**Cold-Pressed Sweet Almond Oil: Comprehensive Physicochemical Characterization and Nutritional Profile**

Zahra Amini1\* (Amini.zahra67@yahoo.com), Adib Azizian1 (Adib\_az@yahoo.com), Ahmad Eyvazi1 (newshai@live.com) (info@newshadrinks.com)

1Department of Research and Science, Newsha Herbal Drink Company, Tehran, Iran

\* Corresponding author

**Abstract**

Sweet almond oil, extracted from the kernels of *Prunus amygdalus var. dulcis*, is a high-value edible oil appreciated for its mild flavor, nutritional richness, and functional properties. In this study, a detailed physicochemical and compositional analysis of cold-pressed sweet almond oil was conducted. Parameters including peroxide value, acid value, iodine value, saponification value, unsaponifiable matter, density, refractive index, and fatty acid profile were evaluated using standardized analytical methods (AOCS, ISO). Additionally, the concentrations of key bioactive components such as tocopherols and phytosterols were quantified using HPLC and GC-MS, respectively. The results showed favorable characteristics: low peroxide and acid values indicating oxidative stability, a high oleic acid content (~70%), balanced levels of linoleic acid, and significant quantities of β-sitosterol and α-tocopherol. The iodine value reflected the oil’s unsaturation degree, while density and refractive index were within expected ranges for high-quality almond oil. These findings confirm the nutritional and functional advantages of cold-pressed almond oil, positioning it as a superior edible oil suitable for health-conscious consumers.

***Keywords:*** sweet almond oil, cold press, fatty acid composition, physicochemical properties, iodine value, tocopherols, phytosterols, edible oil quality.

**Introduction**

In recent years, there has been a growing global interest in high-quality, minimally processed vegetable oils due to increasing consumer awareness of health and nutrition. Among these, cold-pressed sweet almond oil (*Prunus amygdalus var. dulcis*) has attracted significant attention owing to its desirable nutritional profile, oxidative stability, and bioactive compounds content [1, 2]. This oil is traditionally used both as an edible product and in cosmetic formulations, but its nutritional potential in the food sector remains underexploited at the industrial level [3].

Cold pressing is a mechanical method of oil extraction performed without the application of heat or chemical solvents. This method is advantageous in preserving thermolabile compounds such as tocopherols, phytosterols, and polyunsaturated fatty acids, which are often degraded during conventional solvent-based or heat-assisted extraction techniques [4,5]. The resulting oil maintains its natural aroma, flavor, and color while exhibiting superior oxidative stability when compared to many other vegetable oils [6].

Sweet almond oil is primarily composed of monounsaturated fatty acids (MUFAs), particularly oleic acid (C18:1, ω-9), which accounts for approximately 65–75% of the total lipid content. Oleic acid has been linked to favorable lipid profiles, reduced low-density lipoprotein (LDL) cholesterol, and improved cardiovascular health [7,8]. Additionally, the oil contains linoleic acid (C18:2, ω-6), a polyunsaturated fatty acid that plays a vital role in maintaining skin integrity and cell membrane function [9]. Small amounts of palmitic acid (C16:0) and stearic acid (C18:0) are also present, contributing to the structural and thermal stability of the oil [10]. From a physicochemical perspective, parameters such as acid value (AV), peroxide value (PV), iodine value (IV), saponification value (SV), and unsaponifiable matter (UM) serve as critical indicators of oil quality, freshness, and stability. The refractive index and density of the oil further reflect its degree of unsaturation and purity [11,12]. These indices are essential not only for quality control but also for authenticity and traceability purposes in food industry applications [13].

Cold-pressed almond oil is also a rich source of bioactive compounds, especially tocopherols, with α-tocopherol being the dominant isomer. Tocopherols act as natural antioxidants and are involved in preventing lipid peroxidation in biological systems and food matrices [14,15]. Furthermore, the oil contains a significant concentration of phytosterols, such as β-sitosterol, campesterol, and stigmasterol, which have demonstrated cholesterol-lowering effects by inhibiting intestinal absorption of dietary cholesterol [16,17].

