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REVIEW ARTICLE

Efficacy mechanisms research progress of the active components in the characteristic woody edible oils

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Abstract

Woody edible oils are a type of vegetable oil. Woody edible oils like olive oil have greater quantities of unsaturated fatty acids (UFAs), particularly essential FAs, as well as vitamin E, phytosterols, and other nutrients that are becoming more vital in human health. As a result, finding high-quality woody oil resource plants is critical to ensuring enough edible oil supply. As six novel woody crops, *Paeonia suffruticosa*, *Plukenetia volubilis*, *Acer truncatum*, *Olea europaea*, *Camellia sinensis*, and *Camellia oleifera* are characterized by high oil production, widespread cultivation, adaptability, and various active ingredients. The six woody crop oils contain UFAs (e.g., α-linolenic acid, oleic acid, and linoleic acid), vitamin E, polyphenols, phytosterols, and so forth. The presence of these active ingredients confers anti-inflammatory, antioxidant, cholesterol and lipid metabolism regulating, blood lipid lowering, immune boosting, memory improving, intestinal flora regulating, and other properties to the oils, which are beneficial to body health. This article examined in depth the seed resources, FA composition, active component kinds, active ingredient efficacy mechanism, and physiological impacts of these six novel woody crop oils. These developments lay a solid platform for further study and development of these woody oil crops.

Lili Xu and Wei Wang contributed equally to this study.

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active ingredient, woody oils, physiological effects, unsaturated fatty acid

1 | INTRODUCTION

Woody edible oils are extracted from the seeds or fruits of woody oil plants (such as *Paeonia suffruticosa*, *Plukenetia volubilis*, *Acer truncatum*, *Olea europaea*, *Camellia sinensis*, and *Camellia oleifera*). Its primary constituents are esters produced from straight-chain higher fatty acids (FAs) and glycerol. Woody oil plants with stiff stems are commonly grown in the central subtropics and the southern part of Asia due to their inexpensive investment, broad dispersion, high yield, and flexibility. By 2020, there are 154 woody oil crops with fat generated from seeds or fruits that have more than 40% fat (Wang et al., 2022). Woody oils have more unsaturated FA (UFA) content and nutritional value.

Peonies (*P. suffruticosa*) have long been known as traditional ornamental plants, cultivated in China, Europe, America, and other places. Besides ornamental value, peony seed oil (PSO) is rich in UFAs, amino acids, and other nutrients. The average annual yield of peony seeds can reach 3750 kg/ha (Yang et al., 2017). *P. volubilis* (Euphorbiaceae) is an underutilized oilseed crop native to the Amazon Basin. Its seeds contain about 22%–30% protein and 45%–50% lipids (rich in α-linolenic [ALA] and linoleic acids [LA]). Due to its excellent nutritional profile and good agronomic properties, it has attracted increasing attention in recent years and is being grown more widely, with many potential applications in food, cosmetics, and medicine (Kodahl & Sørensen, 2021). *A. truncatum* Bunge is a versatile oil-producing woody species. It is widely distributed in northern China, Japan, and Korea. *A. truncatum* seed oil (ATSO) is composed mainly of oleic acid, LA, and nervonic acid, and other UFAs. In 2011, *A. truncatum* seed oil was approved as a new food resource by the Ministry of Health of the People's Republic of China, with significant implications for the food and pharmaceutical sectors (Ma et al., 2020). The olive (*O. europaea* L.) originated in the Mediterranean region for more than 5000 years and is now extensively distributed in other places. Olive oil (OO) is rich in the UFA oleic acid and LA. Homer described OO as "liquid gold," due to its nutritional content and unique flavors (Guo et al., 2018). Tea (*C. sinensis*) had long been known as a traditional plant that uses leaves and is grown in China, India, and other places. Besides the value of leaves, tea seed oil was approved as a new resource food by the Ministry of Health of China in 2009. Tea seed oil has received prominent attention due to its abundant functional ingredients, such as UFAs, phenols, and vitamin E, which could play a role in scavenging free radicals and reducing the risk of cardiovascular disease (Scicchitano et al., 2014; Zhenggang et al., 2021). In China alone, the average tea seed yield has reached 525 kg/ha. In 2019, the tea seed production from commercial plantations reached 1600,000 tons (Qian et al., 2021). Other than that, tea seeds have a large amount of saponins (Kim et al., 2015). Taken together, tea seed oil is not only healthy edible oil with health functions but also has significant value and potential as an industrial raw material. *C. oleifera* seed oil (CSO) contains up to 90% UFAs, mainly oleic acid and LA. In recent years, as the functional properties of *C. oleifera* oil have gradually become known to the public, it has spread widely around the world. It is favored by consumers not only as an edible oil but also for cosmetic and medicinal purposes (Zhu et al., 2020).

P. suffruticosa, *P. volubilis*, *A. truncatum*, *O. europaea*, *C. sinensis*, and *C. oleifera* are six developing woody oil crops with high growth potential. This review looked at the germplasm resources of these six woody oils, as well as the FA composition, active ingredient efficacy mechanisms, and physiological effects of extracted oils from seeds or fruits, in order to provide some context for the utilization and development of these six woody oil crops.

2 | OVERVIEW OF GERMPLASM RESOURCES IN SIX WOODY OILSEED CROPS

The tree peony (Paeoniaceae) originated in western China and was later brought to Japan and other Asian countries, as well as North America and Europe (Gao et al., 2018; He et al., 2019). The tree peony has a star-shaped pod that contains some suborbicular seeds. The seeds are high in UFAs. Peonies come in various types, including Ziban (*Paeonia rockii*), Fengdan (*Paeonia ostii*), Caidiefeiwu, Chunrishan, Huadachen, Daonaiteng, Yupantuojin, Daodachen, Sanduihuang, Beiyangfen (*P. suffruticosa*), and others (Liu et al., 2020). In China, there are nine different types of wild peonies. The two subsects of the endemic species, *Delavayanae* and *Vaginatae*, are found alone in the wild in China (Li, Zhang, et al., 2022). The branches, *Paeonia delavayi*, *Passiflora lutea*, *Paeonia potaninii*, and *Paeonia ludlowii*, are the four wild species that make up the subsect. *Delavayanae*. *Paeonia spontanea*, *Paeonia qiui*, *P. ostii*, *P. rockii*, and *Paeonia decomposita* are among the five wild species of the subsect. *Vaginatae*. The subsect was chosen to represent the traditional cultivars of tree peonies in China. However, the majority of *Vaginatae* types in Europe and America were created by distant hybridization between *P. lutea* (or *P. delavayi*) and *P. suffruticosa* (Xue et al., 2021). The tree peony is classified into three types based on its use: oil peonies, decorative peonies, and medicinal peonies. Fengdan and Ziban are the most frequent and significant types of oil peonies (Liu et al., 2020). For example, the seed yield and oil yield of 62 species of peony (Fengdan, *P. ostii*) from 11 different producing regions in China were evaluated. The average 1000-seed weight (TSW) of the seeds in all growing regions ranged from 250.66 to 293.23 g, and oil yields ranged from 20.27% to 22.77%. The samples from Chongqing (Sichuan) had the highest TSW values and oil content of the seeds. However, the lowest TSW value was found in the samples from the Weinan region (Shaanxi), and the lowest oil content of seeds was found in Huadong (China) (Liu et al., 2019). The differences between regions may be caused by different water and fertilizer application, different crop managements, or other factors. Tree peony seeds have an oil content ranging from 20.27% to 37.80% (Liu et al., 2019; Yin et al., 2018). The ultimate oil yield can be affected by several extraction strategies for tree PSO (TPSO), such as heat or cold pressing, supercritical CO_2 extraction, and solvent methods. The oil output rate of cold-pressed peony seed was just 23.11%. Radio frequency pretreatment of peony seeds at 140°C might damage cell structure, raise phytosterol and tocopherol contents to 341.35 and 51.45 mg/kg, respectively, and enhance oil output by 15.23% (Wang, Zheng, et al., 2021).

