TRANSITIONING TO A CIRCULAR FOOD ECONOMY: THE SOLUTIONS FOR FOOD WASTES RETURNING AS BIO-STIMULANTS TO SUSTAINABLE PLANT GROWTH

Prof. Habil. Dr. Grazina JUODEIKIENE

KTU, Department of Food Science and Technology, Lithuania

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Content

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Introduction

Transitioning of food production to a circular bio-economy

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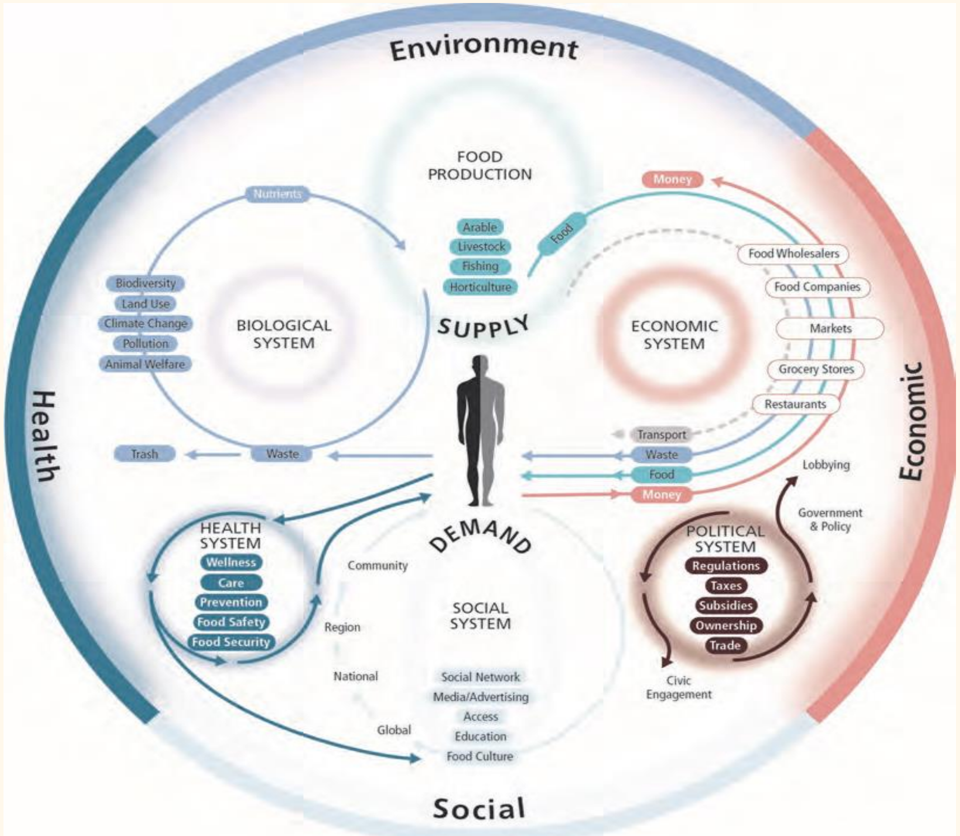
Building the food system that works for consumers, producers, climate and the environment

climate footprint | global transition | new opportunities | resilience

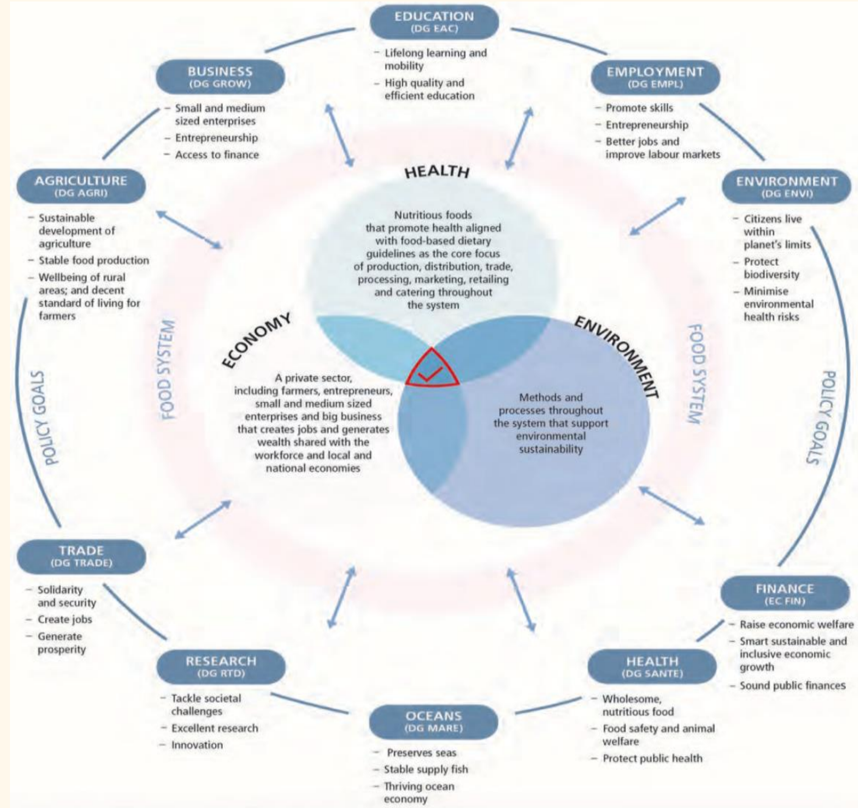
The EU will:

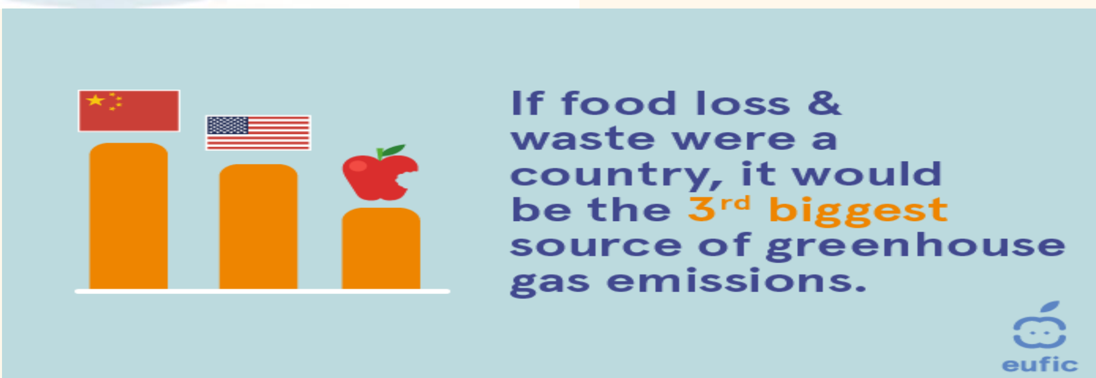
- Become climate-neutral by 2050
- Protect human life, animals and plants, by cutting pollution
- Help companies become world leaders in clean products and technologies
- Help ensure a just and inclusive transition