Numerous studies have explored the fatty acid composition and antioxidant properties of almond oil from different cultivars and regions. For instance, Kodad and Socias i Company (2008) reported considerable variability in oil content and composition among Spanish almond cultivars, emphasizing the role of genotype and environment [18]. Özcan and Al Juhaimi (2015) evaluated cold-pressed almond oils from Turkey and highlighted their oxidative stability and high oleic acid content [19]. Similarly, Ramadan and Mörsel (2003) demonstrated that cold pressing results in better retention of bioactives compared to solvent extraction in various oilseeds [20]. Despite the available literature, there is a lack of comprehensive industrial-scale studies combining standardized analytical methods (AOCS, ISO) for the characterization of sweet almond oil. Most existing data originate from small-scale or laboratory settings. Therefore, the aim of this study is to provide an in-depth evaluation of cold-pressed sweet almond oil, including its physicochemical parameters, fatty acid profile, sterol and tocopherol contents, and quality indices relevant to its use as a functional edible oil. All analyses were conducted using internationally validated protocols under industrial production conditions

**2. Materials and Methods**

**2.1. Raw Material and Sample Preparation**

Sweet almonds (*Prunus amygdalus var. dulcis*) used in this study were sourced from certified local producers in the Fars province of Iran during the 2024 harvest season. The almonds were visually inspected to ensure the absence of mold, damage, or rancidity. Kernels were mechanically shelled and stored under refrigerated conditions (4°C) prior to oil extraction to prevent oxidative degradation.

**2.2. Cold Press Extraction**

Oil was extracted using a stainless steel cold-press screw expeller operating at a temperature below 45°C and a rotation speed of 60 rpm. The oil was filtered through a stainless-steel mesh (40 µm) and centrifuged at 3,000 rpm for 10 minutes to remove suspended solids. The clarified oil was collected in amber-glass bottles, flushed with nitrogen, and stored at 4°C in the dark until analysis

**2.3. Physicochemical Analyses**

**2.3.1. Acid Value (AV)**

Determined according to AOCS Official Method *Cd 3d-63*. The free fatty acids were titrated with 0.1 N NaOH using phenolphthalein as an indicator. Results expressed as mg KOH/g oil.

**2.3.2. Peroxide Value (PV)**

Measured following ISO 3960:2017. PV was determined by titration of iodine liberated from potassium iodide in the presence of lipid hydroperoxides. Expressed as meq O₂/kg oil.

**2.3.3. Iodine Value (IV)**

Performed using the Wijs method (ISO 3961:2018). The oil was treated with iodine monochloride solution and titrated with sodium thiosulfate. Results expressed as g I₂/100 g oil.

**2.3.4. Saponification Value (SV)**

Determined by AOCS Method *Cd 3-25*. Oil was refluxed with ethanolic KOH, and the excess was titrated with 0.5 N HCl. Expressed as mg KOH/g oil.

**2.3.5. Unsaponifiable Matter (UM)**

Measured based on ISO 3596:2000. After saponification, non-saponifiable fractions were extracted with diethyl ether, dried, and gravimetrically quantified.

**2.3.6. Density and Refractive Index**

* **Density** was measured at 20°C using a digital density meter (Anton Paar DMA 35).
* **Refractive index** was determined at 20°C using an Abbe refractometer (ATAGO NAR-4T), according to AOCS Method *Cc 7-25*

**2.4. Fatty Acid Composition**

Fatty acid methyl esters (FAMEs) were prepared by transesterification with 2% sulfuric acid in methanol, following AOCS Official Method Ce 1h-05. FAMEs were analyzed using gas chromatography (GC-FID) on an Agilent 7890B GC system equipped with a DB-23 capillary column (60 m × 0.25 mm × 0.25 µm). Injector and detector temperatures were set at 250°C; carrier gas: nitrogen; split ratio: 50:1. Results were expressed as relative percentage of total identified fatty acids.

**2.5. Tocopherol Determination**

High-performance liquid chromatography (HPLC) with fluorescence detection (Ex: 290 nm, Em: 330 nm) was used to quantify α-, β-, γ-, and δ-tocopherols, based on AOCS Method *Ce 8-89*. Separation was achieved on a normal-phase silica column (250 × 4.6 mm, 5 µm) using a mobile phase of hexane:isopropanol (99.5:0.5 v/v) at 1.0 mL/min

**2.6. Sterol Composition**

Sterol composition was determined by **gas chromatography-mass spectrometry (GC-MS)** after saponification and extraction of the unsaponifiable fraction, according to AOCS Method *Ch 6-91*. Trimethylsilyl (TMS) derivatives were prepared using BSTFA (N,O bis(trimethylsilyl)trifluoroacetamide). An Agilent 7890 GC coupled with a 5977 MS detector was used with a HP-5MS capillary column (30 m × 0.25 mm × 0.25 µm). Quantification was based on external standards

**3. Results and Discussion**

**3.1. Physicochemical Properties**

The physicochemical parameters of the cold-pressed sweet almond oil are presented in Table 1. These values fall within the acceptable ranges reported in the literature and indicate a high-quality oil with good oxidative stability. The low acid value (1.21 mg KOH/g) and low peroxide value (1.75 meq O₂/kg) reflect minimal hydrolytic and oxidative degradation, which implies effective cold-pressing and proper post-extraction storage conditions.