P. volubilis L., popularly known as sacha inchi, is a plant native to South America's Amazon area, particularly the Peruvian jungles. It is an oilseed plant that is a perennial woody liana of the Euphorbiaceae family (Villanueva-Corrales et al., 2021). The mature stellate capsule is dark brown and contains four to six fruit petals, each with an oval seed (1.5–2 cm). Sacha inchi seed oil is both edible and used in cosmetics, and it is good for cardiovascular health and skin care. Under the right conditions of temperature and pressure, seed oil extraction rates can approach 30% (Zanqui et al., 2016). The seeds contain high poly-UFAs (PUFAs), especially omega-3 (44%–50.8%), 6, and 9 PUFA (Silva et al., 2019). In addition, phenols, sterols, and essential amino acids benefit human fitness (Chen, Li, et al., 2022; Wang et al., 2018).

A. truncatum Bunge, is a tiny deciduous tree, often known as Yuan bao maple in China; it is an Aceraceae species. *A. truncatum* Bunge is endemic to northern China, where it grows mostly in alpine forests and arid environments. It is suited to humid and warm temperatures, which are prevalent in the Inner Mongolia Plateau, Northeast Plain, Loess Plateau, Sichuan Basin, North China Plain, Japan, and Korean Peninsula. *A. truncatum* Bunge is cultivated over an area of 115.39×10^4 km^2 (Wu, Yang, et al., 2021). In China, more than 766.7 km^2 of *A. truncatum* have been cultivated (Yang et al., 2018). *A. truncatum* Bunge, in addition to its decorative, sand-preventing, and forest-fixing functions, has significant edible economic potential as a novel source of high-quality edible oil and protein. Its fruit is shoe-shaped, like a gold ingot, and it contains oilseed kernels in the middle (Ma et al., 2020).

A. truncatum Bunge kernel oil, a novel type of edible oil, has a high oil output. Oil yield and FA content of *A. truncatum* Bunge seeds vary substantially depending on location, perhaps due to subvarieties, geographical position, seasonal climate, and other variables. According to research on *A. truncatum* seed resources in 14 locations of China, the oil content of the seeds ranged from 17.81% to 36.56%, with a tendency to increase from south to north. Daiqintala, Inner Mongolia and Yongshou, Shaanxi are the best planting areas with high oil content in the *A. truncatum* seeds (Qiao et al., 2019). The oil yield of *A. truncatum* seeds from 12 areas in China were determined, and the contents were 7.27%–35.05% (Gu et al., 2019).

A. truncatum Bunge seed oil is high in UFAs, particularly nervonic acid (Hu et al., 2017). Changchun, Jilin and Pingquan, Hebei have high nervonic acid levels in their seed oil, making them become the best growing areas for a high yield of nervonic acid (Qiao et al., 2019). The neuronic acid levels of *A. truncatum* seeds from 12 areas in China were determined, and the contents were 0.66–14.86 mg/μL of oil (Gu et al., 2019). The lipid supplement nervonic acid (*cis*-15-tetracosenoic acid) was identified in shark brain and nervous system tissues as an ultra-long-chain mono-UFA (MUFA). It promotes myelinated nerve fiber production and inhibits the activity of immunodeficiency virus type 1 reverse transcriptase. Nervonic acid dysfunction can result in mental illnesses, inattention, and other neurological problems (Ma et al., 2020). Nervonic acid may heal brain cells and nerve tissue damage and is essential for brain function. It also includes phytosterol (β-sitosterol), tocopherol (γ-tocopherol), and other active ingredients (Hu et al., 2017).

O. europaea is a woody oil crop that is evergreen, produces a lot of oil, and has longevity. This oil crop originated in nations around the Mediterranean coast of the Middle East, including Spain (2.40 million ha), Italy (1.40 million ha), Greece (1 million ha), Tunisia, Turkey, Portugal (0.5 million ha), France (0.04 million ha), and others (Dini et al., 2020). As the largest producer of OO, Spain's main olive varieties are: *Picual*, *Hojiblanca*, *Picudo*, *Arbequina*. Among them, *Picual* is the most important olive variety in Spain, accounting for more than half of the olive cultivation area in Spain (Arenas-Castro et al., 2020; Torres-Sánchez et al., 2022). With continuous cultivation, olives are grown in approximately 60 countries with more than 2600 varieties and over 11 million hectares (Petruccelli et al., 2022). *O. europaea* is widely dispersed throughout the world's subtropical areas, which consists of six natural distinct subspecies. *O. europaea* subsp. *europaea*, with its two botanical varieties (*O. europaea* var. *sylvestris*, or oleasters or wild olive, and *O. europaea* var. *europaea*, or cultivated olive) distributed throughout the Mediterranean Basin; *O. europaea* subsp. *laperrinei* grows in the Saharan mountains; *O. europaea* subsp. *cuspidata* is found in southern Africa to southern Egypt, and from Arabia to China. *O. europaea* subsp. *guanchica*, *O. europaea* subsp. *maroccana*, *O. europaea* subsp. *cerasiformis* is native from the Canary Islands, southern Morocco, Madeira Island, respectively (Palomares-Rius et al., 2019). There are classic wild olive trees along the Mediterranean coast. The wild olive tree (*O. europaea* var. *sylvestris*, *Acebuche*) is found in remote mountainous areas and difficult-to-reach places, and its fruit is small and oval in shape. Research on the differences between *Acebuchina* oil extracted from wild Spanish olive trees (*Acebuche*) and commercially available olive (*Picual*) oils. The quality parameters of *Acebuchina* oil comply with current European Union (EU) and international regulations (IOC). Although the oil yield of *Acebuchina* oil is lower than *Picual* oils, however, it is rich in volatile and phenolic compounds and has high antioxidant activity. Based on the high antioxidant activity of *Acebuchina oil*, it has broad application prospects in nutrition, cosmetics, and other industries (Espínola et al., 2021). With rising worldwide demand for OO, more intensive agronomic approaches (such as alternative irrigation treatments) must be investigated and developed in order to enhance production (Sánchez-Rodríguez et al., 2019). The olive fruit is ovoid in shape, weighs about 9–10 g per fruit, and is about 3 cm long. It has a green skin when young and a yellow–green color when ripe. OO is a type of natural oil derived from the olive fruit and has become an essential ingredient of the Mediterranean diet due to its particular health advantages. Oil is abundant in the seed fruits of *Olea capensis* subsp. *macrocarpa* and *Olea perrieri* (Dong et al., 2022). The oil yield of the olive reaches 18.22%–23.5%. OO is classified as saponifiable (free FA and triglyceride) or nonsaponifiable (tocopherols, triterpene, carotenoids, polyphenols, sterols, squalene, and other compounds) (Moral & Escrich, 2022).

Olive residue, a byproduct of OO manufacturing, can be purified and combined with virgin OO (VOO) (5%) for sale and consumption using physical and chemical methods. The majority of the oil in olive pomace is triacylglycerol (>95%). The oil also includes triterpene acids, squalene, FAs, tocopherols, and other trace ingredients (Ketenoglu et al., 2018).

