Exploring novel oil sources: fatty acid composition, oxidative stability, and thermal behaviour of fruit seed oils

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Summary
Vegetable oils are essential components in human nutrition and food technology, providing crucial bioactive compounds and essential fatty acids. Growing concerns about sustainability and environmental impact have driven interest in alternative oils derived from fruit and vegetable by-products, aligning with circular economy principles. This study evaluates the physicochemical properties of oils extracted from blackcurrant, strawberry, melon, pomegranate, and grape seeds using solid-liquid extraction and compares them to commercially available cold-pressed counterparts. Analytical methods including pressure differential scanning calorimetry (PDSC), differential scanning calorimetry (DSC), acid value determination, and gas chromatography (GC) were employed to assess oxidative stability, melting characteristics, hydrolytic degradation, and fatty acid composition. The findings indicate that the extraction method significantly influences oil properties, with solid-liquid extraction generally enhancing oxidative stability due to potential co-extraction of antioxidants. Melon seed oil extracted applying solid-liquid extraction had the highest oxidation induction time: 51.23 ± 1.63 min, compared to 36.98 ± 0.75 min in case of cold-pressed melon seed oil. This research highlights the potential of underutilized fruit seed oils as sustainable and functional alternatives in food applications, offering both nutritional and technological benefits.

Keywords
plant oil; gas chromatography; differential scanning calorimetry; oil quality

Vegetable oils play a crucial role in human nutrition and food technology, serving as both functional ingredients and sources of essential fatty acids, bioactive compounds, and energy. While conventional oils such as rapeseed, sunflower, soybean, and palm oil dominate global production [1], increasing concerns regarding sustainability, biodiversity loss, and the environmental impact of large-scale monoculture farming have intensified the search for alternative oil sources [2]. The growing interest in novel oils derived from fruit and vegetable by-products aligns with the principles of circular economy and sustainable food systems, offering an opportunity to valorise waste streams from the fruit processing industry [3]. Seeds from blackcurrant (*Ribes nigrum* L.), strawberry (*Fragaria* × *ananassa* Duchesne), melon (*Cucumis melo* L.), pomegranate (*Punica granatum* L.), and grape (*Vitis vinifera* L.) represent promising yet underutilized sources of high-value oils with unique compositional and functional properties.

These alternative seed oils exhibit diverse fatty acid profiles, often featuring high proportions of polyunsaturated fatty acids (PUFA), including linoleic acid (n-6) and α-linolenic acid (n-3) [4–9], which are essential for human health [10, 11]. Furthermore, they contain valuable minor constituents such as tocopherols, phytosterols, and polyphenols, which contribute to their oxidative stability and confer potential health benefits. Tocopherols, particularly α-tocopherol, are essential antioxidants in the human body and the only tocols that meet the dietary requirement for vitamin E

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but also play role in protecting oils from oxidation. Phytosterols present in these oils reduce plasma cholesterol by inhibiting its absorption in the intestine, contributing to the prevention of lipid-related disorders such as hypercholesterolemia [12]. Due to their unique physicochemical characteristics, these oils could serve as functional ingredients in food formulations, cosmetics, and nutraceuticals, providing added nutritional value and technological benefits, such as improved texture, mouthfeel, and oxidative resistance. However, the processing method significantly influences the chemical composition and stability of these oils, necessitating a thorough assessment of their quality parameters. Oils with high tocopherol content, particularly those that are highly unsaturated, tocopherols have been observed to lose their antioxidant effectiveness and may even exhibit pro-oxidant effects [13].

The present study investigates the physicochemical properties of oils extracted from blackcurrant, strawberry, melon, pomegranate, and grape seeds using solid-liquid extraction when compared to cold-pressed oils. Quality assessment parameters include oxidative stability determined by pressure differential scanning calorimetry (PDSC), melting characteristics analysed via differential scanning calorimetry (DSC), acid value as an indicator of hydrolytic degradation, and fatty acid composition determined by gas chromatography (GC). Understanding these properties is essential for evaluating the potential applications of these oils in food design, particularly in the development of functional foods with enhanced nutritional and technological properties. The findings of this research aim to contribute to the broader utilization of alternative seed oils, promoting sustainability and diversification in edible oil production while offering consumers health-beneficial options.

