Effect of Lyophilized Mullein (*Verbascum nigrum* L.) Flowers Addition on Selected Cold-pressed Oils' Oxidative Stability and Chemical Composition

Edyta Symoniuk[1], Aleksandra Rosa[1], Anna Grygier[2], Aleksander Siger[2], Bartosz Kruszewski[1]
[1]Department of Food Technology and Assessment, Institute of Food Sciences, Warsaw University of Life Sciences, Nowoursynowska 166, 02-787 Warsaw, Poland
[2]Department of Food Technology of Plant Origin, Poznań University of Life Sciences, Wojska Polskiego 31/33, 60-624 Poznań, Poland
E-mail: edyta_symoniuk@sggw.edu.pl

INTRODUCTION

The chemical composition of cold-pressed oils plays a crucial role in determining their oxidation rate, which is influenced by factors such as the composition of fatty acids, the presence of antioxidant and prooxidizing compounds, and external conditions, including storage time, temperature, scattered radiation, access to oxygen, and light. Natural antioxidants obtained from herbs can inhibit the process of fat oxidation. Mullein flowers (*Verbascum* L.) are used in many medicines due to their rich composition of bioactive compounds and high antioxidant activity.

Keywords: antioxidant activity, cold-pressed oils, mullein, oxidative stability.

AIM

The aim of the study was to analyze the effect of the addition of freeze-dried mullein flowers on the oxidative stability and antioxidant activity of cold-pressed oils.

RESEARCH MATERIAL

- Cold-pressed oils: rapeseed (RO), linseed (LO), hempseed (HO), chia seeed(CHO), camelina seed (CO). Oils after maceration (1:10).
- Mullein flowers (*Verbascum nigrum* L.)
  Collected near the Kozienicka Forest (Mazovian Voivodeship) in August 2022.

RESEARCH METHODS

- Degree of oil hydrolysis (PN-EN ISO 660:2010)
- Primary oxidation state (PN-EN ISO 3960:2017-03)
- Secondary oxidation state (AOCS Official Method Cd 18-90)
- Total oxidation state (Totox)
- Oxidative stability in Rancimat (3g, 20L/h, 90-140°C)
- Total phenol content (Dewanto et al. 2002)
- Antioxidant activity with DPPH* (Pająk i wsp. 2014) and ABTS* (Akmal i Roy 2017)
- fatty acid composition (AOAC 996.01)
- colour difference (CIELab),
- phenolic acids (Siger et al., 2016),
- calculation of kinetics parameters.

Table 1. Oils' quality characteristics, oxidative stability and phenolic compounds content

Oil	AV [mg KOH/g]	PV [mEq O_2/kg]	P-AnV	Totox	IT at 100°C [h]	TPC [mg GAE/100 g]
LO	1.29^{ab}	1.18^{bc}	0.88^{ab}	3.25^{a}	4.68^{c}	341.95^{abc}
LOD	1.51^{bc}	2.57^{a}	0.19^{c}	5.34^{ab}	6.04^{d}	379.43^{abc}
CO	0.84^{a}	0.99^{b}	1.00^{ab}	2.98^{a}	6.06^{d}	558.63^{bc}
COD	0.73^{a}	2.23^{ac}	0.32^{d}	4.79^{ab}	7.39^{e}	645.94^{c}
CHO	2.46^{d}	2.18^{abc}	0.94^{ab}	5.30^{ab}	2.25^{a}	291.13^{abc}
CHOD	2.13^{cd}	2.45^{a}	1.11^{b}	6.01^{b}	3.77^{b}	455.19^{abc}
HO	2.52^{d}	8.20^{e}	0.79^{a}	17.19^{d}	5.33^{cd}	232.28^{ab}
HOD	1.68^{bc}	12.90^{f}	3.16^{d}	28.96^{e}	5.16^{cd}	418.16^{abc}
RO	1.01^{ab}	2.07^{abc}	0.89^{ab}	5.03^{ab}	17.34^{f}	148.02^{a}
ROD	0.73^{a}	4.16^{d}	0.48^{c}	8.80^{c}	17.71^{f}	387.43^{abc}