Tea [*C. sinensis* (L.) O. Ktze] is a species of Theaceae; tea trees are cultivated in 48 countries of Asia, Africa, South America, Oceania, and Europe (Wang, Contreras, et al., 2021). It is one of the world's top three nonalcoholic beverages, together with cocoa and coffee. For a long time, people have paid more attention to the cultivation of tea trees, the processing of tea leaves, and other tea products, but relatively little attention has been paid to the use of tea seeds. Seeds are another product in addition to leaves (raw materials for green tea, black tea, oolong tea, etc.) of tea (*C. sinensis* L.) plant. With an annual production of over 3 million tons (Khan & Mukhtar, 2007), tea tree seeds can be used to extract tea seed oil. Tea seeds are rich in oil (approximately 33.5%) (Qian et al., 2021; Wang et al., 2011). The physiological active components mainly include polyphenols, tocopherols, *β*-carotene, and phytosterols (Shao et al., 2015).

C. oleifera belongs to the genus *Camellia* in the family Theaceae, which is a tiny evergreen tree with great culinary and medicinal properties. *C. oleifera* grows mostly in China, Southeast Asia, Japan, and other nations. It arrived in Europe about the 16th century (Barreiro et al., 2021). China accounts for over 90% of the world's camellia acreage (Wu et al., 2018). It is mostly concentrated in Hunan, Zhejiang, Guangxi, Jiangxi, Henan, and other regions in China. *C. oleifera* planted area and seed yield in China reached 4.46 million ha and 3140,000 tons, respectively, in 2020 (Li, Ma, et al., 2022). The primary cultivars are *C. oleifera Abel*, *Camellia gigantocarpa*, *Camellia vietnamensis Huang*, and *Camellia chekiangoleosa* (Yu, Yan, et al., 2022). Among them, *C. oleifera Abel* has the most extensive planting area, which accounts for 70% of the total cultivated area and 85% of the production in China (Wu et al., 2022). Wild *C. oleifera* is widely spread in the subtropical mountainous and hilly regions of the Yangtze River Basin and Southern China, with elevations ranging from around 200 to 2000 m, and is one of the representative plant species in subtropical evergreen broadleaf forests. The wild *C. oleifera* in the high-altitude area of Mount Lushan (Shanxi Province, China) can survive under the low temperature below −30°C, and it is more frost-resistant than the cultivated *C. oleifera*. Low-temperature tolerance may be due to the key genes of the lignin biosynthesis process, the Ca^{2+} and gibberellin signal transduction pathways, and the flg22 signal transduction pathways have a role in the freezing-stress responses (Xie et al., 2023). The seed of *C. oleifera* is oval and triangular in shape, with fine hairs on the surface, mostly yellow–brown. CSO is a valuable source of developing woody edible oil derived from mature seed pressing. The mature seed oil yield is approximately 456.98 mg/dry kernel (g) (Lin et al., 2018). CSO output in China reached 720,000 tons in 2020 (Li, Ma, et al., 2022). The oil content of most camellia seeds is between 40% and 55%. The *C. oleifera Abel* seeds have an oil content of 40%–45%, whereas *C. vietnamensis* Huang had the most oil (58.96%) (Yu, Yan, et al., 2022). Camellia seed oil is mostly constituted of 95%–98% triglycerides and non-saponified compounds (tocopherols, phytosterols, squalene, phenols, etc.) (Li, Ma, et al., 2022). Taking advantage of the differences among *Camellia* spp., the breeding of varieties and the development and application of functional components can be further improved.

3 | FATTY ACID COMPOSITION IN SIX WOODY OIL CROPS

Wood-based oils consist mainly of long-chain triglycerides, formed by the esterification of long-chain FAs and glycerol. After ingestion, long-chain triglycerides is first hydrolyzed in the gastrointestinal tract by lipase into glycerol monoesters and free long-chain FAs, which mix with bile salts to form microclusters for absorption into the small intestinal mucosa. The hydrolyzed monoesters and FAs then combine again to form triglycerides. Triglycerides are bound to lipoproteins and enter the bloodstream, and the tissues through the lymphatic circulation system. The long-chain FAs entering the tissues need to rely on carnitine transporters to reach the mitochondria, where they are oxidatively metabolized (Mu & Høy, 2004). The degree of unsaturation of FAs in oils has a huge impact on human health. Excessive consumption of Saturated fatty acids (SFAs) like palmitic acid (PA) raises the risk of cardiovascular disease (Shramko et al., 2020). SFA might cause a 50% rise in liver fat content (Rosqvist et al., 2019). A diet heavy in animal fat and cholesterol, on the other hand, raised the risk of the bladder cancer illness, particularly in men (Dianatinasab et al., 2022). According to the World Health Organization, SFA dietary consumption, as much as feasible, should be less than or equal to 10% of total energy intake (Gutiérrez-Luna et al., 2022). On the contrary, UFAs provide various health advantages (Muhammad et al., 2022; Shahidi & Ambigaipalan, 2018). UFAs are divided into MUFAs and PUFAs. MUFAs, for example, include necessary FAs that the body cannot produce. Oleic acid, as an omega-9 MUFA, has antithrombotic and cancer-prevention properties and is frequently used in cosmetics and functional foods, as well as pharmaceutical industries (Zanqui et al., 2020). A pooled study of data from 11 prospective cohorts in 11 countries found that the consumption of woody edible oils, particularly those rich in MUFAs, lowered the incidence of bladder cancer. The Mediterranean dietary pattern, which emphasizes the consumption of vegetable fats (such as OO rich in oleic acid-based MUFAs), lowers the risk of bladder cancer prevalence (Dianatinasab et al., 2022). PUFA, on the other hand, lowered the likelihood of hyperlipidemia and serum ceramide levels during weight increase and excessive energy intake in overweight persons, as well as fat accumulation (Rosqvist et al., 2019). In mice, omega-3 PUFA supplementation can operate as an additional anti-cancer strategy, inhibiting tumor cell proliferation. Dietary PUFAs have a stronger inhibitory impact than MUFA supplementation (Dierge et al., 2021). Omega-3 PUFAs (ALA) have anti-inflammatory and immunomodulatory properties (Isanejad et al., 2022). By restoring mitochondrial redox balance and autophagy flux and recovering vascular Sirtuin 3 damage, ALA can decrease experimental hypertension and ameliorate endothelial dysfunction (Li, Wang, et al., 2020). Omega-3 FAs (eicosapentaenoic acid or docosahexaenoic acid + eicosapentaenoic acid) at 4 g/day are a safe and practical option for lowering triglycerides (Skulas-Ray et al., 2019). Increased dietary intake of omega-6 PUFAs (LA, etc.) can prevent diabetes mellitus (Henderson et al., 2018). Higher second trimester omega-6 PUFA levels were linked to atopic dermatitis in offspring of atopic dermatitis pregnant mothers. Atopic dermatitis in childhood was not associated with either the maternal prenatal omega-3:omega-6 ratio or omega-3 PUFAs (Gardner et al., 2020).

Omega-3 and omega-6 PUFAs preferentially collect in lipid droplets in acidic cancer cells, inducing ferroptosis by peroxidation. Docose hexaenoic acid and eicosapentaenoic acid are ALA (omega-3) derivatives, whereas arachidonic acid (ARA) is an LA (omega-6) derivative (Saini & Keum, 2018). These essential FAs have been shown in studies to moisturize the skin and stimulate keratinocyte differentiation (Soimee et al., 2020).

The omega-3/omega-6 PUFA ratio may be a predictor of acute coronary syndrome (Nishizaki et al., 2020). A 1:20 omega-3:omega-6 ratio is thought to be an inflammatory marker of carcinogenesis and is linked to the development of numerous chronic diseases (Deniz et al., 2019). In contrast, a review of 83 randomized controlled studies that lasted at least 24 weeks revealed no evidence that the omega-3/omega-6 ratio is relevant for glucose metabolism or diabetes (Brown et al., 2019).

