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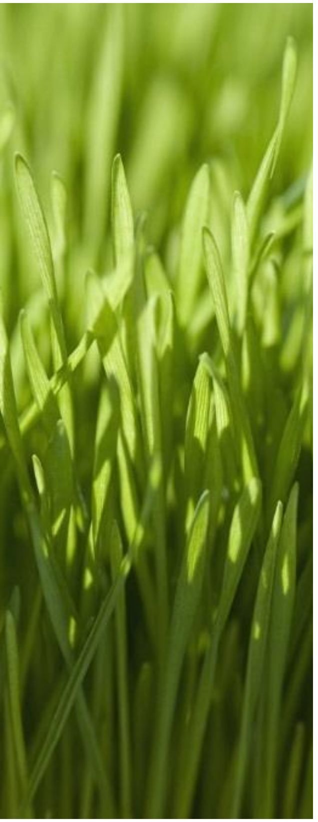

Analytical evaluation of safety and quality of food byproducts in the context of circular food system

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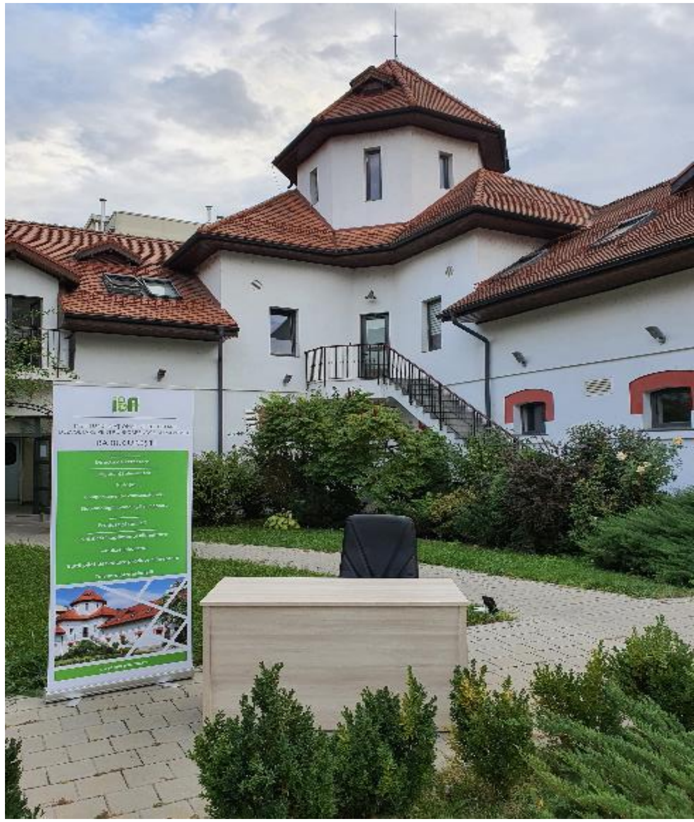

Introduction

Competition on resources (raw materials, soil, water, energy) **will increase** within the food system level.

Food waste quantity **is also increasing** → challenges with accumulation, handling and disposal.

Some of the food waste categories are byproducts containing **valuable nutritive compounds** → can be considered new raw materials and re-introduced in the food system.

Introduction

During the process of obtaining vegetable oils, high amounts of waste and byproducts are generated → they are important due to their high value-added substances, and they represent an excellent source of bioactive components, such as antioxidants[1].

Byproducts such as flour, meals, and groats resulting from the vegetable oil industry are considered economic resources due to the antioxidant compounds, which have attracted interest in making functional products with a higher nutritional value, satisfying consumer demand for such products[1].

The potential safety concerns about such vegetable oil byproducts should be emphasized and discussed while they are being valorized for human consumption[2].

1. Multescu, M.; Marinas, I.C.; Susman, I.E.; Belc, N. Byproducts (Flour, Meals, and Groats) from the Vegetable Oil Industry as a Potential Source of Antioxidants. *Foods.* **2022**, 11, 253.
2. Smeu, I.; Dobre, A.A.; Cucu, E.M.; Mustatea, G.; Belc, N.; Ungureanu, E.L. Byproducts from the Vegetable Oil Industry: The Challenges of Safety and Sustainability. *Sustainability*. **2022**, 14, 2039.