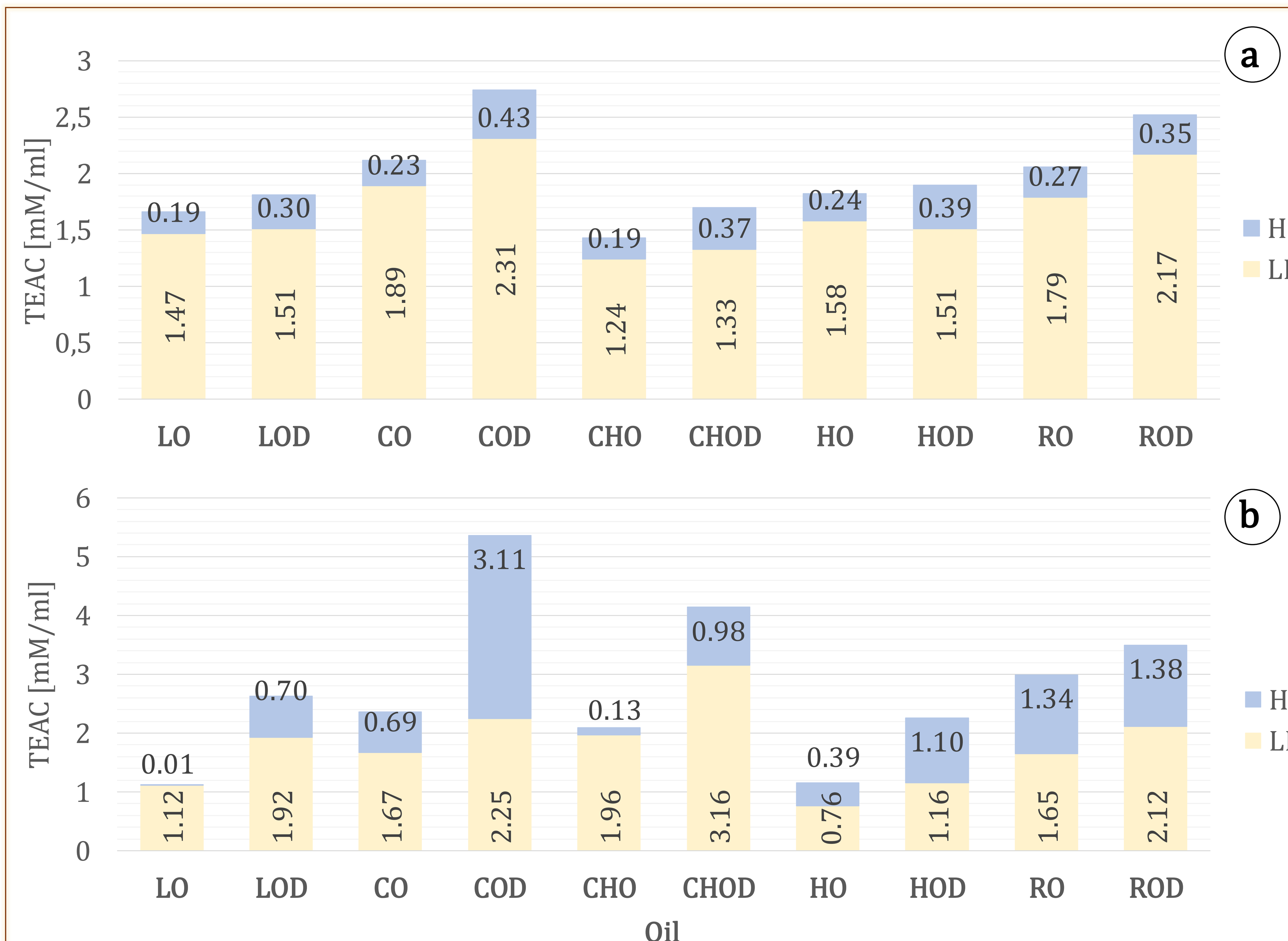

Figure 1. Antioxidant activity of analysed oils lipophilic and hydrophilic fraction analysed using DPPH (a) and ABTS (b) method