The interpretation of sustainable food systems

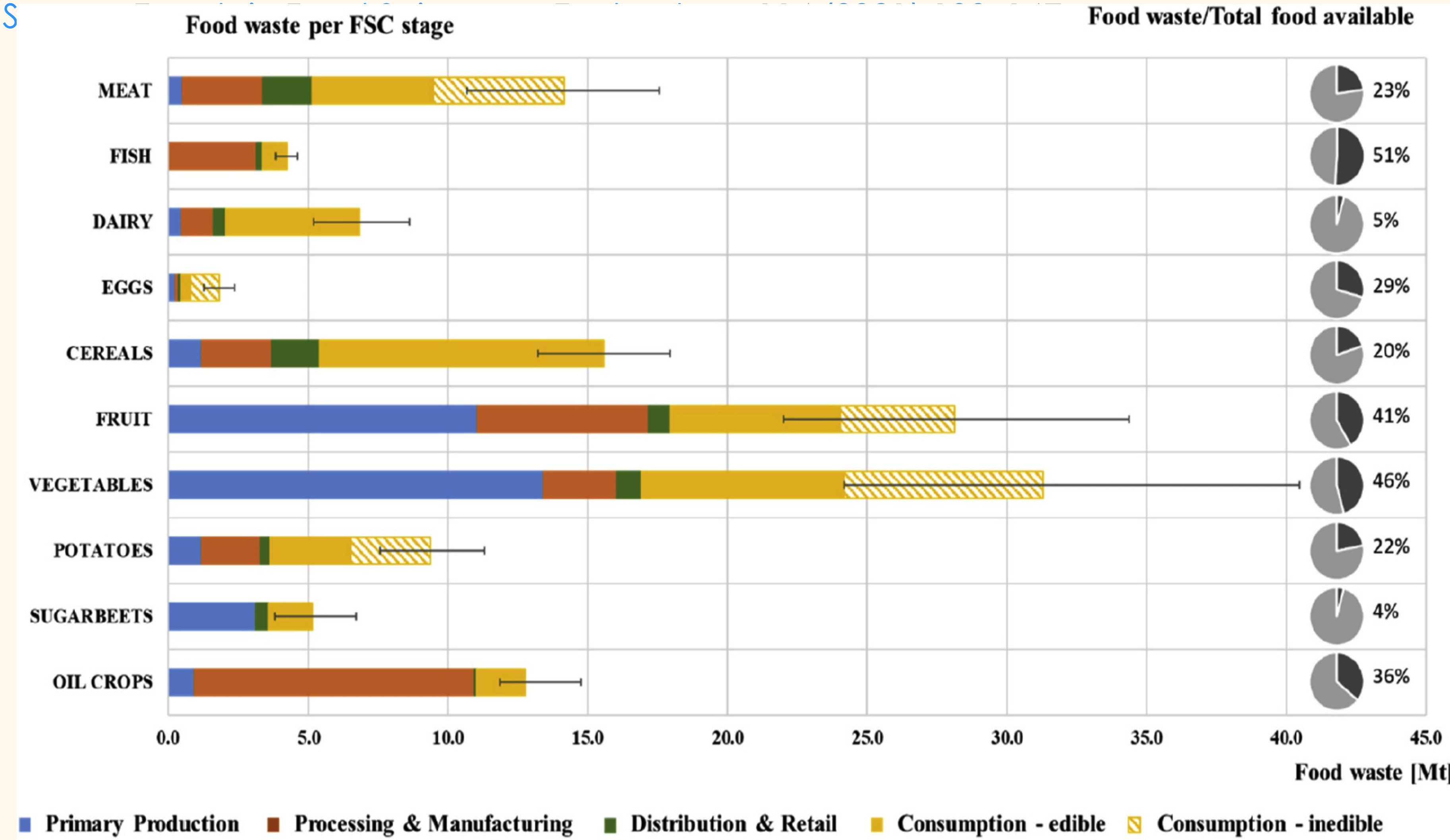


A vision for food systems with co-benefits

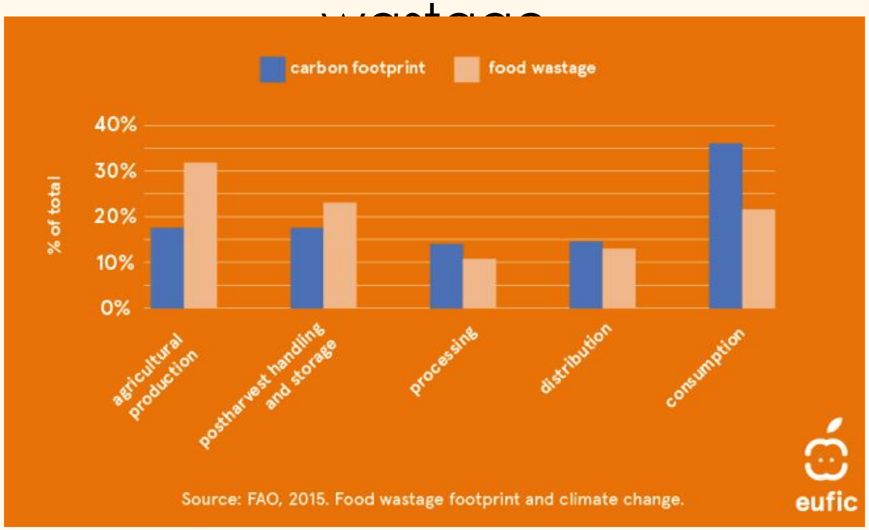




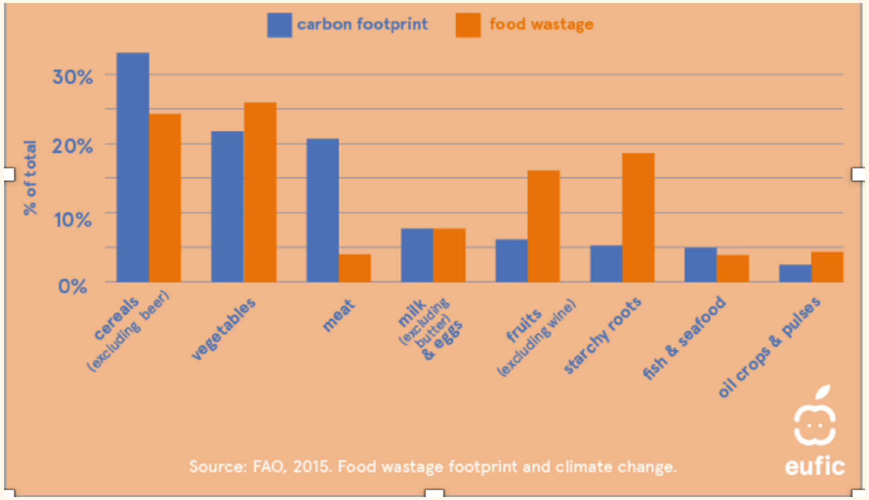
Left: Total food waste amount (including edible and inedible components) calculated along food supply chain (FSC) for each food group.
Right: percentage of food waste (dark grey) out of the total food available.



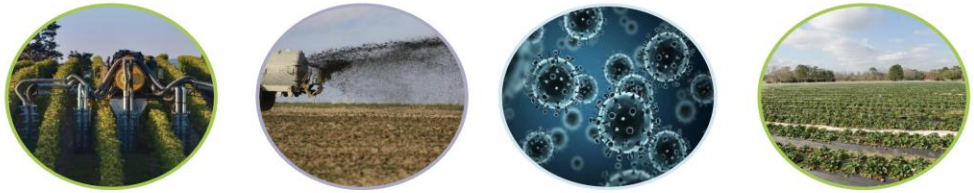
Contribution of each phase of the food supply chain to carbon footprint and food wastage



Contribution of each commodity to carbon footprint and food wastage



Ensuring sustainable food production

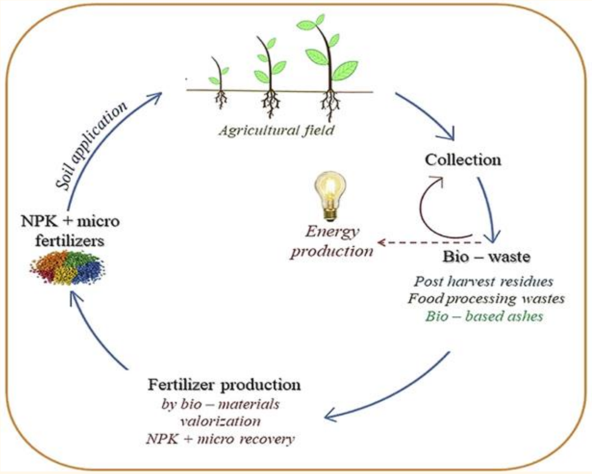


Reduce by 50% the overall use and risk of **chemical pesticides** and reduce use by 50% of more hazardous **pesticides**

Reduce **nutrient losses** by at least 50% while ensuring no deterioration in soil fertility; this will reduce use of **fertilisers** by at least 20 %

Reduce sales of **antimicrobials** for farmed animals and in aquaculture by 50%

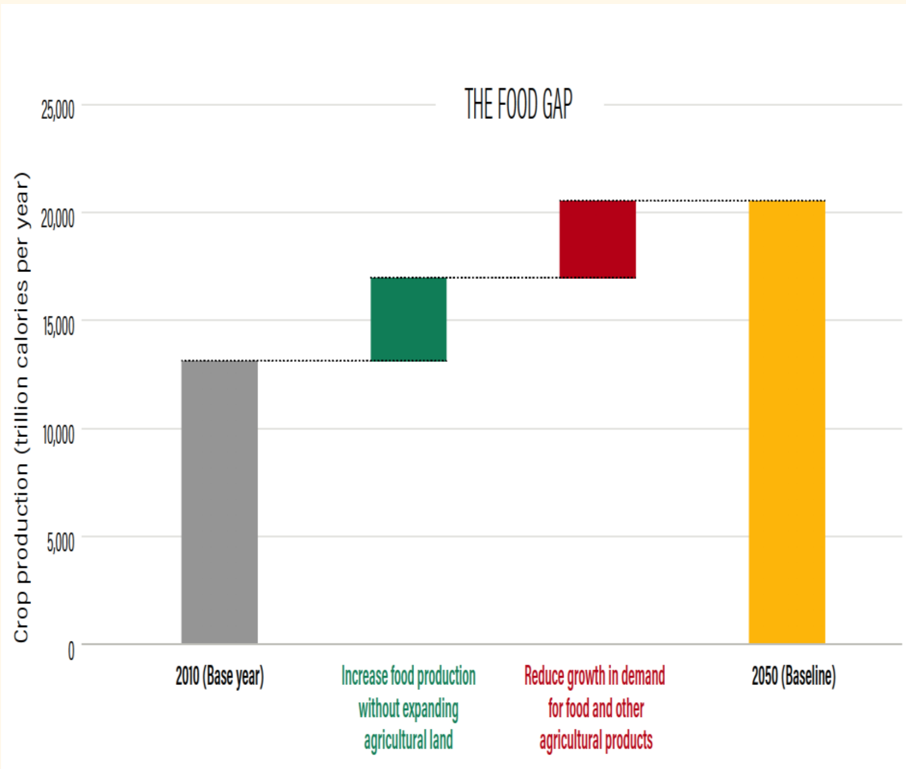
Achieve at least 25% of the EU's agricultural land under **organic farming** and a significant increase in **organic aquaculture**