Objective

Evaluation of the quality and safety of different byproducts.

Antioxidant capacity

Mycotoxins

Microbiological parameters

Heavy metals

Samples of byproducts from vegetable oils industry

Sea buckthorn flour Hemp flour Walnut flour Grape seed flour
Rapeseed meals Sunflower meals Black sesame meals Red grape seed meals Golden flax meals Thistle meals
Sesame groats Thistle groats Coriander groats Sunflower groats

Methods

Antioxidant capacity

PCL
photo chemiluminescence

DPPH
2,2-diphenyl-1-picryl-hydrazyl

ABTS
2,2'-azinobis-3-ethylbenzothiazoline-6-sulfonic acid

FRAP
ferric reducing antioxidant power

CUPRAC
cupric ion reducing antioxidant capacity

Safety analyses

Mycotoxins
DON – Deoxynivalenol
Total aflatoxins
ZEA – Zearalenone
by ELISA

Microbiological parameters
Mesophilic bacteria
Yeasts and Moulds

Heavy metals
Pb, Cd, Cr by ICP-MS

Results and discussion

Antioxidant capacity

Sample name	PCL	DPPH	ABTS	FRAP	CUPRAC
Sea buckthorn flour	728.21	394.17	419.46	547.45	503.43
Hemp flour	392.51	139.59	113.73	285.81	231.94
Walnut flour	2039.42	1257.49	1423.98	913.44	1202.75
Grape seed flour	9269.32	7182.53	3500.52	4716.75	5936.76
Rapeseed meals	1712.39	647.29	406.55	1034.92	478.43
Sunflower meals	14329.32	628.58	347.01	1350.86	510.49
Black sesame meals	107.25	17.73	48.81	42.69	63.31
Red grape seed meals	486.96	200.77	322.76	119.92	119.99
Golden flax meals	191.27	9.25	12.13	61.54	75.50
Thistle meals	352.19	85.58	292.81	84.89	125.75
Sesame groats	139.62	7.58	15.77	66.21	62.45
Thistle groats	452.22	22.74	293.14	105.31	112.54
Coriander groats	169.23	17.64	9.37	26.47	67.53
Sunflower groats	125.36	55.06	n.d.	34.46	70.47

All values are expressed as mg Trolox / g fresh weight

Results and discussion

The response of antioxidants to different radical/oxidant source is different. That's why, no single method can accurately reflect the mechanism of action of all radical sources / antioxidant compounds in a complex system.

The contribution of the phenolic compounds to the overall antioxidant capacity is different, so, a correlation analysis was performed.

	DPPH	ABTS	FRAP	CUPRAC
TPC (Total phenolic content)	**0.9927**	0.9660	0.9752	0.9920

Results and discussion

Strong positive correlations between the antioxidant capacity measured by PCL and the other methods used were observed.

Method	DPPH	ABTS	FRAP	CUPRAC
PCL	0.9952	0.9735	0.9874	0.9930

FRAP and CUPRAC methods showed high values of antioxidant capacity, for most of the analyzed byproducts, probably due to other structures that can function as ligands.

Results and discussion

Microbiological parameters

Sample name	Total Mesophilic bacteria	Yeasts and Moulds
Sea buckthorn flour	n.d.	n.d.
Hemp flour	2.51	2.00
Walnut flour	2.32	2.38
Grape seed flour	n.d.	n.d.
Rapeseed meals	2.62	2.36
Sunflower meals	2.41	n.d.
Black sesame meals	2.48	n.d.
Red grape seed meals	3.73	n.d.
Golden flax meals	1.30	n.d.
Thistle meals	1.74	n.d.
Sesame groats	2.95	n.d.
Thistle groats	3.51	n.d.
Coriander groats	4.32	2.89
Sunflower groats	4.41	2.04

All values are expressed as log cfu g^{-1}

Lack of regulation → risks on the possibility of exploiting this byproducts.

Moderate contamination with bacteria, associated with the natural microflora present in the main matrices.