Table 2. Phenolic acid composition content (μg/100g) of analysed oils

Compound	OILS									
	LO	LOD	CO	COD	CHO	CHOD	HO	HOD	RO	ROD
gallic acid	0.00	144.04	0.00	691.02	0.00	641.10	0.00	691.02	0.00	2523.67
p-hydroxybenzoic acid	1.49	8.14	1.21	0.00	2.91	4.75	0.00	9.14	0.00	0.00
protocatechuic acid	0.00	17.13	0.00	9.85	4.95	11.46	0.00	26.01	0.00	0.00
p-coumaric acid	0.00	8.72	0.00	6.76	0.00	5.03	0.00	9.84	0.00	6.12
ferulic acid	3.89	3.51	0.00	0.00	0.00	0.00	1.63	4.40	4.79	5.26
sinapic acid	0.00	0.00	7.38	13.36	7.22	5.78	0.00	0.00	79.37	85.89
Total	5.38^{b}	181.53^{g}	8.59^{c}	720.98^{i}	15.08^{d}	668.10^{h}	1.63^{a}	75.20^{e}	84.16^{f}	2620.93^{j}

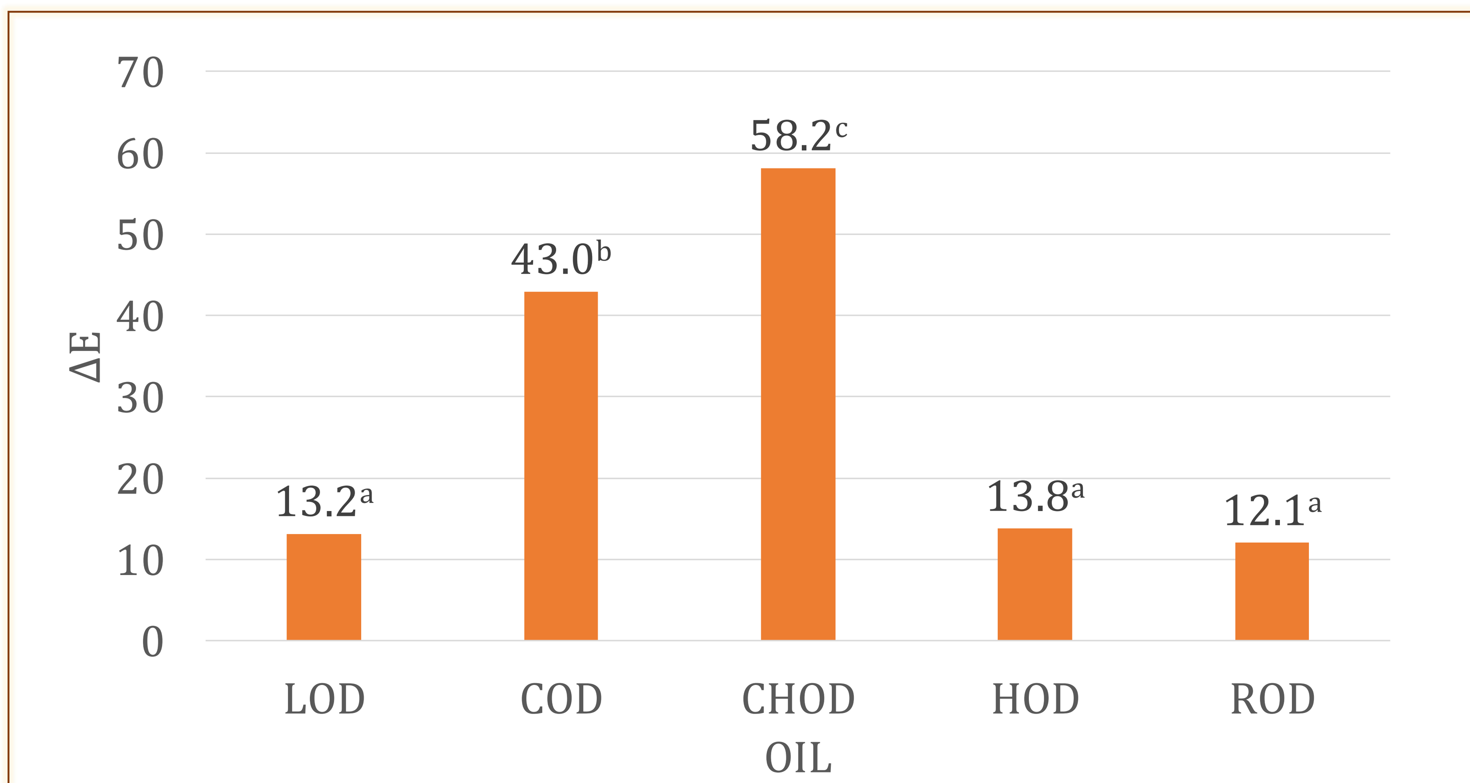

Figure 2. Oils' colour change after maceration proces

Table 3. Oxidation kinetic parameters of analysed cold-pressed oils before and after maceration with mullein flowers

KINETIC PARAMETERS	OILS									
	LO	LOD	CO	COD	CHO	CHOD	HO	HOD	RO	ROD
T coeff [K^{-1}]	$7,2*10^{-2}$	$7.7*10^{-2}$	$7.4*10^{-2}$	$7.04*10^{-2}$	$7.07*10^{-3}$	$7.57*10^{-4}$	$7.34*10^{-5}$	$7.64*10^{-6}$	$6.79*10^{-5}$	$7.15*10^{-8}$
Z [h^{-1}]	$4.69*10^{13}$	$1.96*10^{14}$	$6.07*10^{13}$	$1.67*10^{13}$	$5.5*10^{13}$	$2.21*10^{14}$	$1.10*10^{13}$	$4.38*10^{13}$	$7.0*10^{13}$	$2.01*10^{14}$