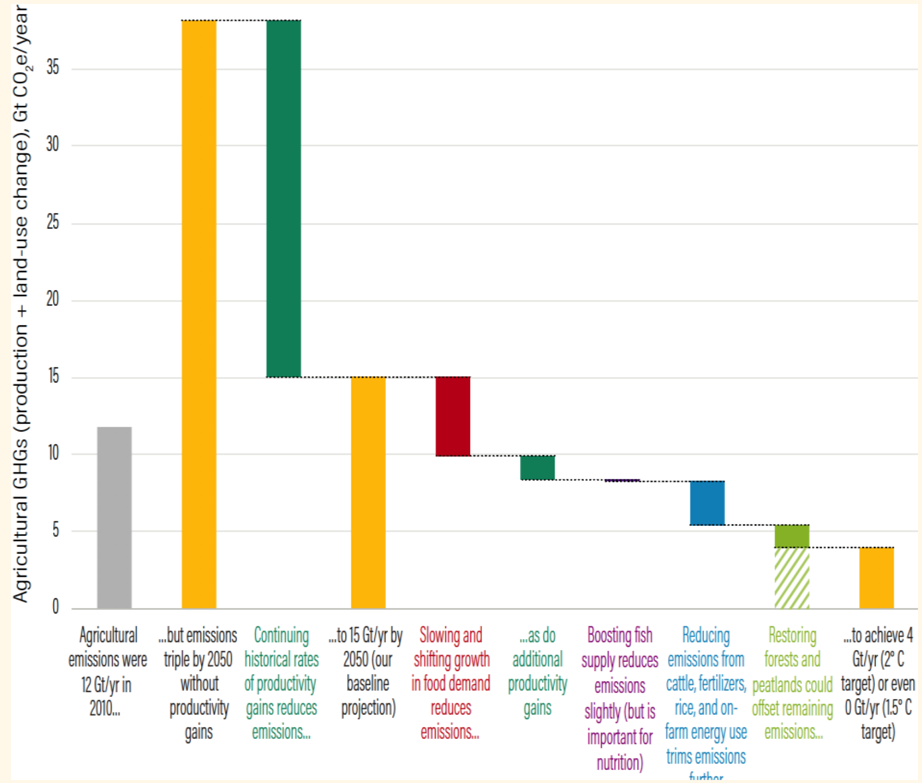


Ambitious efforts across all menu items will be necessary to feed 10 billion people and help keep global temperature rise well below 2 degrees Celsius

The emissions mitigation gap

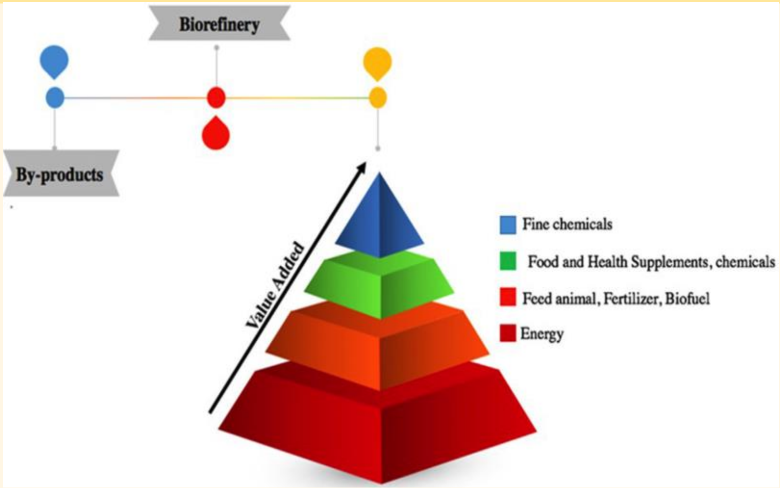
Source: GlobAgri-WRR model.



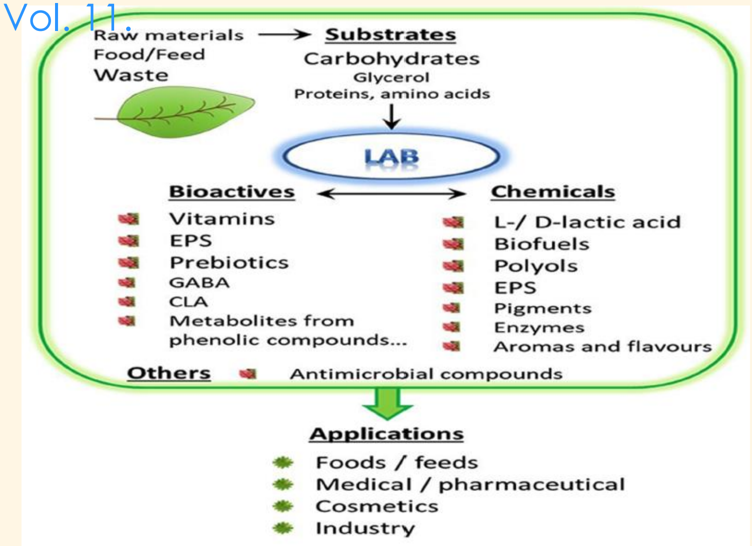


Hierarchy of solutions to address food loss and waste

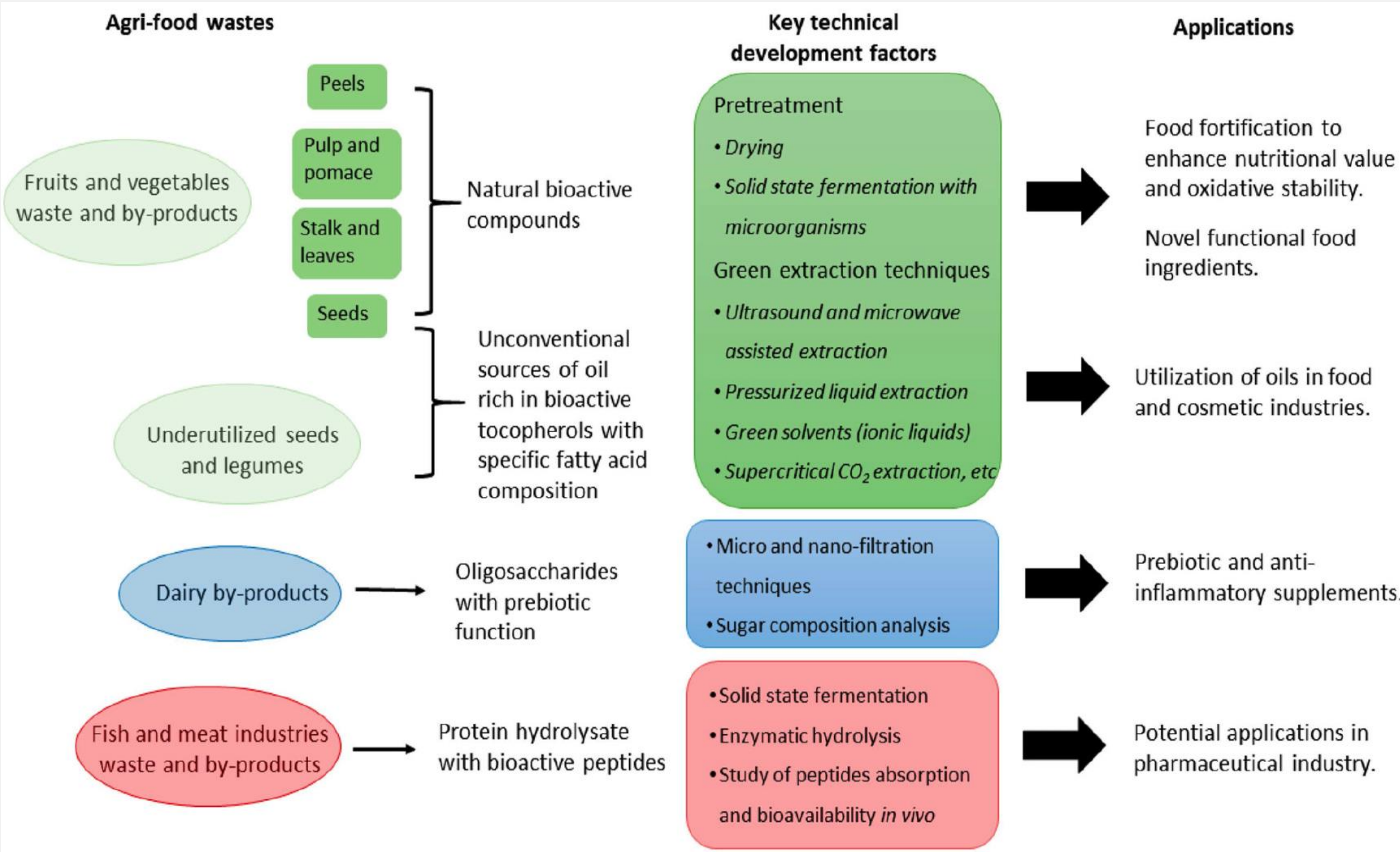
Biorefinery concept and circular economy



Production of some chemical and/or bioactive compounds from plant-waste by the metabolic activity of lactic acid bacteria (LAB) Source: Frontiers in Microbiology, 2020, Vol. 11.