MATERIAL AND METHODS

Material

The material for the solid-liquid extraction (S/L) of oils consisted of seeds from: melon, grape, strawberry, pomegranate, and blackcurrant obtained from Planteon (Żelazków, Poland) and Naturini (Poznań, Poland). The seeds were ground in a laboratory mill Tube Mill Control (IKA Werke, Staufen im Breisgau, Germany). Also, cold-pressed (CP) oils from the blackcurrant, strawberry, melon, pomegranate and grape seeds were purchased in the local market in Warsaw (Poland).

Extraction procedure

A 10 g sample of this prepared material was weighed into conical flasks. The solvent used for extraction was *n*-hexane (99% pure for analysis, Chempur, Piekary Śląskie, Poland) – 150 ml.

After the extraction process was completed, the extract was filtered and dried using anhydrous magnesium sulfate (VI). Then, after filtering out the drying agent, the solvent was evaporated using a rotary vacuum evaporator (BUCHI Labortechnik, Flawil, Switzerland). The sample was further dried under nitrogen to remove any residual solvent.

Pressure differential scanning calorimetry

To determine the oxidative stability of the obtained oils, the maximum and initial induction times for the oxidation reaction were measured using PDSC on a Thermal Analysis DSC Q20 instrument (TA Instruments, New Castle, Delaware, USA). The measurement was conducted under isothermal conditions at 120 °C and a pressure of about 1 400 kPa. Approximately 3–4 mg of the oil sample was weighed into open aluminium pans, with an empty pan serving as the reference [14]. Induction times were determined based on curves analysed in the Universal Analysis V4.5A software (TA Instruments).

Differential scanning calorimetry

The melting characteristics of the fats were determined by DSC using the Q200 instrument (TA Instruments). Hermetically sealed aluminium pans containing 3–4 mg of the oil samples were cooled to –80 °C and then heated at a rate of 10 °C·min^{-1} to a final temperature of 80 °C. The result was a DSC diagram, illustrating the relationship between temperature and heat flow [15].

Acid value

The acid value (*AV*) was determined according to the procedure described in the standard PN-EN ISO 660:2010 [16]. The oil sample was weighed into a beaker and dissolved in 50 ml of an ethanol-diethyl ether mixture (1 : 1, v/v). The sample was then placed on a magnetic stirrer, and titration was performed using an ethanolic solution of potassium hydroxide (KOH, 0.1 mol·l^{-1}) as the titrant with a TitraLab AT100 titrator (HACH LANGE, Wrocław, Poland). The acid value was expressed as the mass of KOH in grams needed to neutralize the fatty acids present in 1 kg of the oil sample.

Gas chromatography

The fatty acid profile was determined using

a YL6100 gas chromatograph (Young Lin Instrument, Anyang, South Korea) equipped with a flame ionization detector and a BPX 70 capillary column (inner diameter 0.25 mm × length 60 m × film thickness 0.25 μm) from SGE Analytical Science (Milton Keynes, United Kingdom). Nitrogen was used as the carrier gas at a flow rate of 1 ml·min^{-1}. Fatty acids were derivatized to methyl esters (FAME) according to the PN-EN ISO 5509:2001 standard [17] and the procedure described by Bryś et al [18]. The identification of FAME was based on the comparison of relative retention times of peaks in the tested samples with the FAME standard (Supelco 37 Component FAME Mix, Supelco, Bellefonte, Pennsylvania, USA).

Statistical analysis of results

The analyses were performed in triplicate, and the results are expressed as the mean ± standard deviation. The results were statistically processed using Statistica 13.3 software (StatSoft, Tulsa, Oklahoma, USA), employing multi-factor ANOVA and Tukey's post hoc test. The significance level (p) was set at 0.05.

RESULTS AND DISCUSSION

Oxidative stability of oils

The oxidation induction time (*OIT*) and maximum induction time (τ_{max}) of different seed oils were evaluated based on the extraction method used cold pressing and solid-liquid extraction. Detailed results are summarized in Tab. 1, and examples of PDSC curves are shown in Fig. 1. For melon seed oil, solid-liquid extraction resulted in significantly higher *OIT* (51.23 min) and τ_{max} (57.17 min) compared to cold pressing (36.98 min, 43.91 min). Similarly, grape seed oil extracted via solid-liquid extraction showed an increased *OIT* (20.19 min) and τ_{max} (25.17 min) compared to cold pressing (9.88 min, 15.73 min). Strawberry seed oil exhibited comparable *OIT* values between the two extraction methods (8.60 min vs 8.41 min), though τ_{max} was slightly lower for solid-liquid extraction (13.47 min) than cold pressing (13.96 min). Pomegranate seed oil was characterized by the lowest *OIT* and τ_{max} values among the tested oils, with cold pressing showing slightly higher values (2.40 min, 2.72 min) than solid-liquid extraction (2.03 min, 2.33 min). For blackcurrant seed oil, solid-liquid extraction enhanced both *OIT* (23.61 min vs 20.93 min) and τ_{max} (28.05 min vs 26.61 min) compared to cold pressing.