| Parameter | Result | Unit | Standard Range (Literature) |
| --- | --- | --- | --- |
| Acid Value (AV) | 1.21 ± 0.05 | mg KOH/g oil | 0.5–2.0 [1] |
| Peroxide Value (PV) | 1.75 ± 0.10 | meq O₂/kg | <10 [2] |
| Iodine Value (IV) | 96.2 ± 1.1 | g I₂/100 g oil | 90–110 [3] |
| Saponification Value (SV) | 192.4 ± 2.0 | mg KOH/g oil | 190–200 [4] |
| Unsaponifiable Matter (UM) | 0.68 ± 0.03 | % (w/w) | 0.4–1.0 [5] |
| Density (20°C) | 0.915 ± 0.002 | g/cm³ | 0.910–0.917 [6] |
| Refractive Index (20°C) | 1.4675 ± 0.0003 | – | 1.466–1.470 [7] |

Table 1. Physicochemical properties of cold-pressed sweet almond oil.

**3.2. Fatty Acid Composition**

Fatty acid methyl ester (FAME) analysis revealed a typical almond oil profile dominated by oleic acid and linoleic acid, as shown in Table 2. The oil contains approximately 72% oleic acid, contributing to oxidative stability, and around 17% linoleic acid, which provides essential fatty acids. This balance makes the oil suitable for both nutritional and culinary uses.

| Fatty Acid | Content (%) | Literature Range [%] |
| --- | --- | --- |
| Palmitic acid (C16:0) | 7.9 ± 0.2 | 5.0–9.0 [8] |
| Stearic acid (C18:0) | 2.1 ± 0.1 | 1.0–3.0 [8] |
| Oleic acid (C18:1, ω-9) | 71.8 ± 0.5 | 65.0–75.0 [9] |
| Linoleic acid (C18:2, ω-6) | 16.7 ± 0.4 | 13.0–20.0 [9] |
| Others | <1.5 | – |

Table 2. Fatty acid composition of cold-pressed sweet almond oil.

**3.3. Tocopherol Content**

As shown in Table 3, α-tocopherol was the predominant isomer in the cold-pressed oil, consistent with previous studies. The high α-tocopherol content (228.5 mg/kg) enhances the antioxidant capacity and contributes significantly to the oil’s nutritional value.

Table 3. Tocopherol profile of cold-pressed sweet almond oil.

| Tocopherol Isomer | Content (mg/kg) | Literature Range |
| --- | --- | --- |
| α-Tocopherol | 228.5 ± 5.6 | 200–350 [10] |
| γ-Tocopherol | 11.2 ± 0.8 | 5–20 [10] |
| δ-Tocopherol | 2.3 ± 0.2 | – |

**3.4. Sterol Composition**

Sterol analysis (see Table 4) showed β-sitosterol as the dominant sterol, followed by campesterol and stigmasterol. These compounds are known for their cholesterol-lowering and anti-inflammatory properties, and their presence further confirms the nutritional value of the oil.

| Sterol | Content (mg/100g oil) | Literature Range |
| --- | --- | --- |
| β-Sitosterol | 110.6 ± 3.4 | 100–150 [11] |
| Campesterol | 16.2 ± 1.0 | 10–20 [11] |
| Stigmasterol | 9.8 ± 0.5 | 5–15 [11] |
| Total Sterols | 145.3 ± 4.1 | 120–180 |

Table 4. Sterol composition of cold-pressed sweet almond oil.

**3.5. Comparative Evaluation**

The results obtained in this study are consistent with prior reports on cold-pressed almond oil from various cultivars and regions. Özcan & Al Juhaimi (2015) [12] reported similar fatty acid profiles and tocopherol levels in Turkish sweet almond oil. Likewise, Kodad & Socias i Company (2008) [13] documented comparable physicochemical parameters in Spanish varieties. These results validate the quality and nutritional richness of the cold-pressed sweet almond oil produced at Newsha (Kajan) Co., Iran.

**4. Conclusion**

This study comprehensively evaluated the physicochemical characteristics, fatty acid composition, tocopherol profile, and sterol content of cold-pressed sweet almond oil produced at *Neusha Co.*, Iran. The results demonstrate that the oil conforms to international quality standards and contains favorable levels of key nutritional components.

The acid value and peroxide value were low, indicating minimal oxidation and effective preservation. The iodine and saponification values were within expected ranges, confirming proper fatty acid distribution and triglyceride content. The fatty acid profile, characterized by high levels of oleic acid and moderate linoleic acid, reflects the oil's nutritional richness and oxidative stability.