Schematic representation of the potential food and healthcare applications of high added-value compounds from agro-food wastes and by-products, including technical factors to be considered for their efficient utilization (Source: Ben-Othman et al., 2020)



IIA. The solutions for plant drink wastes returning for bio-stimulants production

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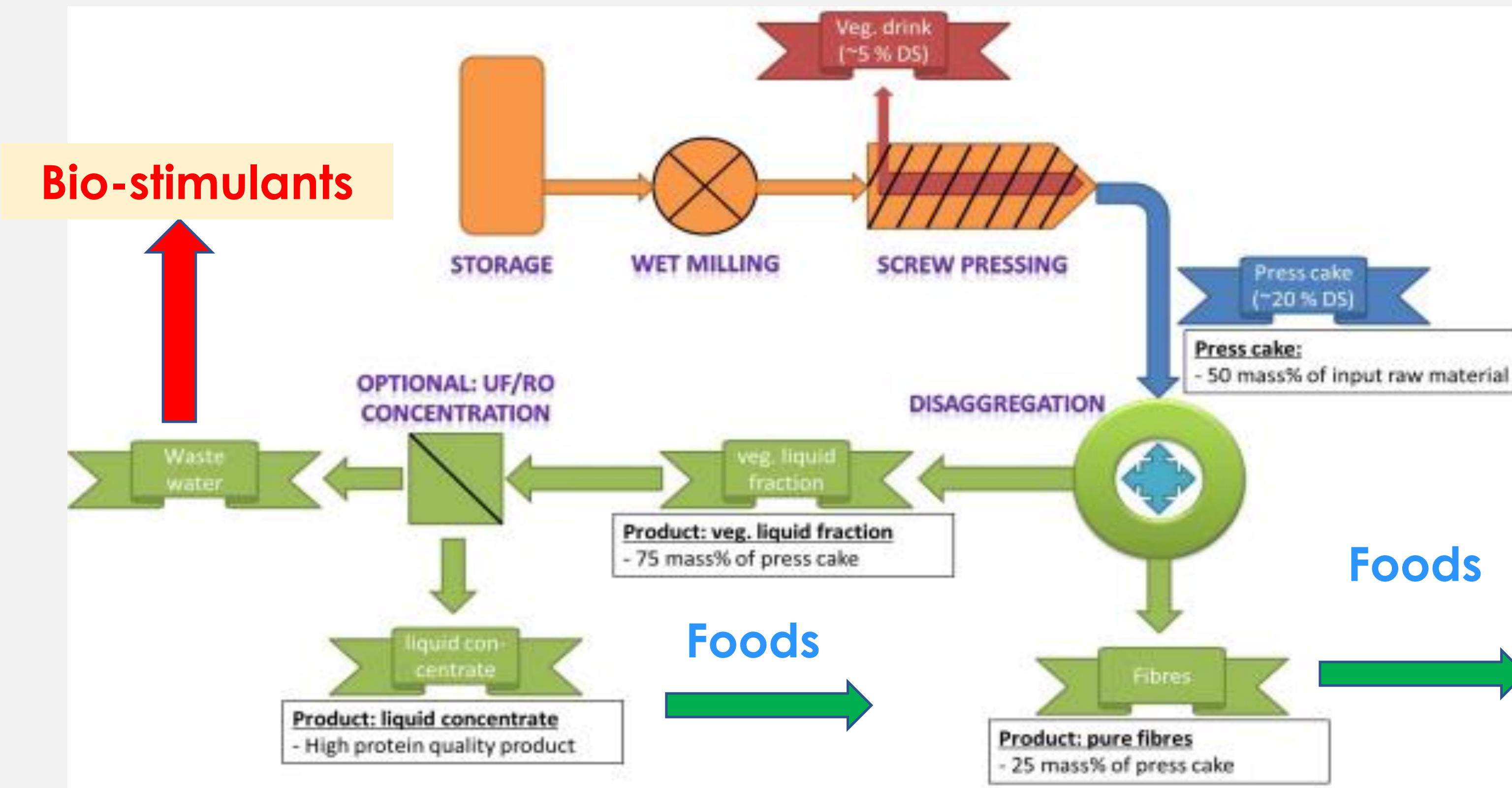
Project ERANET H2020 PROJECT "Disaggregation of conventional vegetable press cakes by novel techniques to receive new products and to increase the yield" (**DISCOVERY**) ktu 1922 kauno technologijos universitetas

INNOVATION OF PROJECT
DISCOVERY OFFERS WASTE-FREE PRODUCTION OF PLANT DRINKS



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I. Chemical composition of raw materials and press cakes (PC) (g/100 g. d. m.)

Samples	Raw material (flour)				Press cakes			
	SK	Protein	Fat	Moisture	Dietary fiber	Protein	Fat	Moisture
Rice	2,95	9,65	3,20	11,68	2,51	20,10	4,05	48,98
Soya	2,86	42,75	15,67	7,93	5,99	28,22	12,05	49,60
Almond	2,11	27,87	17,03	6,07	5,61	18,57	29,57	45,70
Cocos	9,03	23,23	14,42	5,39	11,29	15,47	8,41	42,80
Oat	2,21	19,09	5,05	9,97	2,29	21,42	6,03	50,60

By-products of plant drinks production can be used as valuable components for the development of new products

II. Development of the concept of press cakes (PC) bio-decomposition

Composition of the Protein Ingredients from Insoluble **Oat Byproducts** Treated with Food-Grade Enzymes

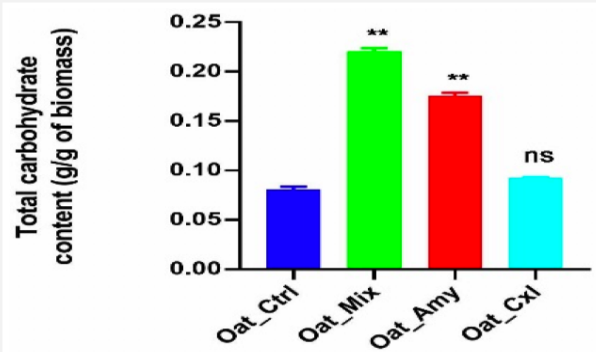


Fig. Total carbohydrate content determination

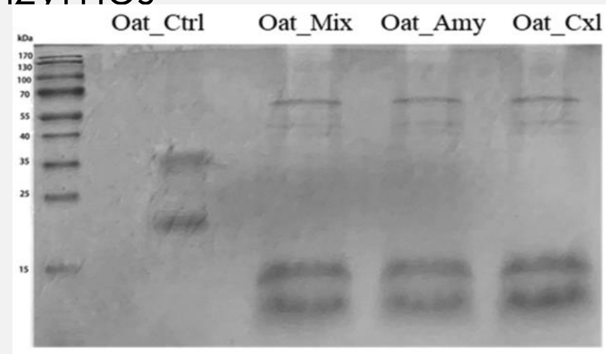


Fig. Reduced SDS–PAGE protein profile of untreated and enzymatically treated oat press cake proteins: M, pre-stained molecular marker; Oat_Ctrl, Oat_Amy, Oat_Mix, Oat_Cxl.