Overall, solid-liquid extraction resulted in higher oxidative stability, except for strawberry and pomegranate seed oils, where the differences were minimal. Considering general differences in terms of oxidative stability, it is mainly influenced by the fatty acid profile and composition of triacylglycerols [19] and partly by the presence of natural antioxidants [20]. Based on the obtained results, and previous studies [21], extraction method can also impact the *OIT* or τ_{max}. Solid-liquid extraction was conducted with the use of organic solvent – hexane, which might cause co-extraction of antioxidant compounds during oil extraction from the seeds. That's why in most samples it resulted in higher oxidative stability of oils. The cold-pressed samples came from market oils, so the details of the cold pressing procedure remain unknown. However, if the temperature of such procedure was not controlled properly, or the raw material was somehow deteriorated, it might have influenced the PDSC results.

Melting characteristics

DSC analysis of various seed oils revealed distinct thermal transitions influenced by both the

Tab. 1. Oxidation induction times and maximum oxidation times of studied fruit seed oils.

	Extraction method			
	Cold pressing		Solid-liquid extraction	
	OIT [min]	τ_{max} [min]	*OIT* [min]	τ_{max} [min]
Melon seed oil	36.98 ± 0.75^{e}	43.91 ± 0.23^{F}	51.23 ± 1.63^{f}	57.17 ± 1.97^{G}
Grape seed oil	9.88 ± 1.57^{b}	15.73 ± 0.82^{C}	20.19 ± 0.06^{c}	25.17 ± 0.10^{D}
Strawberry seed oil	8.60 ± 0.77^{b}	13.96 ± 0.81^{BC}	8.41 ± 0.13^{b}	13.47 ± 0.18^{B}
Pomegranate seed oil	2.40 ± 0.07^{a}	2.72 ± 0.06^{A}	2.03 ± 0.23^{a}	2.33 ± 0.23^{A}
Blackcurrant seed oil	20.93 ± 0.15^{c}	26.61 ± 0.16^{DE}	23.61 ± 0.46^{d}	28.05 ± 0.60^{E}

Values represent mean ± standard deviation (n = 3). Different letters in superscript indicate significantly different ($p < 0.05$) results; lowercase for *OIT* and capital for τ_{max}.
OIT – oxidation induction time; τ_{max} – maximum oxidation time.