In comparison to palm oil, peanut oil, and other herbal oils, which are high in saturated FAs, new woody oil crops (such as *P. suffruticosa*, *P. volubilis*, *A. truncatum*, *O. europaea*, *C. sinensis*, and *C. oleifera*) are particularly high in UFAs, such as oleic acid, LA, and ALA, in different quantities. As a result, it is critical to explore the FA content, particularly the UFAs, of these six developing woody oils.

3.1 | Fatty acid composition in tree peony seed oil

The PUFAs and ALA concentrations of PSO were greater than 90% and 40%, respectively (Yin et al., 2018). The UFA concentrations (mg/g DW) of ALA (123.2, 75.79, 69.06) > oleic acid (62.55, 68.67, 47.11) > LA (59.44, 45.60, 18.23) (Zhang et al., 2018). Omega-3 PUFAs (ALA) have been shown to lower the risk of cardiovascular and inflammatory diseases (Cao et al., 2022). The omega-6-to-omega-3 PUFA ratio in PSO was 0.69 (Yang et al., 2017).

3.2 | Fatty acid composition in *Plukenetia volubilis* seed oil

P. volubilis oilseeds are used to make sacha inchi oil (SIO). The SIO is abundant in PUFAs, particularly ALA (44%–50.8%) and LA (33.4%–36%) (Silva et al., 2019). However, PA (C 16:0) and stearic acid (C 18:0) levels are relatively low. The UFA ratio among them might reach 93.13%. The PUFA ratio of omega-6-to-omega-3 series is less than 1, at 0.72 (Rave et al., 2020).

3.3 | Fatty acid composition in *Acer truncatum* Bunge seed oil

The primary components of *A. truncatum* Bunge seed oil are omega-9 MUFAs (oleic acid) and omega-6 PUFAs (LA). Oleic acid, nervonic acid (6.89%), *cis*, *cis*-11-eicosenoic acid, and erucic acid are all omega-9 MUFAs. LA was found in greater concentrations in omega-6 PUFAs, followed by γ-linolenic acid, *cis*-11,14-eicosadienoic acid, and other FAs (Song et al., 2022). Neuronic acid can combine with sphingosine to form sphingomyelin and promote brain development (Lewkowicz et al., 2019). Plasma neuronic acid has the potential to be a biomarker for serious depression (Kageyama et al., 2017).

3.4 | Fatty acid composition in olive (*Olea europaea*) oil

Over the mature or enzyme degradation stage, Olea olives will create free FAs (with a preponderance of oleic acid), and subsequently increase acidity, which will negatively influence the quality of the final goods. OO is classified into six types based on its quality: VOO (extra VOO [EVOO], free acidity $\leq$0.8% and medium-grade VOO, free acidity $\leq$2.0%), refined OO (free acidity $\leq$0.3%), blended OO (mixed oil of refined OO and VOO), and olive pomace oil (crude olive pomace oil, refined olive pomace oil, and mixed olive pomace oil) (Jurado-Campos et al., 2023). Many factors influence the FA content of OO, including varietal traits, planting site, climate, fruit storage, and extraction processes, among others. PA is the primary saturated FA in OO. The amount of the UFA oleic acid is the largest, reaching around 55.00%–83.00%, followed by LA (3.50%–21.00%), palmitoleic acid, and ALA (Pastor et al., 2021; Sánchez-Rodríguez et al., 2019).

O. europaea pomace contains around 3%–4% oil, which may be extracted and processed for consumption (Heinzl et al., 2022). Olive pomace oil is high in UFAs, including linolenic acid (0.1%–1.5%), LA (3%–21%), and oleic acid (56%–85%) (Mateos et al., 2020). On an as-fed basis, 6% palm oil and olive pomace oil were added to the chicken feed. Olive pomace oil has more oleic acid, an MUFA, than palm oil. Feed digestibility rose as FA unsaturation increased. The olive pomace oil diet considerably increased SFA digestibility levels when compared to palm oil. Furthermore, it reduced SFA content while increasing MUFA content in breast meat and belly fat (Verge-Mèrida et al., 2022).

TABLE 1 The comparison of fatty acid compositions between six woody edible oils.

Fatty acid	TPSO (%)	SIO (%)	ATSO (%)	EVOO (g/100 g)	OPO (%)	ROPO (%)	TSO (%)	CSO (%)
Palmitic acid	7.50	3.89	4.05	13.88	12.66	15.54	15.3–17.7	7.45–9.05
Stearic acid	1.80	2.80	2.18	2.57	2.69	2.92	3.3–3.8	1.89–3.56
Oleic acid	24.10	9.34	25.01	72.08	70.06	56.94	52.9–57.5	75.97–79.49
Linoleic acid	27.20	35.01	33.80	7.78	10.09	20.79	22.3–24.2	7.46–10.28
ALA	39.50	48.39	2.40	0.67	0.68	1.04	0.3	0.18–0.38
SFA	10.66	6.87	7.59	16.96	16.20	19.13	0.7–0.9	9.89–12.40
ΣMUFA	ND	9.73	56.31	73.46	73.03	59.04	53.6–58.4	77.25–81.19
ΣPUFA	ND	83.40	35.40	9.12	10.77	21.83	22.3–24.2	7.86–10.75
UFA	89.34	93.13	91.71	82.52	83.80	80.87	80.51	ND
$\omega-6{:}\omega-3$	0.69:1	0.72:1	ND	12.45:1	14.73:1	19.99:1	ND	ND
Reference	Yang et al. (2017)	Rave et al. (2020)	Liang et al. (2019)	Gutiérrez-Luna et al. (2022)	Verge-Mèrida et al. (2022)	Ben Hammouda et al. (2018)	Wang et al. (2011)	Wang, Zeng, Verardo et al. (2017)

Abbreviations: ALA, α-linolenic acid; ATSO, *Acer truncatum* seed oil; CSO, *Camellia oleifera* seed oil; EVOO, extra virgin olive oil; MUFA, monounsaturated fatty acid; ND, no data or not determined; OPO, olive pomace oil; PUFA, polyunsaturated fatty acid; ROPO, refined olive pomace oil; SIO, sacha inchi oil; TPSO, tree peony seed oil; TSO, tea (*Camellia sinensis*) seed oil; UFA, unsaturated fatty acid.

Olive seed oil, like olive fruit oil, offers value-added potential as edible oil. Olive seeds include around approximately 30% rich lipids, 47% total dietary fiber, and 17% protein (Maestri et al., 2019). C18:1 (56%), C16:0 (18%), C18:2 (17%), and C18:3 (0.11%) FAs are the most abundant in olive seeds (Alves et al., 2018).

3.5 | Fatty acid composition in tea (*Camellia sinensis*) seed oil

Tea seed oil is considered a kind of edible oil with high quality, because the predominant FAs are the oleic acid (62.5% wt) and LA (18.1% wt) (Demirbas & Kinsara, 2017; Sahari et al., 2004).

3.6 | Fatty acid composition in *Camellia oleifera* seed oil

CSO contains a high concentration of MUFAs, particularly oleic acid (Luo et al., 2017; Zeng & Endo, 2019). In CSO, UFAs amounted for 84.23%–89.27% of total FAs. The oleic acid concentration is the greatest among them. It accounted for 95.79%–99.23% of total MUFAs, with a little contribution from PUFA LA and SFA PA (Lin et al., 2018).

Based on the above literature review and the data in Table 1, all six woody edible oils are relatively low in SFAs and high in UFAs. The type and content of UFAs in each woody oil can also vary somewhat. *A. truncatum* Bunge seed oil (ATSO), OO, tea (*C. sinensis*) seed oil (TSO), and CSO are rich in MUFAs. TPSO and SIO are rich in PUFAs. TSO, CSO, and OO are mainly rich in oleic acid, with higher levels than TPSO and ATSO. There is little difference in the content of the latter two oils, whereas SIO has the lowest oleic acid content. The content of LA is higher in TPSO, SIO, and ATSO, with a small difference among the three, all higher than OO, TSO, and CSO. TPSO and SIO are rich in ALA and contain much higher levels than ATSO, OO, TSO, and CSO.