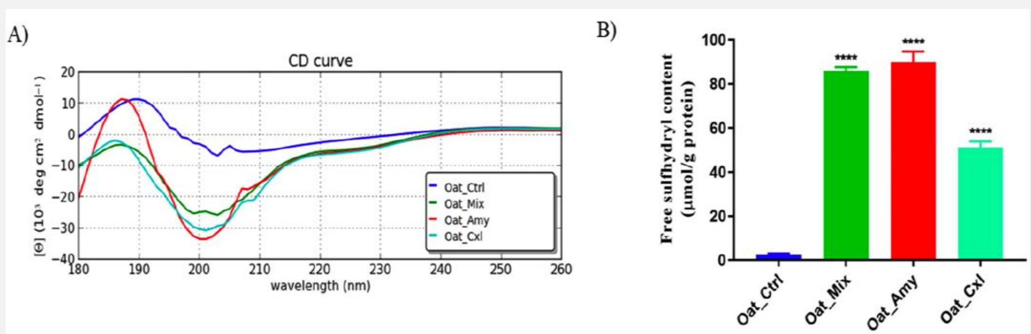


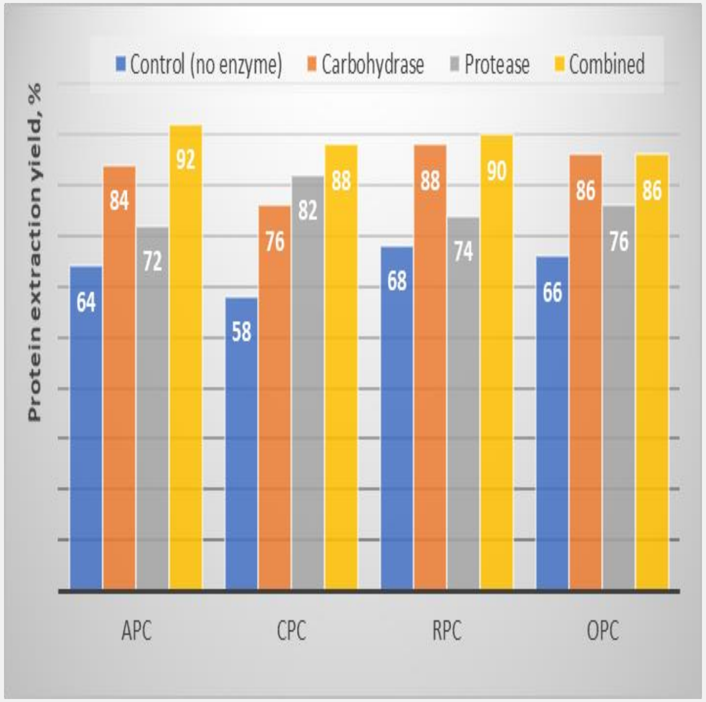
Fig. (A) CD spectra and (B) free SH group determination of Oat_Ctrl, Oat_Amy, Oat_Cxl, and Oat_Mix.

Milan university & KTU results were published in the Journal **Foods** 2021, 10, 2695.
https://doi.org/10.3390/foods10112695

III. Development of the concept of different press cakes (PC) bio-decomposition

Press cake	Amylase /cellulase/protease ratio	Solid/ water ratio	Hydrolysis time (temp. 50 °C)	Protein recovery, %
Rice PC	1:4:2	1:3	90 min.	90
Cocos PC	1:4:8	1:6	90 min.	88
Almond PC	1:2:4	1:2	90 min.	92
Oat PC	1:4:2	1:3	90 min.	86

Effect of enzymatic hydrolysis on the extraction of soluble proteins from PC's samples of analysed press cakes



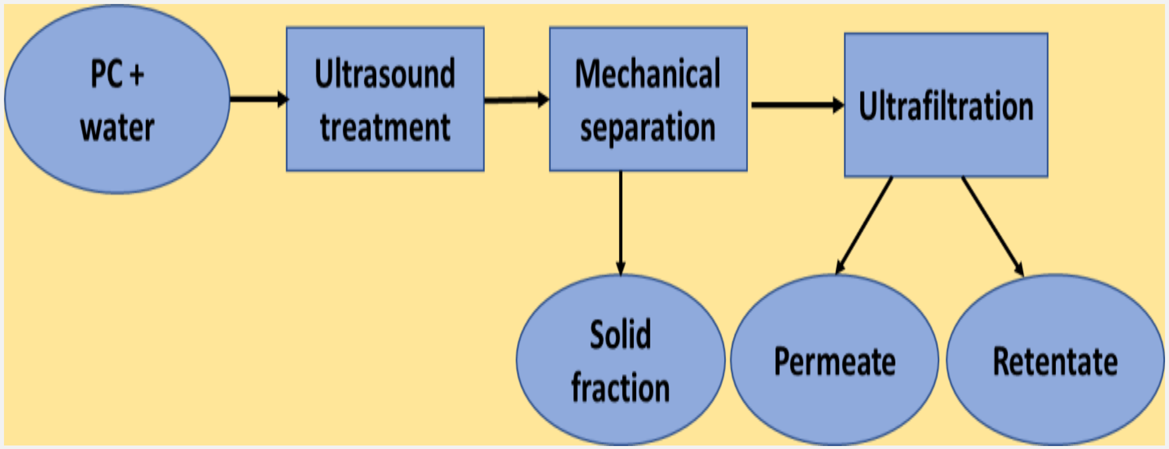
Using a combination of carbohydrases and proteases, protein recovery can be increased to 84-92% (depending on the type of PC).

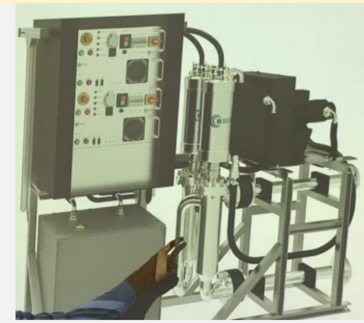
KTU results of PC application for baked goods production were published:

- ➢ **LWT - Food Science and Technology** 152 (2021), 112337
- ➢ **Foods** 2020, 9, 614; doi:10.3390/foods9050614
- ➢ **Frontiers in Microbiology**, 2021, Vol. 12, Article 652548

IV. Development of the concept of liquid fraction (permeate) bio-treatment and application for bio-stimulant production

Permeate of soy, coconut, oat, rice and almond obtained during the processing of press cakes - PCs (Berief Food GmbH, Germany):



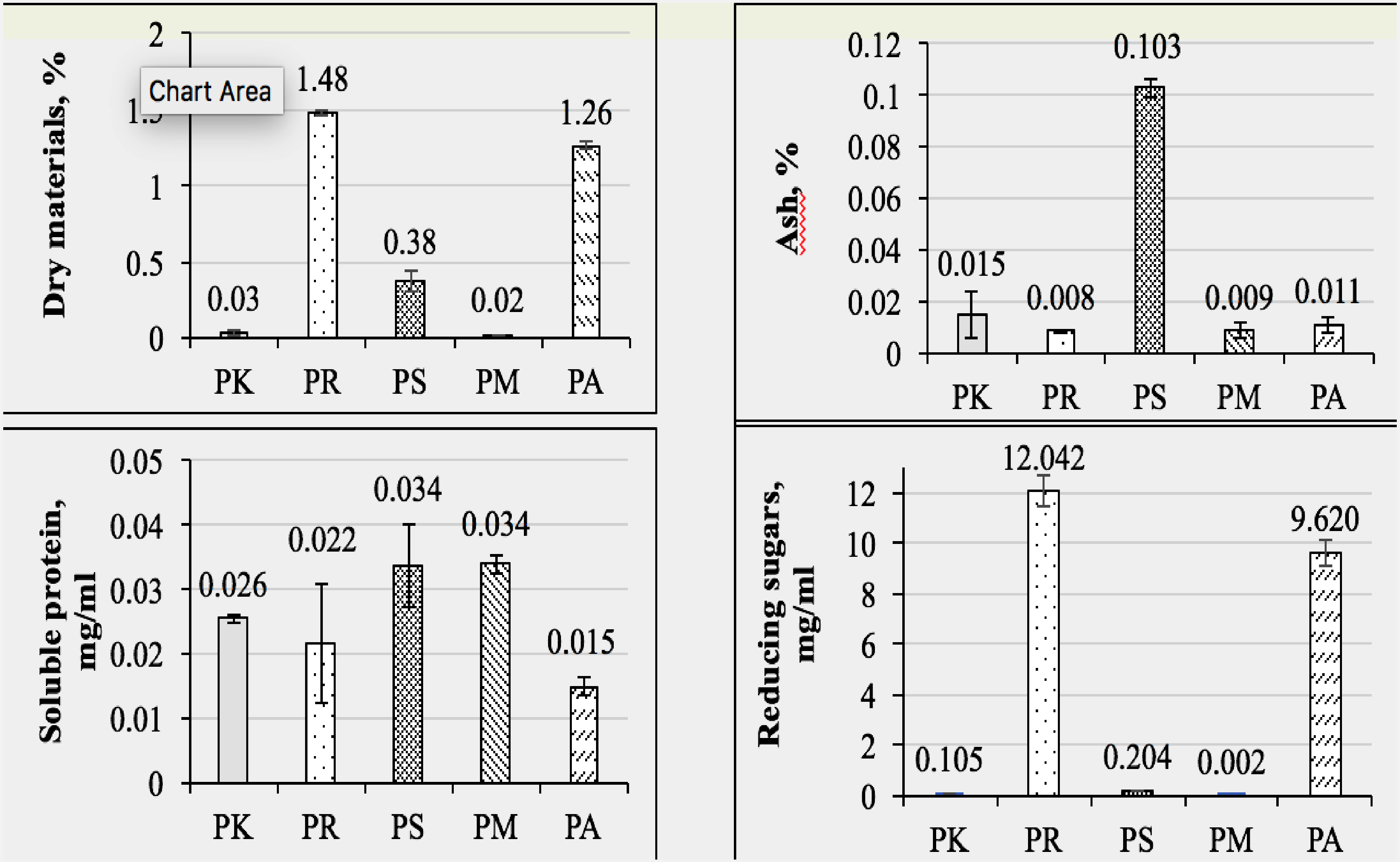


Fraunhofer Institute **UMSICHT , Germany** ultrasound equipment (18 kHz; amplitude – 50 μm; power - 4,8 kW)