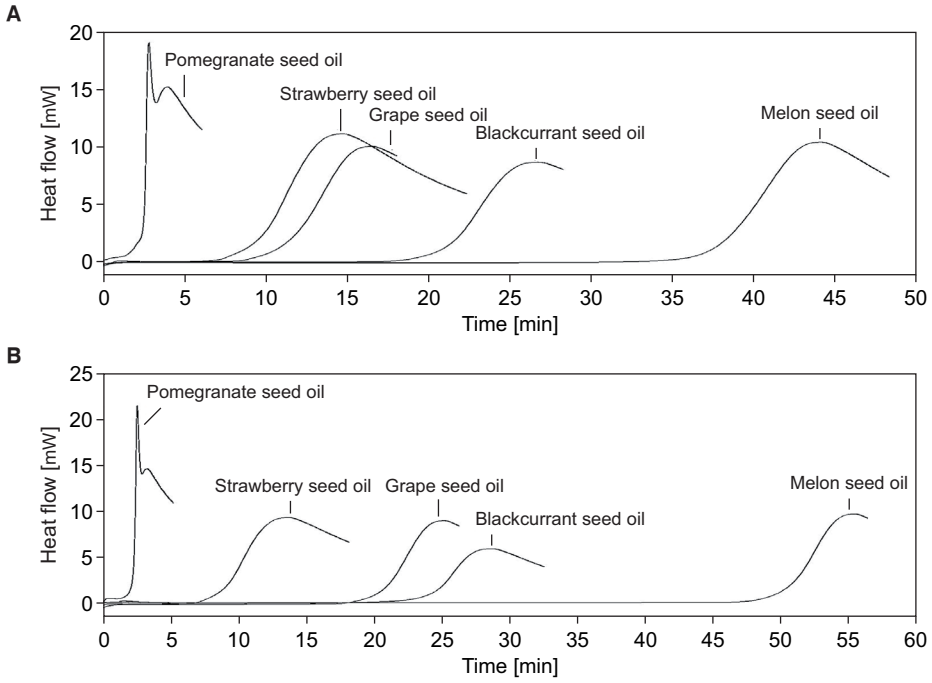

Fig. 1. Examples of pressure differential scanning calorimetry curves of studied fruit seed oils. A – cold-pressed oils, B – oils extracted in solid-liquid extraction procedure.

botanical source and extraction method. The results for peak temperatures and enthalpy changes are shown in Tab. 2. Examples of melting curves are presented in Fig. 2. Melon seed oil exhibited three thermal events when cold-pressed (CP) at approximately –38.26 °C, –25.82 °C, and –9.13 °C, with the second transition accompanied by the greatest enthalpy change (ΔH) of 31.14 kJ·kg^{-1}. Under solid-liquid extraction (S/L), melon oil showed four transitions at –43.03 °C, –28.68 °C, –18.32 °C, and –2.98 °C. Grape seed oil presented two transitions in both extraction methods: for CP, peaks occurred at –37.29 °C and –26.45 °C, with the latter having a ΔH of 20.34 kJ·kg-1; for S/L, peaks were observed at –35.19 °C and –14.95 °C. Cold-pressed strawberry seed oil displayed two transitions at –38.27 °C and –30.76 °C, whereas S/L extraction resulted in a single prominent peak at –39.66 °C with a substantial ΔH of 41.24 kJ·kg^{-1}. Cold-pressed pomegranate seed oil showed a single transition at –21.28 °C with a notable ΔH of 33.71 kJ·kg^{-1}, while S/L extraction exhibited a peak at –17.52 °C. In the case of cold-pressed blackcurrant seed oil two transitions at –36.95 °C and –26.99 °C were observed, with the second transition having a ΔH of 19.03 kJ·kg^{-1}; S/L extraction resulted in oil characterized by two peaks at –40.69 °C and –28.03 °C. These findings suggest that both the seed origin and extraction method significantly influenced the thermal behaviour of the oils, as reflected in their DSC profiles.

The course of DSC curve depends on the triacylglycerol profile of oil. The peaks at low temperatures (–40 °C to –30 °C) correspond with low-melting fractions of triacylglycerols, rich in polyunsaturated fatty acids. Middle-melting fractions of triacylglycerols (rich in poly- and monounsaturated fatty acids) are reflected as peaks at temperatures around (–20 °C to –10 °C). Peaks at temperatures above –10 °C are related to the presence of high-melting fractions of triacylglycerols which contain saturated fatty acids. As the DSC is recognized as an authentication method of oils [22], changes in the DSC curves for oils obtained by different extraction methods are only slight, however visible, as their triacylglycerol profile may have been influenced by the extraction conditions. Obtained results show significant differences especially between thermal behaviour of melon seed oils and strawberry seed oils as the number of visible thermal events was dependent on the extraction method. Differences were also observed for hempseed oil between samples extracted in microwave-assisted procedure and Soxhlet extraction [23]. Minor changes in the fatty acid profiles and triacylglycerol compositions were suspected to cause alterations in the course of the hempseed oil DSC curves. Similarly, lemon

Tab. 2. Results of differential scanning calorimetry study – peak temperatures of thermal events and enthalpies of events for studied fruit seed oils.

