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COMPARATIVE GC-MS ANALYSIS OF HIGH-VALUE SEED OILS: EVALUATING BIOFUEL VS. NUTRITIONAL POTENTIAL

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Abstract
This study presents a systematic meta-analysis of the chemical profiles of high-value seed oils derived from flax, sunflower, and chia seeds. Utilizing data synthesized from recent peer-reviewed literature (2021-2025) via Gas Chromatography-Mass Spectrometry (GC-MS), we compare how different extraction techniques impact the concentration of fatty acids. Our findings highlight that while sunflower oil is best suited for biofuel due to its moderate saturation, chia and flax oils offer superior nutritional value due to their high Omega-3 content.
Keywords
Flax seed oil, sunflower oil, chia seed oil, GC-MS, fatty acids, biofuel, nutrition

СРАВНИТЕЛЬНЫЙ ГХ-МС АНАЛИЗ ВЫСОКОЦЕННЫХ РАСТИТЕЛЬНЫХ МАСЕЛ: ОЦЕНКА ПОТЕНЦИАЛА ДЛЯ БИОТОПЛИВА И ПИТАНИЯ

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Аннотация
В данном исследовании представлен систематический мета-анализ химических профилей ценных растительных масел, полученных из семян льна, подсолнечника и чиа. Используя данные, синтезированные из последних рецензируемых научных работ (2021-2025 гг.) с помощью газовой хроматографии-масс-спектрометрии (ГХ-МС), мы сравниваем, как различные методы экстракции влияют на концентрацию жирных кислот. Наши результаты показывают, что подсолнечное масло лучше всего подходит для биотоплива благодаря умеренному насыщению, в то время как масла чиа и льна обладают превосходной питательной ценностью из-за высокого содержания Омега-3.
Ключевые слова
Льняное масло, подсолнечное масло, масло чиа, ГХ-МС, жирные кислоты, биотопливо, питание

The global demand for sustainable sources of high-value lipids for both nutritional and industrial applications present a significant challenge, as traditional sourcing often involves resource-intensive agriculture. A meta-analysis approach allows for a critique of existing extraction methods and final product utility without generating new waste or consuming lab resources. This study synthesizes GC-MS data from recent literature (2021-2025) to compare the potential of three distinct seed oils for biofuel versus nutritional use. Previous studies often focus

on single oil types; however, this comparative approach provides a broader blueprint for the circular economy, identifying how chemical "fingerprints" dictate industrial utility.

The primary issue addressed is the categorization of flax, sunflower, and chia oils based on their specific fatty acid profiles as determined by GC-MS. Recent GC-MS studies (2023-2025) for flaxseed oil identify oleic acid (approx. 43.72%) and various volatile esters as key markers, while germination-focused research recognizes up to 68 volatile compounds, highlighting a matrix consistently rich in alpha-linolenic and linoleic acids [1–2]. Volatile profiling of sunflower oils across various commercial and industrial processing units reveals a dominance of linoleic acid (approx. 55–70%) and oleic acid (20–35%). Microwave-assisted enzymatic treatments of sunflower seeds show that while processing induces minor changes, the triglyceride matrix remains stable, supporting its industrial viability [3–4]. Finally, GC-MS data for chia oil consistently identifies alpha-linolenic acid as the predominant fatty acid (approx. 60–65%). While this makes the oil an excellent nutritional source, the high Polyunsaturated Fatty Acid (PUFA) content results in poor oxidative stability, which is a critical factor for storage and industrial processing [5].

Our analysis confirms that for biofuel applications, sunflower seed oil is the optimal candidate due to its moderate saturation, providing a balance between cold-flow properties and oxidative stability. Conversely, flax and chia oils are less suitable for long-term fuel storage as they oxidize rapidly due to their high omega-3 content. For nutritional use, chia and flax oils provide superior potential due to their high alpha-linolenic acid content, offering a favorable omega-3/omega-6 balance for human health.

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