	Soy	Almond	Coconut	Oat	Rice
Mixture	15 kg PC + 37,5 L H_2O				
Ultrasound treatment	Power input: 4,7 kW; 18 kHz; 60 μm Time 2 min*	Power input: 4,7 kW; 18 kHz at 60 μm amplitude Time 2 min			Power input: 4,7 kW; 18 kHz; 60 μm Time 2 min***
Mechanical separation of liquid phase	Screw press 33.5 L		Screw press 29.5 L	Screw pressing was not applicable Textile sieving 22,5 L	Screw press 26,5 L
Ultrafiltration of liquid fraction with direct freezing of permeate and retentate	PES Membrane, ~ 0,7 m², 10 kDa Time: ~3h Output: 19,5L permeate 10,5L retentate		PES Membrane, ~ 0,7m², 10 kDa Time: ~ 3h Output: 19,5L permeate 9L retentate	PES Membrane, ~ 0,7 m², 10 kDa Filtration time: ~ 4h*** Output: 15,7 L permeate 5 L retentate	PES Membrane, ~ 0,7 m², 10 kDa Time: ~4 h*** Output: 15L permeate 9 L retentate
Drying of solid fraction	Temp. 60 °C**		Temp. 80°C**		

* In continuous flow reactor
** Solid phase had to be treated carefully at low temp. and thin layers in order to prevent samples
*** Strong foaming occurred during treatment

V. Chemical composition of permeate

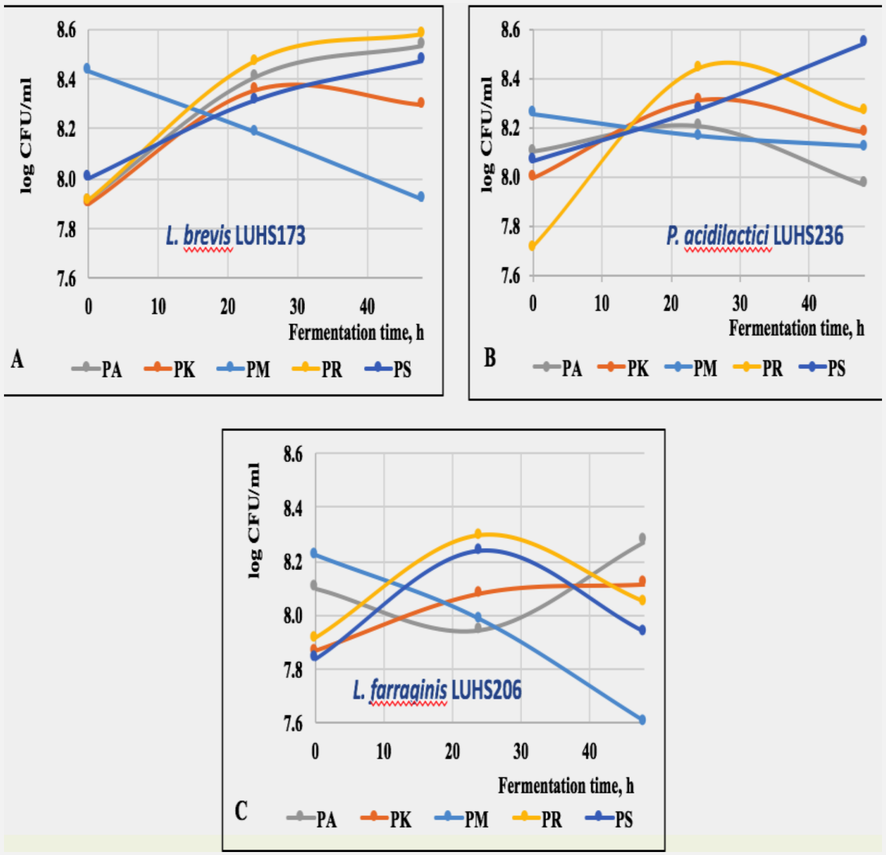


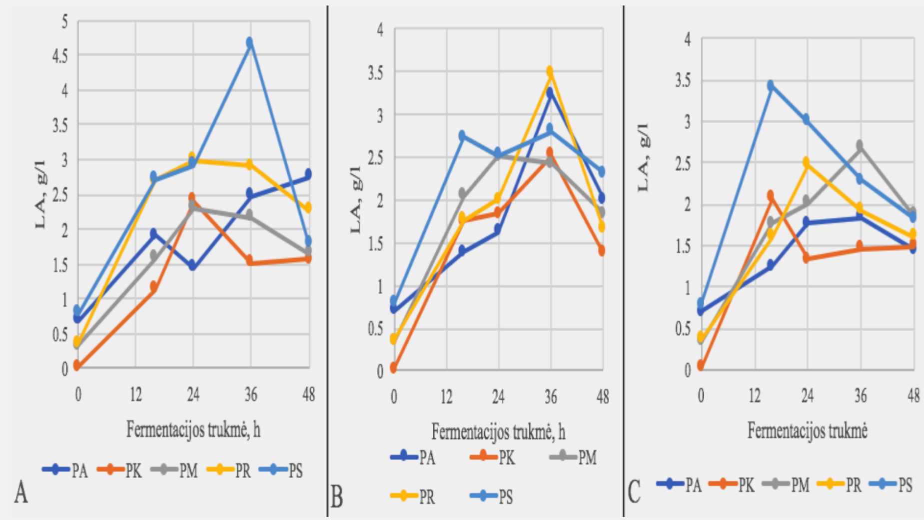
PK – coconut; PR – rice; PS – soya; PM – almond; PA - oat

VI. Bio-treatment of permeate using LAB

Fig. **The growth curves of LAB**

Fig. **Lactic acid production**



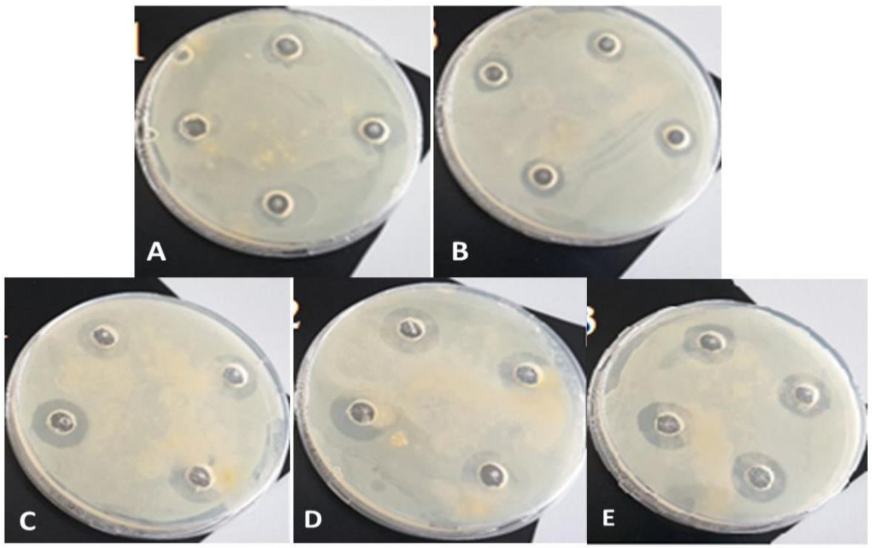


Permeate samples: PK – coconut, PR – rice, PS – soy, PM – almond, PA – oat

VII. Evaluation of antifungal activity LAB fermented permeate (48 h) against *Fusarium* spp. (Table and Fig.)

Sample	Inhibition zone on agar plate against fungi, mm					
	Fusarium graminearum F		*Fusarium graminearum*		*Fusarium culmorum*	
	24h	48h	24h	48h	24h	48h
PK$_{LUHS173}$	10.10±0.8^{a}	17.00±2.9^{c}	11.00±0.8^{a}	14.25±0.5^{b}	9.50±1.0^{a}	14.50±0.7^{a}
PR$_{LUHS173}$	12.50±0.6^{b}	19.25±1.5^{d}	12.00±0.8^{a}	15.25±1.3^{c}	12.50±1.0^{a}	15.00±0.8^{b}
PS$_{LUHS173}$	12.75±1.0^{b}	13.50±0.6^{a}	13.50±1.3^{b}	13.50±1.0^{a}	12.75±0.5^{a}	13.00±0.8^{a}
PS$_{LUHS236}$	12.25±0.5^{b}	11.50±1.7^{a}	11.50±0.6^{a}	12.50±1.3^{a}	11.75±0.5^{a}	13.25±1.5^{a}
PS$_{LUHS206}$	13.00±2.0^{c}	14.00±0.8^{b}	14.50±2.4^{c}	15.67±1.2^{c}	13.25±1.0^{b}	14.50±1.0^{a}
PA$_{LUHS173}$	13.75±0.5^{c}	13.50±0.6^{a}	13.75±2.4^{b}	14.67±0.6^{b}	13.50±1.9^{b}	14.75±0.5^{b}
PA$_{LUHS206}$	17.00±1.2^{d}	17.75±0.5^{c}	16.00±0.^{d}	17.50±0.6^{d}	16.75±0.5^{c}	18.75±0.5^{c}

Data expressed as a mean value (n = 3) ± SD; SD – standard deviation. $^{a-c}$ Means within a column with different superscript letters are significantly different ($p < 0.05$); PK$_{LUHS173}$, PR$_{LUHS173}$, PS$_{LUHS173}$ and PA$_{LUHS173}$– coconut, rice, soyabean and oat permeates fermented with *L. brevis*, respectively; PS$_{LUHS236}$ – soyabean permeated fermented with *P. acidilactici*; PS$_{LUHS206}$ and PA$_{LUHS206}$ – soyabean and oat permeates fermented with *L. farraginis*, respectively.