Ea [kJ/mol]	80.72	86.21	83.53	79.13	79.47	85.03	80.45	84.76	82.59	85.86
k at 100 °C [h^{-1}]	0.2137	0.1657	0.2077	0.1343	0.4167	0.2656	0.1878	0.1938	0.0577	0.0565
Q10	1.91	1.99	1.93	1.89	1.89	1.97	1.94	1.97	1.85	1.90
ΔH [kJ/mol]	77.67	83.15	78.96	76.59	76.42	81.98	79.53	82.81	77.32	81.62
ΔS [J/mol K]	-118.77	-106.89	-116.63	-126.13	-117.44	-105.87	-115.43	-106.65	-131.06	-119.55
ΔG at 100 °C [kJ/mol]	121.97	123.02	122.47	123.63	120.23	121.47	122.59	122.59	126.20	126.22
$IP^{25°C}$ [days]	14	27	22	25	8	15	21	22	42	50
$IP^{4°C}$ [days]	54	113	87	95	32	64	85	93	153	190

SUMMARY

The findings from this research strongly support the conclusion that the addition of mullein flowers can substantially enhance the oxidative stability of cold-pressed oils. The maceration process of oils with mullein flowers also increased the content of bioactive antioxidant compounds. However, further investigation is warranted to deepen our understanding, optimize the maceration parameters, and conduct in-depth analysis of the bioactive compounds involved. These areas of research hold promising potential for further advancements in this field.