There is a growing demand for UFAs in the market, especially in the field of dietary supplements and functional foods, and more research is being done on the health benefits of quality fish oils, especially the omega-3 family of PUFAs. In the future, in addition to high-quality fish oils, new wood-based oils are also good choices to provide more UFAs. Taking the advantage of the differences in the FA composition of wood-based oils, nutritious blended oils can be prepared in different ratios or new structural oils can be prepared through biochemical techniques. In the future, the enzymatic enrichment of UFAs by transesterification, hydrolysis, and catalyzing esterification is a promising option. However, the biological enzymes currently used to enrich omega-3 PUFA, such as *Rhizomucor miehei* lipase, lipase AY “Amano” 400SD, are expensive and not conducive to industrial production (Yang et al., 2021). In the future, further optimization of the reaction conditions is needed to find the optimal lipase and reaction conditions for the enrichment of UFAs. If necessary, immobilization techniques and modification of lipases will be used to improve the catalytic capacity, selectivity, and reproducibility of lipases to increase yields (Xie et al., 2022).

4 | ACTIVE INGREDIENTS AND ITS ACTION MECHANISMS IN SIX WOODY OIL CROPS

4.1 | Tocopherols and tocotrienols

Tocopherols and tocotrienols, which are fat-soluble, can inhibit free radical propagation in plasma lipoproteins and membranes (Azzi, 2019; Gonzalez-Ramila et al., 2020). The distinction between the two is

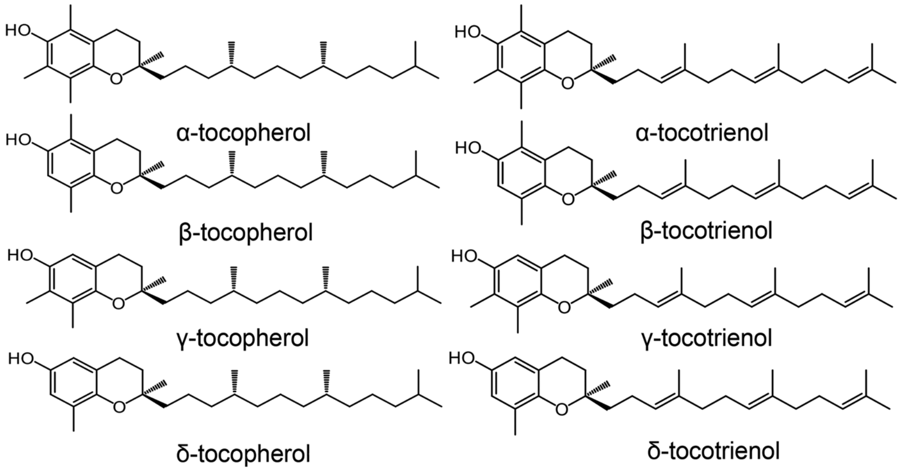


FIGURE 1 Chemical structures of tocopherols and tocotrienols.

that tocopherol's side chains are saturated FAs, whereas tocotrienol's chains are UFAs (having three double bonds) (Mao et al., 2017). They are classified into *α*-, *β*-, *γ*-, and *δ*-forms based on the different locations and amounts of methyl groups in the chroman ring (Lu et al., 2018). Figure 1 shows the chemical structure of tocopherols and tocotrienols. Among them, *α*-tocopherol can scavenge free radicals, strengthen the body's immunity, and plays an important role in the prevention and/or treatment of central nervous system disorders and cardiovascular diseases (Ranard & Erdman, 2017). As for free radical scavenging, *α*-tocopherol's reaction rate with peroxy radicals is 1000 times greater than that of PUFAs (Dugo et al., 2020). In the protection of nervous system structure and function, *α*-tocopherol prevents ataxia with selective vitamin E deficiency (AVED) (Finno et al., 2019). AVED is neuronal damage, loss of proprioception and loss of reflexes, among other things, produced by mutations in the gene encoding the tocopherol transfer protein (*α*-TTP). The main active form of *α*-tocopherol is RRR-*α*-tocopherol. RRR-*α*-tocopherol formulations are used as a lifelong treatment for AVED patients. This treatment could halt the disease's course and occasionally lessen neurological symptoms (Azzi et al., 2023; Kohlschütter et al., 2020). At the molecular level, RRR-*α*-tocopherol affects the expression of genes related to transcriptional regulation, cell signaling, and cell death pathways, such as protein kinase C, monocyte NADPH oxidase, and xanthine oxidase, due to molecular structure specificity rather than antioxidant properties (Azzi, 2018, 2019). *α*-Tocopherol may promote the transport of physiologically active target molecules (quercetin) by neuronal cells to cross the blood–brain barrier and the increase of *α*-tocopherol and quercetin concentration in the rat brain (Ferri et al., 2015). In the treatment of cardiovascular disease, supplementation with 400–800 IU of *α*-tocopherol daily reduces myocardial infarction and exerts an anti-atherosclerotic effect by inhibiting the accumulation of low-density lipoprotein (LDL) in blood vessel walls (Loffredo et al., 2015). This therapeutic effect is probably mediated through the oxidative stress-mediated mechanism of *α*-tocopherol and its anti-inflammatory activity (monocyte-endothelial cell adhesion and muscle cell proliferation, inflammatory cytokine release) (Azzi, 2007; Iuliano et al., 2000; Villacorta et al., 2003). In addition to the highly active *α*-tocopherol, other forms of tocopherol are increasingly being investigated. Although *β*-tocopherol did not reduce protein kinase C activity, cell proliferation, or gene expression, it does have antioxidant effects similar to *α*-tocopherol (Azzi, 2018). In vitro, *β*-tocopherol and *γ*-tocopherol may inhibit melanin formation in mouse melanoma cells by inhibiting the expression of tyrosinase and tyrosinase-associated protein-2 mRNA (Kamei et al., 2009). Based on this, these two tocopherols can be explored in further in-depth research in improving skin pigmentation and whitening. *γ*-Tocopherol may exert anti-inflammatory effects through the generation of gamma-carboxyethyl hydroxychroman metabolites (Li et al., 2016). In addition, *γ*-tocopherol has anti-cancer activity. For example, *γ*-tocopherol causes apoptosis in human breast cancer cells by affecting death receptor 5 (DR5) (Azzi, 2018). *δ*-Tocopherol possesses anti-inflammatory properties and inhibits pro-inflammatory responses promoted by reactive oxygen species and stress-activated NF-*κ*B and Nrf2 (Elisia & Kitts, 2013). Tocotrienols have been shown in vitro experiments to have benefits against cancer (mostly by inhibiting angiogenesis), neurological illnesses (by inhibiting glutamate-induced activation of c-Src kinase), and cardiovascular disease, as well as other ailments (Aggarwal et al., 2010). *γ*-Tocotrienol can reduce vascular oxidative stress, ameliorate gastrointestinal tract damage, protect hematopoietic tissue, be anti-inflammatory, and protect against radiation injury (Kumar et al., 2020). Furthermore, *δ*-tocotrienol and *γ*-tocotrienol showed strong anti-cancer activity (Mao et al., 2017). In conclusion, current research shows that *α*-tocopherol has the highest activity in the human body. The health mechanism of *α*-tocopherol in the organism has been studied more deeply. Although *β*-, *γ*-, and *δ*-tocopherol and tocotrienols have become the hotspots of domestic and international research in recent years, the main focus is on the in vitro activity of these substances, and the in vivo and clinical studies are rare. In the future, more in-depth studies on the effects of these substances on the human body are needed. Figure 2