A - LUHS173 against *F. graminearum* F;
B - LUHS173 against *F. culmorum*;
C - LUHS206 against F. *graminearum* F;
D - LUHS206 against *F. graminearum*;
E - LUHS206 against *F. culmorum*.

VIIIA. The effect of permeate (without bio-treatment) application for growth characteristics of wheat seeds *in vivo* (Table)

Sample	GP (%)	Root length (cm)	Stem length (cm)	Root fresh Wt. (g)	Stem fresh Wt. (g)
Control	86.0±2.5^{a}	8.13±0.88^{a}	4.89±1.10^{a}	0.0276±0.003^{a}	0.0360±0.001^{a}
PK	93.3±1.0^{c}	8.95±0.13^{b}	5.74±0.46^{b}	0.0610±0.004^{c}	0.0630±0.007^{c}
PR	88.5±0.5^{b}	6.94±0.93^{a}	4.10±0.22^{a}	0.0390±0.003^{b}	0.0490±0.002^{b}
PS	92.5±1.5^{c}	7.88±0.64^{a}	5.45±0.65^{b}	0.0660±0.010^{c}	0.0640±0.007^{c}
PM	93.0±1.0^{c}	8.80±0.34^{b}	5.80±0.13^{b}	0.0560±0.005^{c}	0.0630±0.006^{c}
PA	88.5±1.1^{b}	6.53±0.14^{a}	4.58±0.11^{a}	0.0340±0.006^{b}	0.0480±0.004^{b}

Data expressed as a mean value (n = 3) ± SD; SD – standard deviation. $^{a-c}$ Means within a column with different superscript letters are significantly different ($p < 0.05$); GP – germination percentage. PK-coconut permeate; PR-rice permeate; PS-soyabean permeate; PM-almond permeate; PA-oat permeate.

VIIIB. The effect of permeate (with bio-treatment) application for growth characteristics of contaminated wheat seeds *in vivo* (Table)

Sample	GP (%)	Root length (cm)	Stem length (cm)	Root fresh Wt. (g)	Stem fresh Wt. (g)
Control	64.0±1.4^{a}	5.95±0.08^{a}	4.85±0.01^{a}	0.039±0.03^{a}	0.049±0.002^{a}
$PK_{LUHS173}$	79.0±2.8^{b}	7.42±0.32^{a}	5.12±0.04^{a}	0.050±0.06^{b}	0.054±0.003^{a}
$PR_{LUHS173}$	66.0±2.4^{a}	6.48±0.02^{a}	4.74±0.16^{a}	0.032±0.04^{a}	0.052±0.004^{a}
$PS_{LUHS206}$	66.0±2.7^{a}	6.97±0.52^{a}	4.85±0.36^{a}	0.053±0.04^{b}	0.053±0.004^{a}
$PA_{LUHS206}$	72.0±3.1^{a}	6.80±0.52^{a}	5.09±0.39^{a}	0.041±0.06^{a}	0.050±0.002^{a}

Data expressed as a mean value (n = 3) ± SD; SD – standard deviation. $^{a-c}$ Means within a column with different superscript letters are significantly different ($p < 0.05$); GP – germination percentage. $PK_{LUHS173}$ and $PR_{LUHS173}$ – coconut and rice permeates fermented (48h) with *L. brevis*, respectively; $PS_{LUHS206}$ and $PA_{LUHS206}$ – soyabean and oat permeates fermented (48h) with *L. farraginis*, respectively.

CONCLUSIONS

- The study showed that bio-refinery approach of press cakes obtained from plant drinks production could be alternative strategy to ensure sustainable production and zero-waste economy.
- This study demonstrates that developed bio-refinery using ultrasonication and membrane separation could find new application perspectives in bio-stimulants production.
- These findings expand the functionality of waste usage and improves the sustainability of plant drinks production.

KTU results were published in Journal **"Food Bioscience"**, 2021
doi:https://doi.org/10.1016/j.fbio.2021.101427