Peak	Extraction method			
	Cold pressing		Solid-liquid extraction	
	T_{peak} [°C]	ΔH [kJ·kg^{-1}]	T_{peak} [°C]	ΔH [kJ·kg^{-1}]
Melon seed oil				
1	–38.26 ± 0.10^{d}	3.81 ± 0.25^{B}	–43.03 ± 0.25^{a}	4.19 ± 0.14^{B}
2	–25.82 ± 0.15^{e}	31.14 ± 0.05^{G}	–28.68 ± 0.62^{b}	2.60 ± 0.36^{B}
3	–9.13 ± 0.46^{b}	0.57 ± 0.01^{A}	–18.32 ± 0.01^{a}	1.00 ± 0.14^{B}
4	–	–	–2.98 ± 0.99	0.84 ± 0.32
Grape seed oil				
1	–37.29 ± 0.04^{e}	6.05 ± 0.09^{C}	–35.19 ± 0.87^{f}	12.62 ± 1.35^{E}
2	–26.45 ± 0.02^{de}	20.34 ± 0.05^{F}	–14.95 ± 0.28^{f}	9.52 ± 0.16^{C}
3	–	–	–	–
4	–	–	–	–
Strawberry seed oil				
1	–38.27 ± 0.05^{d}	2.93 ± 0.08^{B}	–39.66 ± 0.16^{c}	41.24 ± 0.92^{G}
2	–30.76 ± 0.02^{a}	13.03 ± 0.42^{D}	–	–
3	–	–	–	–
4	–	–	–	–
Pomegranate seed oil				
1	–21.28 ± 0.05^{g}	33.71 ± 0.13^{F}	–17.52 ± 0.31^{h}	0.84 ± 0.19^{A}
2	–	–	–	–
3	–	–	–	–
4	–	–	–	–
Blackcurrant seed oil				
1	–36.95 ± 0.02^{e}	2.94 ± 0.07^{B}	–40.69 ± 0.09^{b}	10.33 ± 0.05^{D}
2	–26.99 ± 0.02^{d}	19.03 ± 0.51^{E}	–28.03 ± 0.08^{c}	0.02 ± 0.01^{A}
3	–	–	–	–
4	–	–	–	–

Values represent mean ± standard deviation (n = 3). Different letters in superscript indicate significantly different ($p < 0.05$) results in columns; lowercase for T_{peak} and capital for ΔH.
T_{peak} – peak temperature; ΔH – enthalpy change.

Tab. 3. Acid value of studied fruit seed oils.

	Extraction method	
	Cold pressing	Solid-liquid extraction
	Acid value [g·kg^{-1}]	
Melon seed oil	4.5477 ± 0.0129^{e}	9.6075 ± 0.0156^{i}
Grape seed oil	0.8067 ± 0.0187^{a}	1.3952 ± 0.0060^{b}
Strawberry seed oil	3.9599 ± 0.0206^{d}	13.8290 ± 0.0010^{j}
Pomegranate seed oil	7.9559 ± 0.0105^{g}	9.3292 ± 0.0008^{h}
Blackcurrant seed oil	2.4773 ± 0.0114^{c}	4.6271 ± 0.0011^{f}

Values (expressed as grams of KOH per kilogram of sample) represent mean ± standard deviation (n = 3). Different letters in superscript indicate significantly different ($p < 0.05$) results.