Tocopherol concentrations in PSO reached 435.23–576.40 mg/kg (Wang et al., 2023). PSO exhibits a significant abundance of

γ-tocotrienol, constituting approximately 66.7% of the total tocol content (comprising both tocopherols and tocotrienols) (Mao et al., 2017; Yang et al., 2017). Tocopherol concentrations in SIO reached 2540.1 mg/kg. It is mostly constituted of γ-tocopherol (1108–1367 mg/kg) and δ-tocopherol (641–856 mg/kg), with corresponding percentages of 64.7% and 35.3% (Ramos-Escudero et al., 2019). Tocopherols help to keep PUFAs in SIOs stable (Rodríguez et al., 2021). The total tocopherol content in *A. truncatum* seed oil was 2.35–2.65 μmol/g. The main tocopherol was γ-tocopherol (1.29–1.44 μmol/g) (Hu et al., 2017). VOO, EVOO, and olive pomace oil are all high in α-tocopherol. The concentration of α-tocopherol in commercial OO ranges from 59 to 426 mg/kg (Zhang et al., 2019). The tocopherol fraction in tea seed oil is mainly α-tocopherol (Shao et al., 2015). Total Tocopherol content in *camellia* seed oil reached 1441.1–1686.9 mg/kg. It is mostly constituted of γ-tocopherol (1145.7–1364.1 mg/kg) (Günç Ergönül & Aksoylu Özbek, 2018).

Based on the above literature review and the data in Table 2, TPSO, SIO, ATSO, and CSO are rich in γ-tocopherol, whereas OO and TSO are rich in α-tocopherol. Compared with other oils, woody oil contains more tocopherols, which have antioxidant and anti-inflammatory effects. Make use of its advantages, according to local conditions, grow more woody oil crops, and apply in the food industry, develop more nutritious and healthy food resources.

4.2 | Polyphenols

Polyphenols have antioxidant, anti-inflammatory, and anti-degenerative disease properties. Polyphenols can regulate postprandial blood glucose levels by inhibiting key digestive enzymes such as α-glucosidase and α-amylase, which inhibit starch digestion and glucose transport (Sun & Miao, 2020). Polyphenols are classified into three broad classes based on their chemical structures: flavonoids, phenolic acids, and non-flavonoids. Flavonoids have a fundamental molecular skeleton of C6–C3–C6 (Fan et al., 2022). Certain flavonoids have been shown to induce vasodilation, prevent atherosclerosis, alleviate endothelial dysfunction and insulin resistance, and reduce blood pressure. Furthermore, flavonoids directly interact with a wide range of protein targets known as kinases to modulate signaling pathways, therefore protecting the cardiovascular system (Sánchez et al., 2019). Phenolic acids are a class of organic acids that contain phenolic rings. At least one carboxyl functional group and one phenolic functional group are present in phenolic acids. Phenolic acid has a variety of biological activities, including antioxidant, anti-tumor, anticoagulant, anti-HIV, anti-thrombotic, and other biological activities (Shi, Huang, et al., 2019). Lignans, which have a molecular structure comparable to steroids, have anti-cancer, anti-oxidation, and cardiovascular disease-preventative properties (Rodríguez-García et al., 2019). Oleuropein, a secondary metabolite of OO, imparts bitterness and acidity to the oil. Oleuropein is a glycosylated ester of elenolic acid with hydroxytyrosol found in secoiridoids. Oleuropein not only promotes cell death but also inhibits cell proliferation, migration, and viability in breast cancer cell lines (Moral & Escrich, 2022). Oleuropein aglycone is the form in

TABLE 2 Contents of different tocopherols in woody edible oils.

Compound	TPSO (mg/kg)	SIO (mg/kg)	ATSO (μmol/kg)	VOO (mg/kg)	EVOO (mg/kg)	OPO (mg/kg)	TSO (mg/kg)	CSO (mg/kg)
α-Tocopherol	15.38–23.03	60–70	313.7–362.9	485.1–756.3	159.7	357	353–707	18.3–87.9
β-Tocopherol	ND	18–29	75.1–78.5	6.3–50	2.7	<2	ND	192.8–289.3
γ-Tocopherol	403.31–535.15	1108–1367	1296.9–1442.3	3.7–15.3	7.8	32	ND	1145.7–1364.1
δ-Tocopherol	14.76–22.02	641–856	658.1–770.6	ND	ND	<2	ND	22.9–58.2
Reference	Wang et al. (2023)	Ramos-Escudero et al. (2019)	Hu et al. (2017)	Chtourou et al. (2021)	Dugo et al. (2020)	González-Rámila et al. (2022)	Shao et al. (2015)	Günç Ergönül and Aksoylu Özbek (2018)

Abbreviations: ATSO, *Acer truncatum* seed oil; CSO, *Camellia oleifera* seed oil; EVOO, extra virgin olive oil; OPO, olive pomace oil; SIO, sacha inchi oil; TPSO, tree peony seed oil; TSO, tea (*Camellia sinensis*) seed oil; VOO, virgin olive oil.

which it is absorbed. Oleuropein aglycone might increase uncoupling protein 1 expression (which is important in maintaining the balance of energy metabolism) and regulate hormone production in interscapular brown adipose tissue of obese rats fed a high fat diet via activating β-adrenergic signaling. It can also lower plasma leptin and visceral fat levels (Oi-Kano et al., 2017). Table 3 shows the chemical structures of the phenolic substances in the six woody crops.

The phenolic content of *P. delavayi* and other peony seeds was greater (11.26–41.05 mg GAE/g), flavonoids (3.82–17.07 mg CGE/g DW), flavanols (4.01–13.95 mg RE/g DW), and procyanidin B2 (0.15–1.75 mg/g DW) (Yan et al., 2020). PSO contains phenolic acids and flavonoids, which are mainly rich in benzoic acid (0.010 mg/g) and catechins (0.028 mg/g) (Wang et al., 2023).

In commercial SIOs, 16 phenolic constituents were found. Along with simple phenol, SIOs include five phenolic substances: secoiridoids, lignan, flavonoids, phenyl alcohols, and isocoumarin, which contribute 40.96%, 19.69%, 14.40%, 14.39%, and 10.56% of the total phenolic substance content, respectively (Ramos-Escudero et al., 2021). The total phenolic content of SIO varied from 21.68 to 43.86 mg GAE/kg under various processing and extraction conditions (Cornelio-Santiago, et al., 2022). The overall flavonoid concentration of SIO as well as the two primary flavonoids, myricetin and luteolin, were 6.17, 4.60, and 1.57 mg/mL, respectively (Xuan et al., 2018).

The primary phenolic components in the seed bark of Yuanbao maple were six procyanidin oligomers of procyanidins and six flavonoids (catechin, rutin, epicatechin, quercetin, and naringenin), accounting for 31.02% and 63.27% of the 13 phenolic compounds, respectively (Farha et al., 2022).

OO also includes trace elements, including phenolic compounds (flavonoids, lignans, and phenolic alcohols). The European Food Safety Authority (EFSA) accepted a health claim on the phenolic efficacy of OO in 2011, stating that 0.25 mg/g of EVOO per day is sufficient (Rocchetti et al., 2022). EVOO is high in lignans and secoiridoids (oleuropein), followed by flavonoids (such as rutin, luteolin-7-glucosides, and quercetin, among others) high in rutin, phenolic alcohols rich in hydroxytyrosol and tyrosol, and phenolic acids (Alu'datt et al., 2017). Lignans in EVOO are mostly made up of two components: lariciresinol (1.28 mg/kg) and pinoresinol (9.11 mg/kg). The lignan content is much greater than that of palm oil (1.00 mg/kg), coconut oil (0.89 mg/kg), and Brazil nut oil (0.94 mg/kg), among others (Tardugno et al., 2022). The raw EVOO samples contained 334.1 mg equivalents/kg of tyrosol on average (Rocchetti et al., 2020). A third of the phenolic compounds in EVOO are phenolic acids. Syringic acid, *p*-coumaric acid, vanillic acid, caffeic acid, and 4-hydroxybenzoic acid are the most common phenolic acids. The syringic acid concentration was the greatest among them (Tang et al., 2018).

