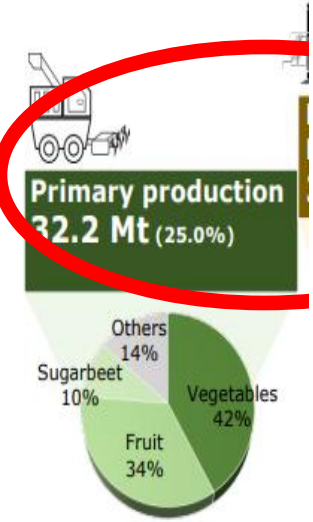
Agro-food waste

DOUBLE GREEN EFFECT

Biomaterials based on agro-food waste

Valorization of agro-industrial waste

- Resource optimization and creation of new value.
- Instead of landfilling, agro-industrial waste is used for bioenergy, sustainable packaging, compost, animal feed, biochemicals, etc.
- Contribution to environmental protection and economic sustainability through innovative technologies and circular business models.
- Fostering innovation by applying new technologies for waste processing.



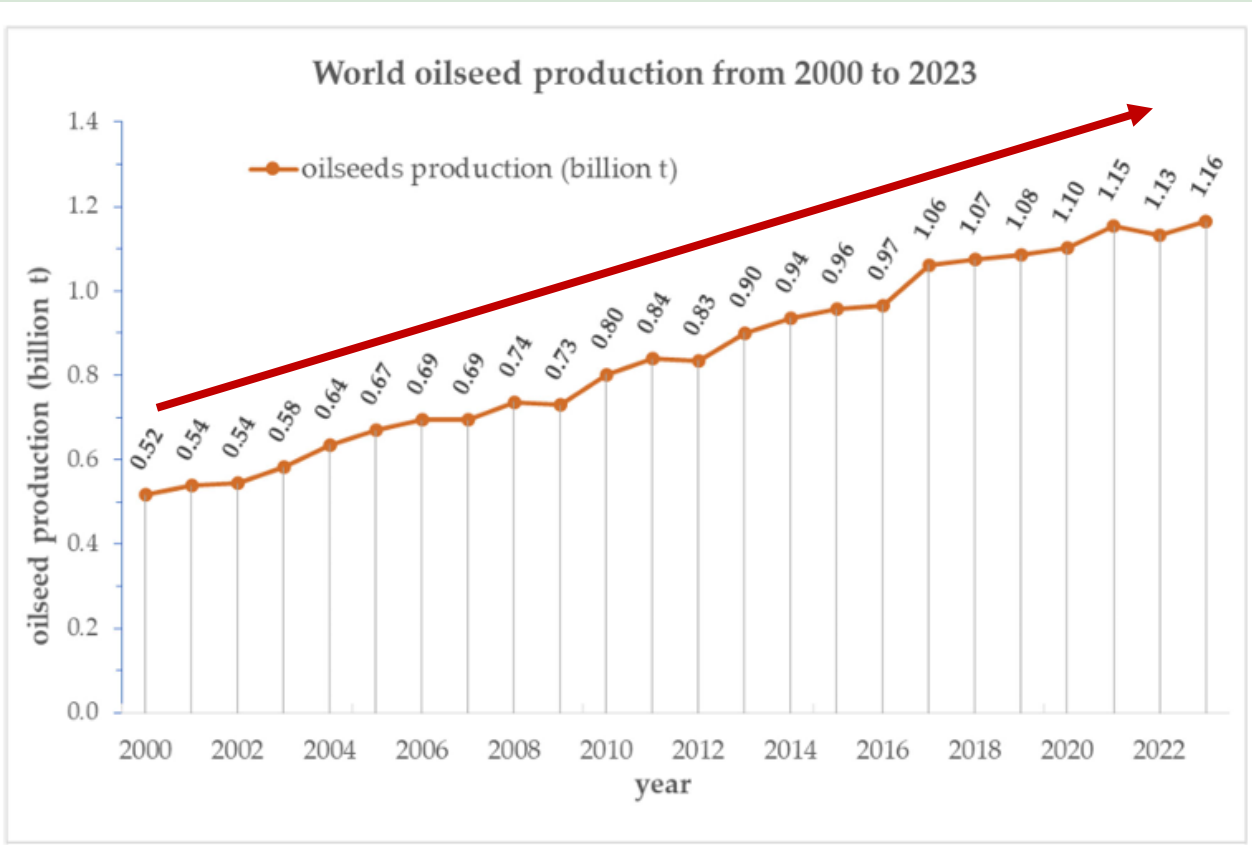


Figure 1. Global oilseed production trends from 2000 to 2023 (in billion tons).

Why

PLUM AMONG OIL SEEDS?