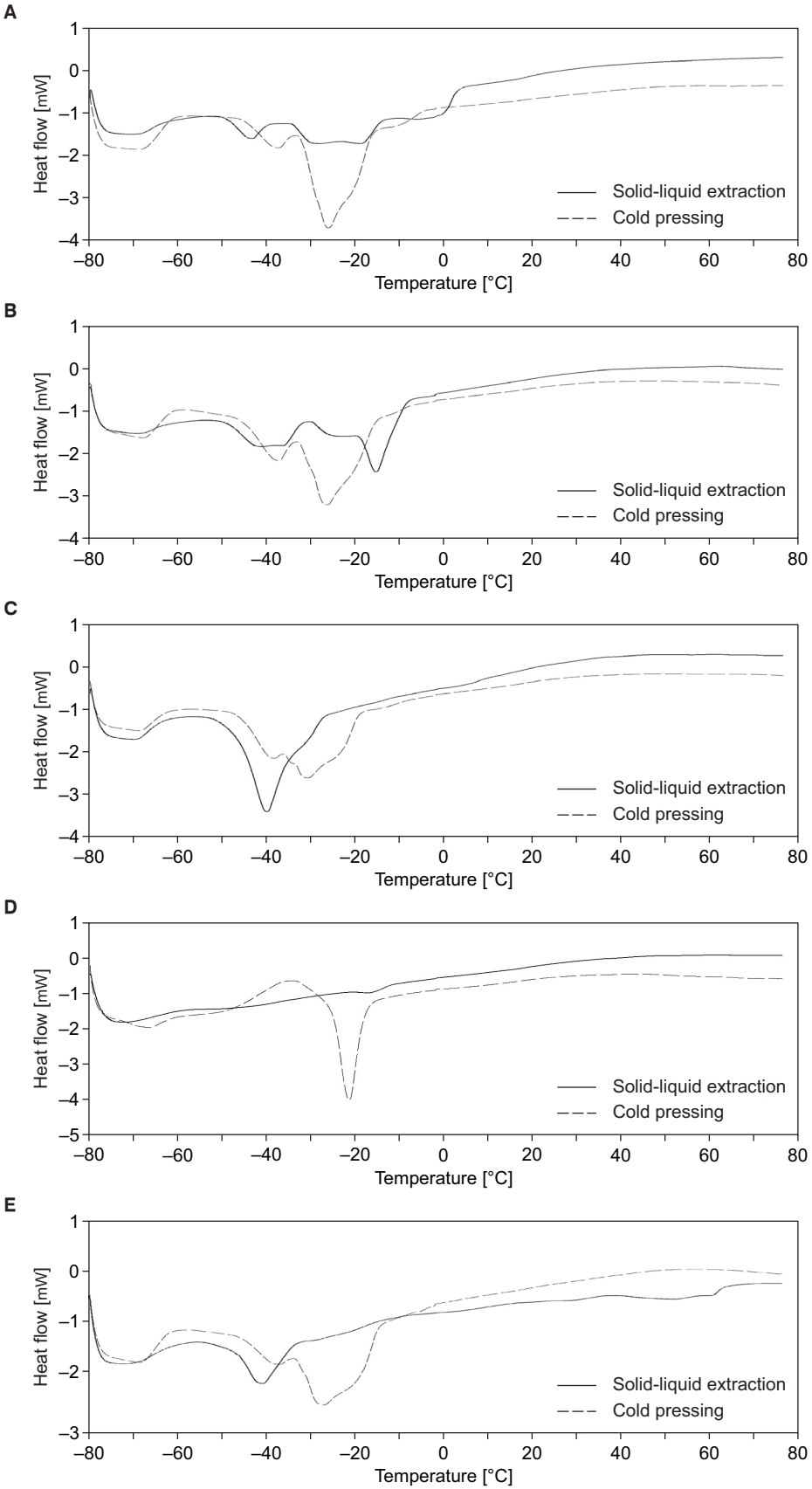

Fig. 2. Examples of differential scanning calorimetry curves for seed oils.

A – melon seed oil, B – grape seed oil, C – strawberry seed oil, D – pomegranate seed oil, E – blackcurrant seed oil.

seed oils obtained in cold pressing and solvent extraction exposed different courses of DSC melting curves [24]. Cold-pressed oil was characterized by a 3-peak DSC curve, while in the case of solvent extracted oil 2 melting peaks were observed. Their different behaviour was also explained by the varying profiles of triacylglycerol fractions in the samples.

Acid value

One of the chemical properties of oils indicating their quality and possible utilization as edible oil is acid value. It measures the free fatty acid content in oil samples [25]. Results for studied oils are summarized in Tab. 3. Referring to Codex Alimentarius [26], the threshold *AV* for cold-pressed oils is 4 g KOH per kilogram of oil. In the case of cold-pressed oils, melon seed oil and pomegranate seed oil exceed that value. Among hexane-extracted oil, only grape seed oil had acceptable *AV*. Generally, cold-pressed oils were characterized by lower *AV*. That is the opposite result to the results obtained by CHEN et al. [27]. In the cited study, cinnamon kernel oil extracted by mechanical pressing exposed higher *AV* than solvent-extracted oil. ZENG et al. [28] reported that *Camelia oleifera* C. Abel oils obtained through solvent extraction exhibited higher *AV* compared to those produced via cold pressing. This difference was attributed to the impact of elevated temperatures during extraction, which promoted peroxide formation and increased free fatty acid content. Additionally, the presence of impurities, including free fatty acids and hydrogen peroxides in solvent-extracted oil were suspected to contribute to deterioration in its overall quality.