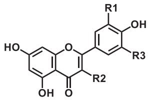
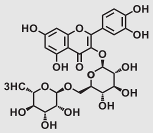
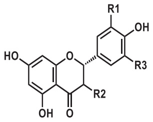
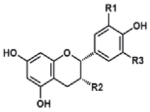
The total phenolic content of tea seed oil ranged from 85.5 to 119.1 mg/kg. It involves 61.7%–77.8% free phenolic compounds and 22.2%–38.3% bound phenolic compounds. Tea seed oil mainly comprises benzoic acids, cinnamic acids, catechins, flavones, flavonols, and dihydroflavonoids (Wang, Contreras, et al., 2021). The total phenolic content of virgin CSO was 84.8–154.5 mg/kg. It mostly comprises phenolic acids, flavanones, flavones, flavonols, flavan-3-ols, and other flavonoids. Phenolic acids (49.3–107.6 mg/kg) represented for 46.6%–79.4% of all phenolic substances (Wei et al., 2022).

4.3 | Phytosterols

In nature, phytosterols and their derivatives, such as phytosterol esters, are abundant. Phytosterols are structurally and functionally comparable to cholesterol. Phytosterols are beneficial in stimulating important cellular and physiological activities to control lipid and glucose metabolism, as well as insulin resistance (Prasad et al., 2022). Sterols limit the formation of cholesterol in the blood. The C-3 and C-5 locations (hydroxyl or ester functional groups) of phytosterols (or phytosterol esters) may be responsible for their lowering cholesterol effect (Yuan et al., 2020). β-Sitosterol can be used to enhance the activation of the glucose transporter 4 protein (GLUT4) and the insulin receptor in adipose tissue to further control glucose metabolism. In diabetic rats fed a high-fat diet, β-sitosterol reduced the serine phosphorylation of insulin receptor substrate-1 (IRS-1). It increased insulin receptor and post-receptor insulin signaling mRNA expression (β-arrestin-2, GLUT4, IRS-1, etc.) (Babu et al., 2020).

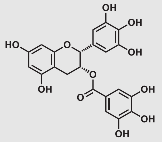
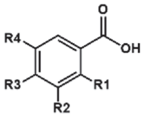
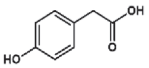
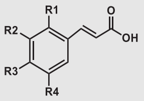
The three primary phytosterol concentrations in decreasing order were β-sitosterol, Δ5-avenasterol, and cycloartenol, according to the GC–MS analysis of phytosterols in six peony species. The maximum amount of β-sitosterol, in particular, might reach 2.62 ± 0.08 mg/g (Chang et al., 2020). The primary phytosterols found in PSO from 10 Chinese locations were β-sitosterol and fucosterol, with concentrations of both reaching 1.80–2.79 and 0.68–1.22 mg/g, respectively (Wang et al., 2020). β-Sitosterol, stigmasterol, and campesterol are the dominant phytosterols in sacha inchi seed oil (Norhazlindah et al., 2023). Under varied processing and extraction methods, the β-sitosterol content of sacha inchi seed oil ranged from 0.31 to 0.57 mg/g of oil (Cornelio-Santiago et al., 2022). The principal phytosterols in *A. truncatum* seed oil are β-sitosterol and Δ7-sitosterol. The average total phytosterol concentration might reach 3.27 ± 0.42 mg/g (Liang et al., 2019). The total sterol content of 61 *O. europaea* species' pulp ranged from 0.119 to 0.969 mg/g (Mousavi et al., 2022). The 4-desmethylsterols group (β-sitosterol, Δ5-avenasterol, stigmasterol, and campesterol), 4,4′-dimethylsterols (cycloartenol and 24-methylenecycloartanol), and 4-monomethylsterols (citrostadienol) are the most abundant phytosterols in OO (Olmo-García & Carrasco-Pancorbo, 2021). β-Sitosterol phytosterol concentration is 93% per 1000–2300 ppm of VOO (Seçmeler & Güçlü Üstündağ, 2019). The 219 substances were found in raw EVOO samples of sterols. The average quantity of total sterols per kilogram was 3007.4 mg equivalents (Rocchetti et al., 2020). The three phytosterols with the greatest level in refined olive pomace oil were β-sitosterol (1734.14 mg/kg), Δ5-avenasterol (121.6 mg/kg), and campesterol (70.45 mg/kg) (Ben Hammouda et al., 2018). The total sterol content in tea seed oil is 3388–3820 mg/kg and contains stigmasterol, α-amyrin, β-amyrin, β-sitosterol, and lanosterol. Among them, the content of β-amyrin and lanosterol is higher (Shao et al., 2015). CSO contains Δ7-stigmasterol, β-amyrin, lupeol, β-sitosterol, canophyllol, cycolartenol, stigmast-7-en-

TABLE 3 Chemical structures of phenolic substances in six woody oils or seeds.

Polyphenols	Chemical structures	R_1	R_2	R_3	R_4	Name	Existence	Reference
Flavonoids		H	H	H	NA	Apigenin	PSO SIO TSO CSO	Ramos-Escudero et al. (2021), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017), Wang et al. (2023)
		OH	H	H	NA	Luteolin	SIO TSO CSO	Ramos-Escudero et al. (2021), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		H	OH	H	NA	Kaempferol	PSO TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017), Wang et al. (2023)
		OH	OH	H	NA	Quercetin	ATSC EVOO TSO CSO	Fan et al. (2018), Tang et al. (2018), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		OH	OH	OH	NA	Myricetin	SIO TSO CSO	Ramos-Escudero et al. (2021), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		NA	NA	NA	NA	Rutin	PSO ATSC	Fan et al. (2018), Wang et al. (2023)
		H	H	H	NA	Naringenin	ATSC TSO CSO	Fan et al. (2018); Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		OH	OH	H	NA	Taxifolin	TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		OH	OH	H	NA	Catechin	PSO ATSC TSO CSO	Fan et al. (2018), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017), Wang et al. (2023)
		OH	OH	H	NA	Epicatechin	ATSC TSO CSO	Fan et al. (2018), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)

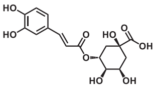
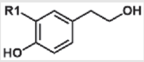
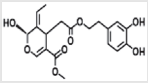
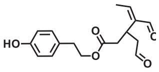
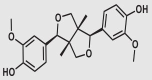
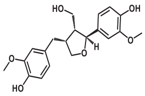
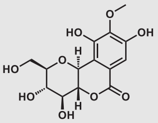
(Continues)

TABLE 3 (Continued)

Polyphenols	Chemical structures	R_1	R_2	R_3	R_4	Name	Existence	Reference
		OH	OH	OH	NA	Epigallocatechin	TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		NA	NA	NA	NA	Epigallocatechin gallate	TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
Phenolic acid		H	H	H	H	Benzoic acid	PSO TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017), Wang et al. (2023)
		H	H	OH	H	*p*-Hydroxybenzoic acid	TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		H	OH	OH	H	Protocatechuic acid	TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		OH	H	OH	H	2,4-Dihydroxybenzoic acid	EVOO	Tang et al. (2018)
		H	OH	OH	OH	Gallic acid	PSO TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017), Wang et al. (2023)
		H	H	OH	OCH3	Vanillic acid	EVOO TSO CSO	Tang et al. (2018), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		H	OCH3	OH	OCH3	Syringic acid	EVOO	Tang et al. (2018)
		COOH	H	H	H	Phthalic acid	TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		NA	NA	NA	NA	*p*-Hydroxyphenylacetic acid	TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		H	H	H	H	Cinnamic acid	TSO CSO	Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		OH	H	H	H	o-Coumaric acid	EVOO	Tang et al. (2018)
		H	H	H	OH	m-Coumaric acid	EVOO	Tang et al. (2018)