71.4% of tested samples did not present fungal contamination, indicating adequate management of the hygienic quality and technology used.

Results and discussion

Mycotoxins

Sample name	DON	Total Aflatoxins	ZEA
Sea buckthorn flour	980.09	0.28	12.45
Hemp flour	107.65	< 0.25	40.30
Walnut flour	59.09	< 0.25	24.46
Grape seed flour	975.57	0.76	79.22
Rapeseed meals	266.76	< 0.25	< 1.75
Sunflower meals	52.39	0.29	1.03
Black sesame meals	26.44	0.27	< 1.75
Red grape seed meals	63.17	< 0.25	< 1.75
Golden flax meals	25.57	0.28	< 1.75
Thistle meals	80.15	< 0.25	10.15
Sesame groats	46.02	1.51	6.01
Thistle groats	226.63	0.39	< 1.75
Coriander groats	81.20	0.27	< 1.75
Sunflower groats	141.79	0.61	< 1.75

All values are expressed in µg/kg

Results and discussion

All samples had DON contamination, but no maximum level is stated in the European legislation.

No sample exceeded the level of 15.0 µg/kg total aflatoxins stated by Regulation (EC) no. 165/2010 (which amends Regulation (EC) no 1881/2006 setting maximum levels for certain contaminants in foodstuffs as regards aflatoxins).

Flour samples showed highest concentrations of ZEA.

Also, studies on the incidence of mycotoxins in byproducts from the oil industry still remain scarce.

Results and discussion

Heavy metals

Sample name	Pb	Cd	Cr
Sea buckthorn flour	0.015 ± 0.007	0.013 ± 0.001	0.331 ± 0.005
Hemp flour	0.004 ± 0.002	0.012 ± 0.001	0.112 ± 0.001
Walnut flour	< 0.00007	0.004 ± 0.001	0.038 ± 0.002
Grape seed flour	< 0.00007	0.002 ± 0.001	0.166 ± 0.004
Rapeseed meals	< 0.00007	0.013 ± 0.007	0.032 ± 0.001
Sunflower meals	< 0.00007	0.140 ± 0.001	0.035 ± 0.002
Black sesame meals	< 0.00007	0.017 ± 0.001	0.127 ± 0.020
Red grape seed meals	0.033 ± 0.002	0.032 ± 0.001	0.311 ± 0.009
Golden flax meals	< 0.00007	0.098 ± 0.002	0.101 ± 0.011
Thistle meals	0.044 ± 0.001	0.052 ± 0.001	0.331 ± 0.010
Sesame groats	0.008 ± 0.004	0.011 ± 0.001	0.162 ± 0.005
Thistle groats	0.001 ± 0.001	0.001 ± 0.001	0.167 ± 0.006
Coriander groats	0.122 ± 0.008	0.053 ± 0.001	0.479 ± 0.002
Sunflower groats	0.038 ± 0.003	0.235 ± 0.004	0.868 ± 0.017

All values are expressed in mg/kg

Limits stated by Regulation (EC) no. 1881/2006 for Pb and Cd.

Only 3 samples exceeded the limits.

Higher values obtained for Cr (total).

Conclusions:

14 samples of byproducts from vegetable oil industry (flours, meals and groats) were tested within the study.

Analyzed byproducts are a good source of biological functional substances due to the considerable amount of total phenolic compounds.

Flours of analyzed byproducts had higher antioxidant activity than meals and groats.

PCL and DPPH, ABTS, FRAP and CUPRAC were assays fully applicable for the evaluation of the antioxidant capacity.

Conclusions:

A safety handling procedures of food byproducts must be conducted in order to prevent microbiological contamination of these materials.

No presence of foodborne pathogens was observed in tested byproducts.

The level of total aflatoxins, the only mycotoxins with maximum allowed limit in the legislation, was not exceeded.

No heavy metals contamination was observed, excepting 1 sample for Pb and 2 samples for Cd.

Conclusions:

Updated regulations with regard to the safety limits of byproducts from vegetable oil industry must be considered.

Byproducts from vegetable oil industry can be used as ingredients for new bakery products with improved antioxidant quality.

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