Fatty acid profile

The fatty acid composition of blackcurrant, strawberry, grape, melon, and pomegranate seed oils varied significantly, with extraction method (cold pressing vs solid-liquid extraction) influencing their profiles (Tab. 4). All of the studied oils were PUFA-dominant, with pomegranate seed oil containing 54.8–83.6 % punicic acid and dominance of linoleic fatty acid (44.1–68.5 %) in the melon, grape, strawberry and blackcurrant seed oils. Obtained values of fatty acids stay in agreement with previously published results [6, 29–33].

Tab. 4. Fatty acid profile of studied fruit seed oils.

Fatty acid [%]	Melon seed oil		Grape seed oil		Strawberry seed oil		Pomegranate seed oil		Blackcurrant seed oil	
	CP	S/L	CP	S/L	CP	S/L	CP	S/L	CP	S/L
C16:0	8.7 ± 0.4	17.5 ± 1.2	7.7 ± 0.4	11.2 ± 0.7	5.7 ± 0.0	5.0 ± 0.2	4.6 ± 0.3	3.3 ± 0.3	6.7 ± 0.0	8.0 ± 0.2
C18:0	6.2 ± 0.2	11.0 ± 0.5	4.8 ± 0.1	4.0 ± 0.8	3.1 ± 0.0	1.8 ± 0.1	2.8 ± 0.1	2.4 ± 0.1	3.7 ± 0.0	1.9 ± 0.0
C18:1 n-9	28.7 ± 0.1	12.8 ± 0.3	27.9 ± 0.1	15.7 ± 0.6	25.1 ± 0.0	16.7 ± 0.1	14.3 ± 0.0	5.5 ± 0.2	31.8 ± 0.0	15.3 ± 0.1
C18:2 n-6	56.1 ± 0.1	58.5 ± 0.2	59.1 ± 0.2	68.5 ± 0.6	49.7 ± 0.0	45.2 ± 0.2	23.4 ± 0.6	5.2 ± 0.2	49.7 ± 0.1	44.1 ± 0.1
C18:3 n-6	nd	nd	nd	nd	nd	nd	nd	nd	3.2 ± 0.0	14.5 ± 0.0
C18:3 n-3	0.2 ± 0.0	0.1 ± 0.0	0.3 ± 0.0	0.5 ± 0.1	14.8 ± 0.0	29.4 ± 0.2	nd	nd	3.7 ± 0.0	12.9 ± 0.1
C18:3 n-5	nd	nd	nd	nd	nd	nd	54.8 ± 0.9	83.6 ± 0.7	nd	nd
C20:1	nd	nd	nd	nd	0.3 ± 0.0	0.3 ± 0.0	nd	nd	0.6 ± 0.0	2.8 ± 0.0
Other	0.1 ± 0.0	0.1 ± 0.0	0.2 ± 0.0	0.1 ± 0.0	1.5 ± 0.0	1.7 ± 0.0	nd	nd	0.5 ± 0.0	0.6 ± 0.0
Σ SFA	15.0 ± 0.2^{f}	28.5 ± 0.6^{g}	12.5 ± 0.3^{e}	15.2 ± 0.1^{f}	9.6 ± 0.0^{c}	7.9 ± 0.3^{b}	7.4 ± 0.2^{b}	5.7 ± 0.3^{a}	10.8 ± 0.0^{d}	10.2 ± 0.2^{cd}
Σ MUFA	28.8 ± 0.1^{i}	12.9 ± 0.3^{b}	28.1 ± 0.1^{h}	15.8 ± 0.6^{d}	25.5 ± 0.0^{g}	17.3 ± 0.1^{e}	14.3 ± 0.0^{c}	5.5 ± 0.2^{a}	32.5 ± 0.0^{j}	18.3 ± 0.0^{f}
Σ PUFA	56.3 ± 0.1^{a}	58.6 ± 0.2^{b}	59.4 ± 0.2^{b}	69.0 ± 0.6^{d}	65.0 ± 0.0^{c}	74.8 ± 0.4^{f}	78.2 ± 0.3^{g}	88.8 ± 0.5^{h}	56.7 ± 0.0^{a}	71.5 ± 0.2^{e}

Values represent mean ± standard deviation (n = 3). The sum of SFA, MUFA and PUFA were subjected to multifactor ANOVA analysis. The results with different letters in superscript in lines indicate significantly different groups of results ($p < 0.05$).
CP – cold-pressed; S/L – solid-liquid extraction; C16:0 – palmitic acid; C18:0 – stearic acid; C18:1 n-9 – oleic acid; C18:2 n-6 – linoleic acid; C18: 3 n-6 – γ-linolenic; C18: 3 n-3 – α-linolenic; C18: 3 n-5 – punicic acid; C20:1 – eicosenoic acid; Σ SFA – sum of saturated fatty acids; Σ MUFA – sum of monounsaturated fatty acids; Σ PUFA – sum of polyunsaturated fatty acids; nd – not detected.

