

Grape Seed Oil: A Sustainable Opportunity for Biomass Valorisation in the Agri-Food Sector

Grape seed oil, a by-product of the winemaking industry, represents a promising example of biomass valorisation. Traditionally discarded, grape seeds have gained attention due to their valuable oil content, which has numerous applications in the food, cosmetic, and pharmaceutical industries. Within the framework of the B-Resilient project, which seeks to enhance the resilience of food-producing and processing SMEs through sustainable and digitalised value chains, the utilisation of grape seed oil aligns perfectly with the goals of the circular economy and sustainability.

The Extraction of Grape Seed Oil

Grape seed oil is extracted through several methods, each impacting its quality, yield, and environmental footprint. Cold pressing is one of the most widely used methods, as it preserves the oil's nutritional profile without involving heat or chemicals. The resulting oil retains a high level of antioxidants and polyphenols, making it ideal for health-conscious consumers. While cold pressing is favoured for its natural preservation of nutrients, it typically results in lower yields compared to other methods.

Solvent extraction is another common technique. It involves the use of solvents like hexane to increase the yield of oil extracted from the seeds. Although this method is highly efficient, it may leave chemical residues and can diminish some of the beneficial compounds in the oil. For this reason, solvent-extracted oils are often refined to remove any unwanted residues, but this can compromise the nutritional integrity of the final product.

Supercritical CO₂ extraction represents the most advanced technique for extracting grape seed oil. It uses carbon dioxide at high pressure and temperature to extract the oil, ensuring high purity and the preservation of beneficial compounds. This method is environmentally friendly and free of chemical residues, but it requires specialised equipment and is more costly than traditional extraction techniques. The balance between cost, efficiency, and nutritional quality remains a key consideration for producers.

Nutritional Composition and Health Benefits

Grape seed oil is particularly valued for its high polyunsaturated fatty acid (PUFA) content, with linoleic acid making up approximately 70% of its fatty acid profile. Linoleic acid is essential for human health, playing a role in maintaining cardiovascular health

and reducing inflammation. Research has shown that diets rich in linoleic acid can help lower LDL cholesterol levels, reducing the risk of heart disease.

In addition to linoleic acid, grape seed oil contains a variety of phenolic compounds, such as flavonoids and tannins, which have strong antioxidant properties. Antioxidants help combat oxidative stress and reduce the damage caused by free radicals, contributing to improved cellular health and reduced inflammation. Vitamin E is another key component of grape seed oil, known for its role in promoting skin health and supporting immune function. The oil's resveratrol content further enhances its health benefits, as this polyphenol has been linked to anti-aging properties and improved cardiovascular function.

The combination of these bioactive compounds makes grape seed oil a valuable ingredient in both dietary and nutraceutical applications. Its light texture and mild flavour make it suitable for cooking, while its high antioxidant content positions it as a beneficial supplement for improving overall health.

Industrial and Commercial Applications

The versatility of grape seed oil extends across multiple industries, making it a highly sought-after ingredient in both food and non-food sectors. In the food industry, grape seed oil's neutral flavour and high smoke point (216°C) make it ideal for a wide range of culinary uses. It is commonly used in salad dressings, mayonnaise, and baking as a healthier alternative to traditional vegetable oils.

In the cosmetics industry, grape seed oil's antioxidant and antimicrobial properties have made it a popular ingredient in skincare and haircare products. It is frequently used in moisturisers and lotions to improve skin elasticity and hydration. Its light texture allows it to be easily absorbed without leaving a greasy residue, making it ideal for massage oils and anti-aging products.

Pharmaceutical and health industries have also recognised the potential of grape seed oil. Its cardiovascular benefits, attributed to its high linoleic acid and antioxidant content, have led to its inclusion in dietary supplements designed to promote heart health and reduce inflammation. Furthermore, its regenerative properties are being explored for wound healing and dermatological treatments.

Beyond food and personal care, grape seed oil is finding new applications in bio-based materials and energy production. Research is being conducted into its potential use as a feedstock for biodiesel production, offering a renewable alternative to petroleum-based fuels. The oil's chemical properties also make it suitable for the production of

bioplastics and bio-lubricants, contributing to the development of sustainable industrial products.

Grape Seed Oil in La Rioja, Spain

La Rioja, one of Spain's most renowned winemaking regions, is pioneering sustainable initiatives within the viticulture industry. As outlined in the *Guía de Buenas Prácticas en Economía Circular. Proyecto Enorregión*, local wineries and research institutions are increasingly focusing on the valorisation of grape by-products, including grape seed oil.

One notable example is the recovery of tartrates and the extraction of grape seed oil from pomace. Several wineries in La Rioja have incorporated these processes into their sustainability efforts, reducing waste and creating high-value products. Additionally, initiatives such as cosmetic applications of grape-derived antioxidants are gaining momentum, leveraging the region's expertise in viticulture to develop new economic opportunities.

By integrating circular economy principles, La Rioja's wineries are demonstrating how traditional industries can embrace innovation to enhance sustainability while maintaining economic viability.

Sustainability and Circular Economy

The integration of grape seed oil into commercial markets contributes to a circular economy by reducing waste in the wine industry. Instead of being discarded, grape seeds are processed into valuable oil and secondary products, maximising resource efficiency and minimising environmental impact. This aligns with the objectives of the B-Resilient project, which aims to support SMEs in adopting more sustainable business models.

By adopting grape seed oil production, SMEs in the agri-food sector can diversify revenue streams, reduce waste management costs, and align with EU sustainability goals. The development of eco-friendly extraction methods and the expansion of commercial applications for grape seed oil are driving innovation in the industry, highlighting the importance of sustainable practices.

Challenges and Future Outlook

Despite its benefits, the production and commercialisation of grape seed oil face several challenges. Cold pressing and supercritical CO₂ extraction are costly compared to solvent methods, posing a barrier for small producers. Market competition from well-established vegetable oils like olive and sunflower oil further complicates the market positioning of grape seed oil. Moreover, consumer awareness of grape seed oil's

benefits remains limited, suggesting a need for greater educational and marketing efforts.

Future research and innovation in cost-effective extraction techniques and new product applications could expand the market potential of grape seed oil. Increasing consumer demand for natural and functional ingredients presents an opportunity for grape seed oil to establish itself as a key player in the sustainable agri-food sector.

Conclusion

Grape seed oil exemplifies the principles of biomass valorisation, offering a sustainable, high-value application for a common by-product of the wine industry. Its nutritional benefits, diverse applications, and alignment with circular economy principles make it an ideal candidate for the B-Resilient project's mission. Encouraging its adoption can lead to economic and environmental benefits, reinforcing the role of SMEs in driving green and digitalised value chains.

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