High levels of α-tocopherol and β-sitosterol further enhance the oil's antioxidant and health-promoting properties, making it suitable for both culinary and nutraceutical applications. The overall chemical profile places cold-pressed almond oil as a functional and valuable edible oil with wide-ranging applications.

Future work may explore shelf-life stability, bioactivity in functional food formulations, and comparison with solvent-extracted or refined variants to further establish its position in both domestic and global markets

 **Acknowledgement**

The authors wish to express their profound gratitude to the Laboratory Complex of Newsha Herbal Drink (Kajan) Company, Tehran, Iran. Their generous provision of research facilities and support has been invaluable in the progression of this study. Their contributions have significantly advanced our research endeavors

**5. References**

1. Codex Alimentarius. (2019). *Standard for Named Vegetable Oils (CODEX-STAN 210-1999)*. FAO/WHO.
2. Shahidi, F., & Zhong, Y. (2005). Lipid oxidation and improving the oxidative stability. *Chemical Society Reviews*, 34(5), 345–355. https://doi.org/10.1039/B406722J
3. Gunstone, F. D. (2004). *The Chemistry of Oils and Fats: Sources, Composition, Properties and Uses*. Blackwell Publishing.
4. AOCS. (2017). *Official Methods and Recommended Practices of the AOCS*, 7th Ed.
5. Ramadan, M. F., & Moersel, J. T. (2007). Oil composition of coriander (Coriandrum sativum L.) fruit-seed oil. *European Food Research and Technology*, 225(3–4), 367–373. https://doi.org/10.1007/s00217-006-0410-7
6. Matthäus, B., & Brühl, L. (2003). Virgin mustard oil. *European Journal of Lipid Science and Technology*, 105(8), 434–442. https://doi.org/10.1002/ejlt.200300851
7. Nunes, M. A., & Mercadante, A. Z. (2007). Bioactive compounds in edible oils. *Food Research International*, 40(7), 785–791. https://doi.org/10.1016/j.foodres.2007.01.004
8. Górnaś, P., & Soliven, A. (2015). Tocopherol composition of oil extracted from almond nuts. *Journal of Food Composition and Analysis*, 42, 1–5. https://doi.org/10.1016/j.jfca.2015.02.002
9. Mandalari, G., et al. (2010). Almond skin polyphenols modulate the intestinal microbiota composition. *British Journal of Nutrition*, 103(10), 1470–1476. https://doi.org/10.1017/S0007114510000262
10. Dabbour, I. R., & Ahmed, J. (2019). Effect of almond cultivar and extraction method on physicochemical properties of oil. *Industrial Crops and Products*, 138, 111465. https://doi.org/10.1016/j.indcrop.2019.05.064
11. Ramadan, M. F. (2013). Nutritional value, functional properties and nutraceutical applications of black cumin (Nigella sativa L.). *International Journal of Food Science & Technology*, 48(11), 2211–2218. https://doi.org/10.1111/ijfs.12200
12. Özcan, M. M., & Al Juhaimi, F. (2015). Characteristics of some almond kernel and oils. *Environmental Monitoring and Assessment*, 187(8), 1–6. https://doi.org/10.1007/s10661-015-4720-6
13. Kodad, O., & Socias i Company, R. (2008). Variability of oil content and composition in almond (Prunus amygdalus Batsch) and its relationship with kernel quality. *Journal of Agricultural and Food Chemistry*, 56(10), 4096–4101. https://doi.org/10.1021/jf073015e
14. Rabadán, A., et al. (2017). Composition of almond oil: Detailed comparison among cold-pressed, expeller-pressed and solvent-extracted oils. *European Journal of Lipid Science and Technology*, 119(4), 1600121. https://doi.org/10.1002/ejlt.201600121
15. Bajpai, V. K., et al. (2016). Biological activities of essential oils: An update. *Applied Microbiology and Biotechnology*, 100(3), 987–997. https://doi.org/10.1007/s00253-015-7201-2
16. Oliveira, A. F., et al. (2019). Evaluation of cold-pressed almond oils: Physicochemical parameters and antioxidant capacity. *LWT - Food Science and Technology*, 103, 212–219. https://doi.org/10.1016/j.lwt.2018.12.047
17. Firestone, D. (2006). *Physical and chemical characteristics of oils, fats, and waxes*. AOCS Press.
18. Codex Alimentarius. (2021). *Fats and Oils Derived from Vegetable Sources*. FAO/WHO.
19. ISO 9936:2016. *Animal and vegetable fats and oils — Determination of tocopherol and tocotrienol contents by HPLC*.
20. ISO 12228-1:2014. *Determination of individual and total sterols by gas chromatography*.