Solid-liquid extraction enhanced PUFA yield in every sample, especially in blackcurrant (CP 56.7 %, S/L 71.5 %) seed oil, while cold pressing preserved higher monounsaturated fatty acid (MUFA) levels in all studied oils (e.g., melon CP 28.8 %, S/L 12.9 %). Thus, cold pressing is preferable for MUFA-rich oils, while solid-liquid extraction increases PUFA recovery. Also, saturated fatty acid (SFA) percentage share increased significantly solid-liquid extracted melon and grape seed oils. Similar results, where solvent extraction promoted PUFA extraction and cold pressing was more efficient in terms of MUFA level, were reported by KONUSKAN et al. [34] for grape seed oil. On the other hand, no differences in fatty acid profiles were noted between cold pressing and solvent extraction for safflower seed oil [35].

Oils rich in PUFA, such as linoleic and punicic acids, are generally more prone to oxidation due to the high number of double bonds, which serve as reactive sites for peroxidation. In this study, pomegranate seed oil, characterized by the highest PUFA content (up to 88.8 %), exhibited the lowest *OIT* and τ_{max}, confirming this susceptibility.

Accordingly, melon, blackcurrant and grape seed oil, which had the relatively lowest PUFA content among our samples, showed the highest *OIT* and τ_{max} values. Furthermore, melon, blackcurrant and grape seed oil had a comparable PUFA content between each other, but exhibited notable differences regarding oxidation time values *OIT* and τ_{max}. This observation can be attributed to varying percentage of MUFA and SFA, but can also be influenced by different contents of other components, such as co-extracted antioxidants (e.g. tocopherols or polyphenols), which may mitigate oxidative degradation. The observed pattern supports the understanding that fatty acid unsaturation level is a key determinant of oil stability, yet it can be modulated by the presence of natural antioxidants and extraction method.

Overall, pomegranate and strawberry seed oils are the most PUFA-rich, making them promising candidates for nutraceutical applications, while blackcurrant oil may serve as valuable MUFA source. The results highlight the potential of these seed oils as alternative lipid sources with distinct nutritional benefits

CONCLUSIONS

This study confirms that fruit seed oils derived from blackcurrant, strawberry, melon, pomegranate, and grape seeds exhibit promising functional and nutritional properties, which are significantly influenced by the extraction method. Solid-liquid extraction, compared to cold pressing, generally enhanced oxidative stability and PUFA yield, likely due to the co-extraction of antioxidant compounds. These findings are particularly relevant for the food, nutraceutical, and cosmetic industries, where oxidative resistance and fatty acid composition are critical for product shelf life, formulation stability, and health-promoting claims.

From a practical standpoint, melon and blackcurrant seed oils, when extracted by solid-liquid methods, showed enhanced oxidative stability, making them suitable for applications in products with extended storage requirements. Pomegranate seed oil, rich in punicic acid, is of particular interest for nutraceutical formulations. Blackcurrant seed oil with higher MUFA content in cold-pressed form, may offer advantages in culinary applications where mild flavour and oxidative resistance are desired. However, the study has certain limitations. It focused solely on selected physicochemical parameters, without detailed analysis of individual antioxidant compounds or sensory quality. Moreover, commercially sourced cold-pressed oils may have undergone uncontrolled processing conditions, affecting comparability. Further research should address these gaps, including refining strategies, bioactive content characterization, and application-specific performance testing, to better define industrial relevance and consumer acceptance.

Acknowledgements

Research equipment was purchased as part of the "Food and Nutrition Centre – modernisation of the WULS campus to create a Food and Nutrition Research and Development Centre (CŻiŻ)" co-financed by the European Union from the European Regional Development Fund under the Regional Operational Programme of the Mazowieckie Voivodeship for 2014-2020 (Project No. RPMA.01.01.00-14-8276/17).

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Received 14 May 2025; 1st revised 18 July 2025; accepted 18 August 2025; published online 25 August 2025.