IIB. Corn starch processing by-products valorization to bio-stimulant

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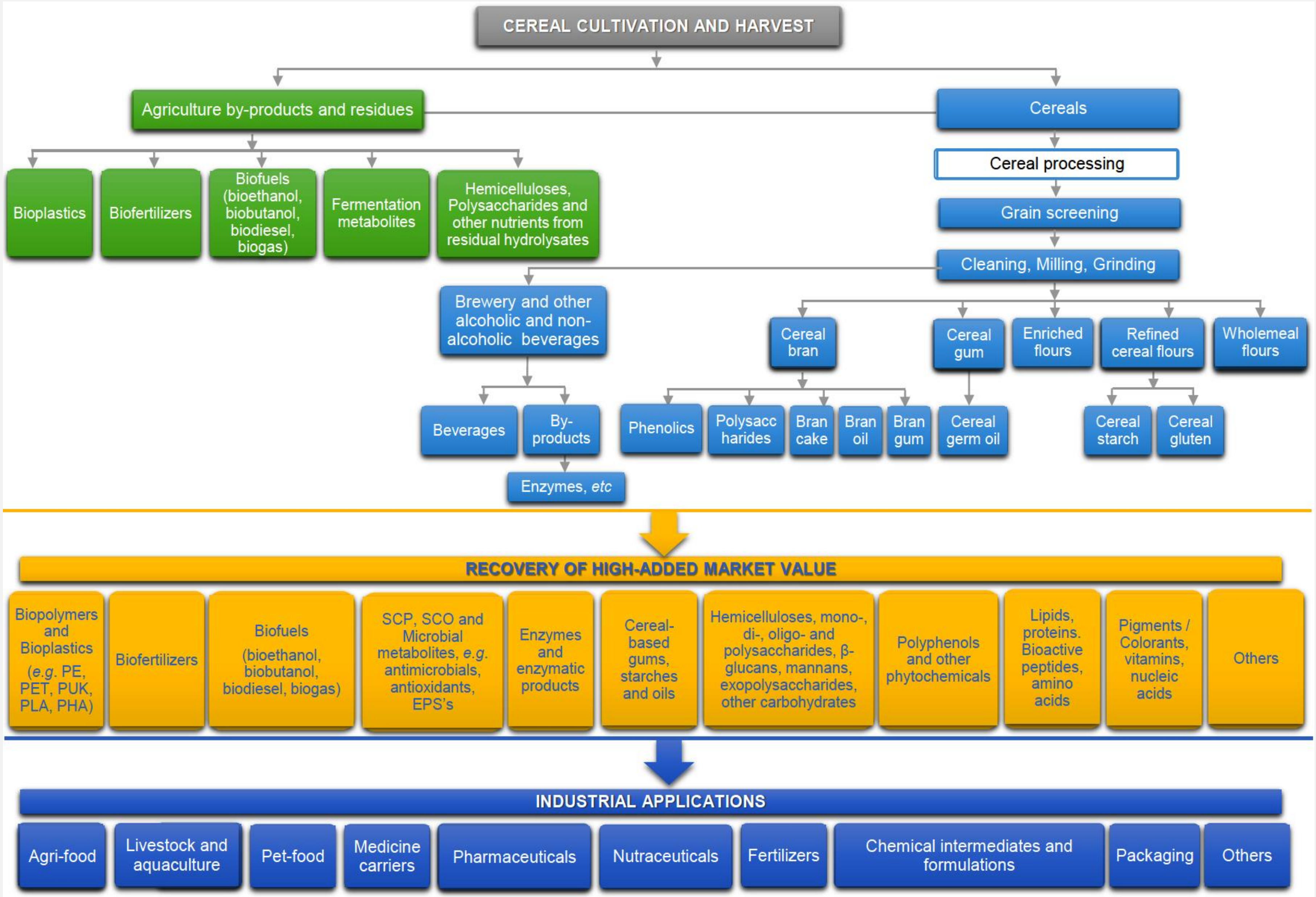
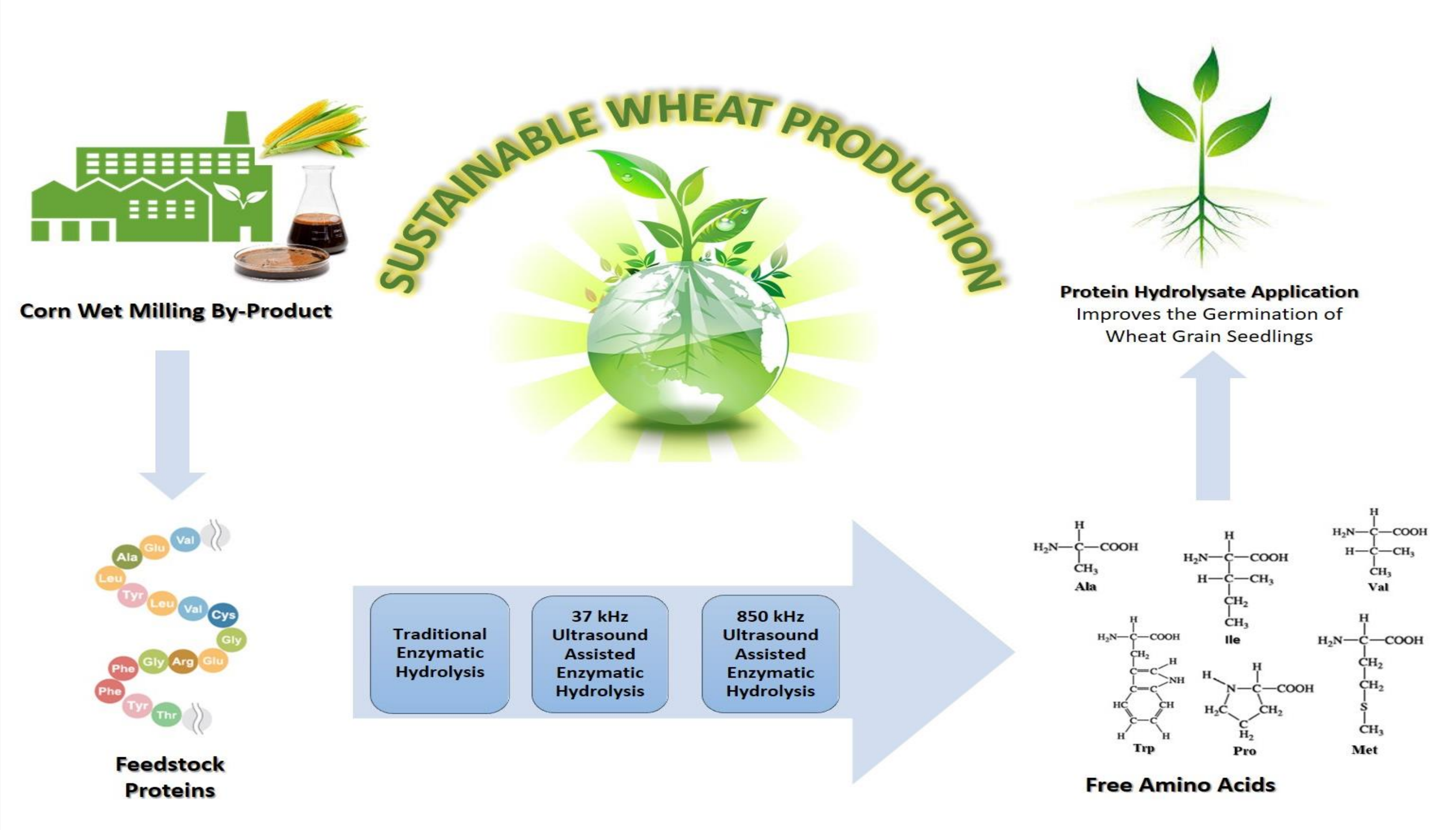
KTU Industrial PhD Student

Valorization of by-products and wastes from cereal-based processing industry (Fig.) Source: Foods 2020, 9, 1243



This study was dedicated to increasing the efficiency of producing plant-based protein hydrolysate from **corn processing by-product** using traditional and non-traditional treatments.



KTU results are published in the Journal "Food Bioscience", 2021 DOI:https://doi.org/10.1016/j.fbio.2021.101427

III. Final conclusion on bio-stimulants production with vision for collaboration

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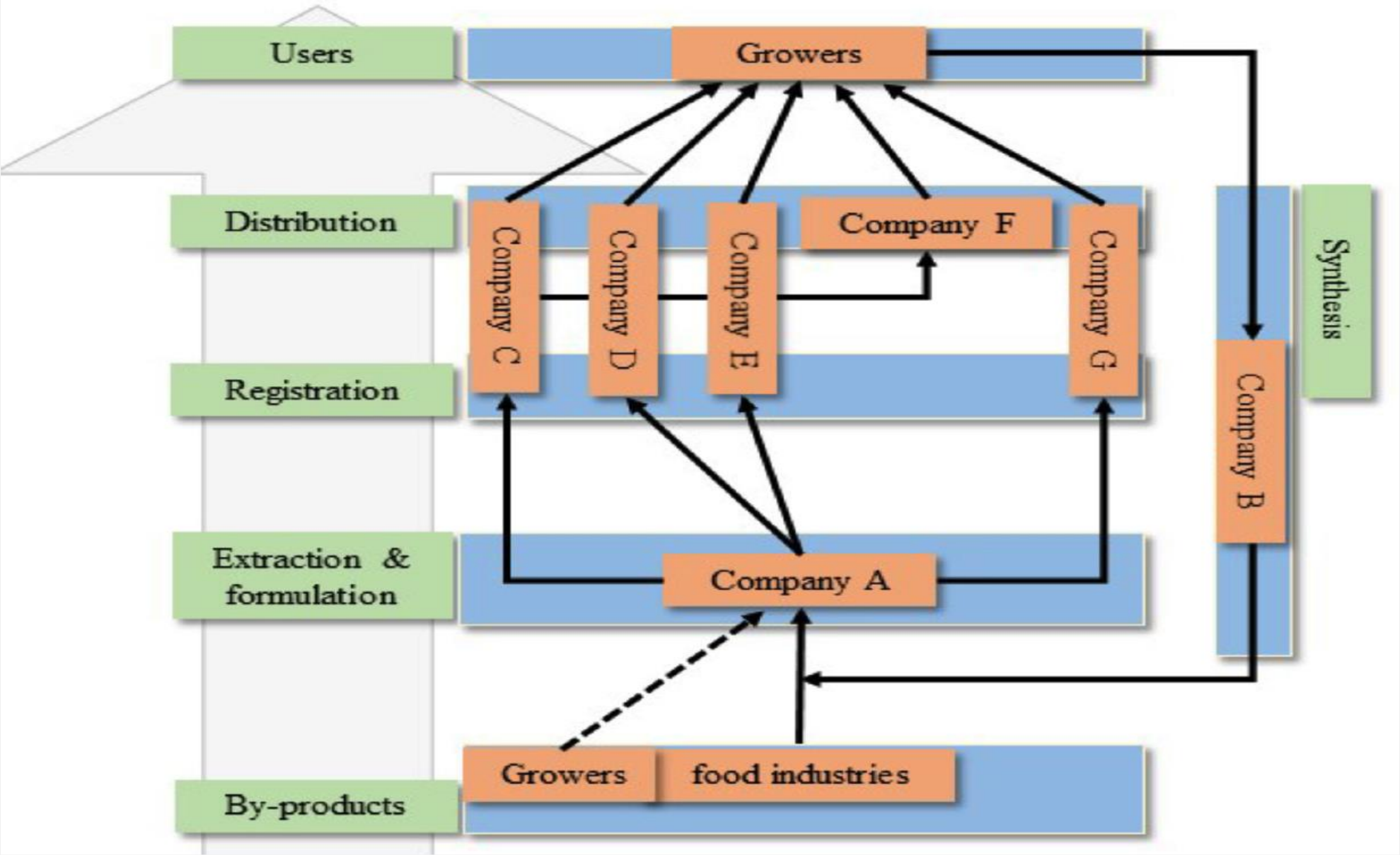
Possible scenario in valorization chain of biostimulants from waste streams,
Source: Frontiers in Plant Science, 2018, Vol. 9, Article 1567



Company A has the expertise in extraction and formulation from by-products.
Company C–E, and **G** are involved in the production and marketing of bio-stimulants and they invest in registration and distribution.
Company C–E are also selling biostimulants to intermediate companies (**Company F**), who produce seeds, substrates or fertilizers.

THANK YOU FOR COLLABORATION

MERRY CHRISTMAS AND HAPPY NEW YEAR !!!

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Latvia University of Life Sciences and Technologies, JELGAVA, 16/12/2021