•Plum availability:

- Serbia ranks third in the world in plum production, right after China and Romania - around 550,000 tons of plums per year.
- Plum is the most widely grown fruit crop in Serbia - 40% of the total orchard area is planted with plums.

•Nutritional value:

- Inside the pit there is a seed that contains oils rich in unsaturated fatty acids (oleic and linoleic acids), as well as proteins, dietary fiber, carbohydrates, and micronutrients.

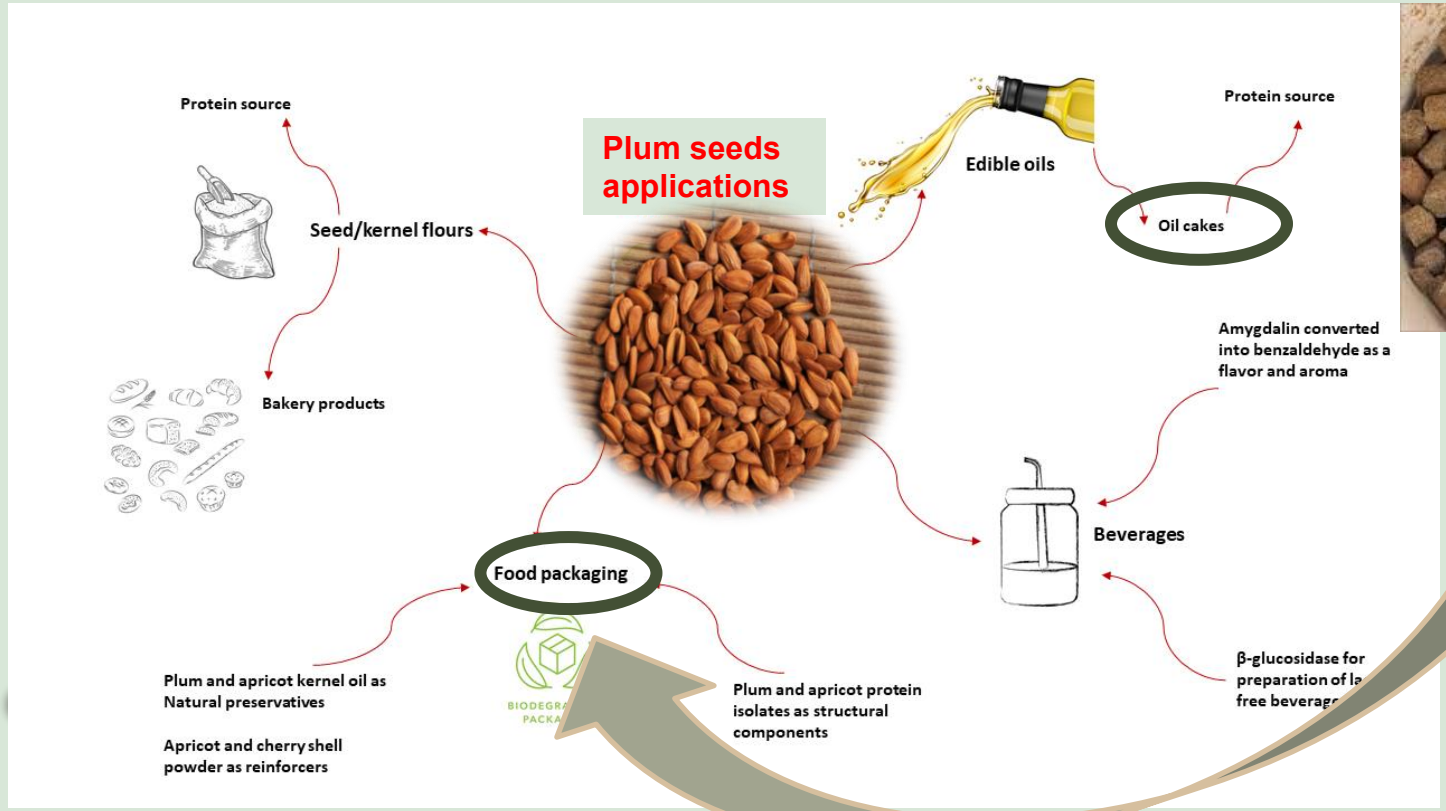
PLUM SEED

Amount and chemical composition

- Plum pits account for ~16% of the fruit mass, generating about 78,174 tons of plum pits in Serbia.
- Given that the seed accounts for 9-30% of the plum pit mass, this corresponds to approximately 7,000–23,450 tons of plum seeds per year in Serbia.

Fruit	Amount of seed	Macronutrients				Micronutrients	
		Proteins	Carbo-hydrates	Oils	Dietary fibers	Total phenolics	Total flavonoids
Prunus Domestica **(plum)**	9–30% (w/w) of pit mass	27.57–35.91%	7.30–17.64%	36.52-50.00 %	1.90–4.84%	170 mg/100 g	3.75 mg/100 g

Where do plum seeds add value?



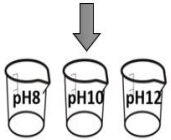
BIOPOLYMER FILMS
for food packaging

Plum stone

Plum seeds

Plum oil cake

Addition of glycerol and deionized water



Incubation in a water bath

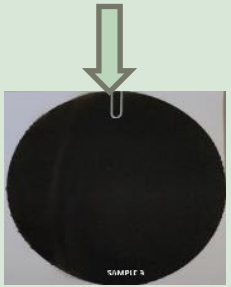
Filtration, drying

Other biomaterials derived from oil cakes

Pumpkin seed oil cake (PuOC)

PuOC biofilm

Sunflower oil cake (SOC)

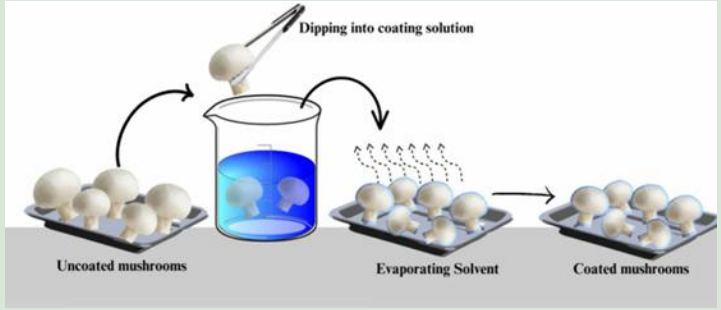


SOC biofilm

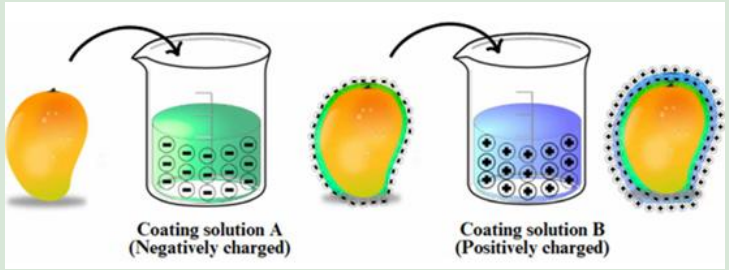
Edible biopolymer coatings based on oil cakes

➢ *Biopolymer coating deposition methods*

- **Spraying**
  - **Dipping**



- **Cross-linking method**



➢ *Grape coated with flaxseed oil cake-based coating*

➢ *Apples coated with plum oil cake-based coating*

Research output

Oil cakes are highly suitable for a zero-waste concept.
They can be valorized into value-added products with no waste streams.

Closing the loop with plum by-product

Agro-waste

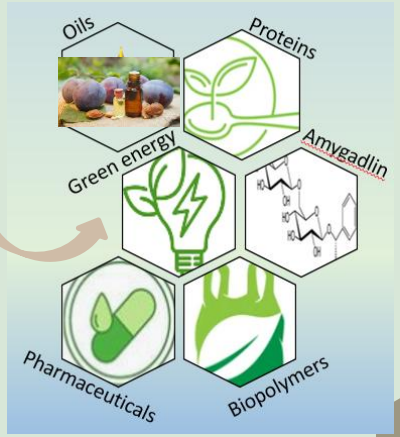
Composting

Biofuel

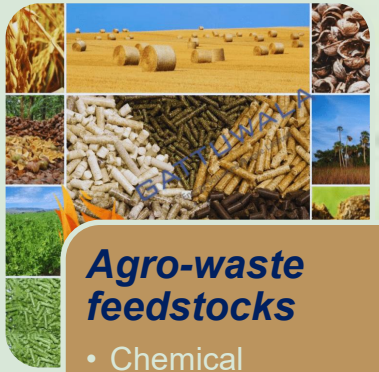
Green solvents

Microwave-assisted extraction

Enzyme-assisted extraction



Beyond plum: A framework for circular biopolymer films and coatings



Agro-waste feedstocks

- Chemical composition
- Availability
- Price

Target biomaterial properties

- Mechanical, barrier properties
- Regulatory requirements
- Compatibility

Food/non-food application

- Fruits and vegetables, meat, cheese, sweets
- Cosmetics
- Farmaceutics
- Nutraceutics

Key: Match **chemistry** + **material's functionality** + **application** to achieve zero-waste valorization.

Thank you for your attention!

Do you have any questions?

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Interested in collaboration?
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