(Continues)

TABLE 3 (Continued)

Polyphenols	Chemical structures	R_1	R_2	R_3	R_4	Name	Existence	Reference
		H	H	OH	H	*p*-Coumaric acid	PSO EVOO TSO CSO	Tang et al. (2018), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017), Wang et al. (2023)
		H	OH	OH	H	Caffeic acid	PSO EVOO TSO CSO	Tang et al. (2018), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras, et al. (2017), Wang et al. (2023)
		H	OCH3	OH	H	Ferulic acid	EVOO TSO CSO	Tang et al. (2018), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		H	OCH3	OH	OCH3	Sinapic acid	EVOO TSO CSO	Tang et al. (2018), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017)
		NA	NA	NA	NA	Chlorogenic acid	PSO EVOO TSO CSO	Tang et al. (2018), Wang, Contreras et al. (2021), Wang, Zeng, Del Mar Contreras et al. (2017), Wang et al. (2023)
Olive polyphenols		H	NA	NA	NA	Tyrosol	SIO EVOO	Ramos-Escudero et al. (2021), Tang et al. (2018)
		OH	NA	NA	NA	Hydroxytyrosol	SIO EVOO	
		NA	NA	NA	NA	Leuropein aglycone	SIO EVOO	Ramos-Escudero et al. (2021), Tang et al. (2018)
		NA	NA	NA	NA	Oleocanthal	EVOO	Tang et al. (2018)
		NA	NA	NA	NA	Pinoresinol	SIO EVOO	Ramos-Escudero et al. (2021), Tang et al. (2018)
		NA	NA	NA	NA	Lariciresinol	EVOO	Tang et al. (2018)
Bergenin		NA	NA	NA	NA	NA	SIO	Ramos-Escudero et al. (2021)

Abbreviations: ATSC, *Acer truncatum* seed coat; CSO, *Camellia oleifera* seed oil; EVOO, extra virgin olive oil; NA, not applicable; PSO, peony seed oil; SIO, sacha inchi oil; TSO, tea (*Camellia sinensis*) seed oil.

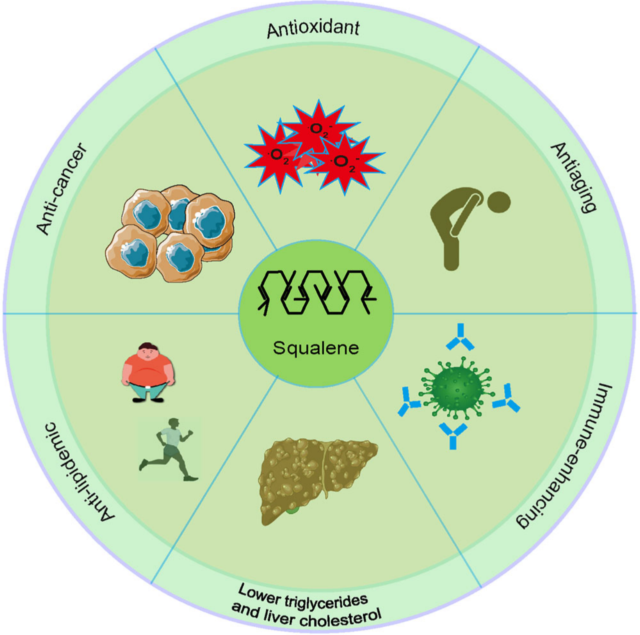


FIGURE 2 The biological effects of squalene.

3-ol, betulin, lanosterol (Wang, Zeng, Verardo, et al., 2017; Wu, Fan, et al., 2021).

Based on the above literature review and the data in Table 4, the highest content of total sterols was found in ATSO. β-sitosterol was abundant in TPSO, ATSO, and OO and was higher than that in SIO, TSO, and CSO.

4.4 | Squalene

As shown in Figure 2, squalene ($C_{30}H_{50}$) is a symmetrical triterpene (isoprenoid), with six double bonds that exhibit antioxidant, antiaging, anti-cancer, anti-lipidemic, and immune-enhancing properties (Lekshmi et al., 2019). It is abundant in plants and animals and has been widely used as a powerful antioxidant in the food sector, particularly in the nutraceutical industry (Li, Liu, et al., 2020). In the presence of Thioredoxin Domain 5 (TXNDC5), squalene encapsulated in PLGA NPs protects AML12 hepatocyte cell lines from oxidative and endoplasmic reticulum stress (Bidooki et al., 2022). Squalene lowers triglycerides and hepatic cholesterol via complicated molecular processes such as transcription and post-transcription gene expression changes (Lou-Bonafonte et al., 2018). Due to the limitation of squalene resources, an increasing number of individuals are paying attention to and developing plant squalene. Squalene is found in a variety of vegetable oils, including rice bran oil (3189 mg/kg), red peanut oil (1343 mg/kg), peanut oil (1329 mg/kg), black sesame oil (572 mg/kg), soybean oil (184 mg/kg), and sunflower oil (144 mg/kg) (Pokkanta et al., 2019). The concentration of plant squalene in the deodorizing distillate of OO is significantly higher than that of other woody edible oils. Squalene-rich woody edible oils include EVOO, in which squalene accounted for 70% of the unsaponifiable portion. EVOO with an average squalene level of 4400 mg/kg is available in large retail markets (Pacetti et al., 2019). The concentration of squalene in 10 PSO kinds ranged from 26.58 to 55.72 mg/kg (Wang et al., 2020), which was lower than the level of EVOO (4540 mg/kg) (Shi, Zhu, et al., 2019). There is essentially little information available on the squalene content of SIO and *A. truncatum* seed oil. Squalene concentration in tea seed oil and CSO was around 194–340 and 80–160 mg/kg, respectively (Shao et al., 2015; Wu, Fan, et al., 2021).

4.5 | Plant pigments

Plant pigments with antioxidant properties include carotenoids, chlorophyllide, and anthocyanins. These chemicals have the potential to prevent chronic illnesses, including cardiovascular disease, diabetes, and cancer (Ahmadi et al., 2022).

Carotenoids serve an important role in the body as precursors for retinoic acid, retinoid, and retinol synthesis (Liang et al., 2021). Carotenoids, particularly β-carotene and lutein, can scavenge reactive oxygen species, reduce inflammatory responses, and control stress-dependent signaling and UV light-induced gene expression (Balić & Mokos, 2019). Lutein, a kind of polyphenolic molecule, possesses anti-inflammatory, antioxidant, anti-tumor, and other biological properties (Chen et al., 2021). Lutein, as a safe antioxidant and anti-apoptotic drug, can repair damaged cystinosis and autophagy-lysosomal degradation pathways. As a possible therapeutic agent, it can be used to treat nephropathic cystinosis (De Leo et al., 2020). The total carotenoid content of the 17 sacha inchi seed cultivars varied from 0.7 to 0.9 μg/g of seed β-carotene equivalent (Wang et al., 2018). *A. truncatum* seed oil had 1.83 μg/g of β-carotene (Li et al., 2021). OO contains β-carotene, lutein, violaxanthin, zeaxanthin, and other carotenoids (Martakos et al., 2020). The most prevalent carotenoids in OO are β-carotene and lutein (Anselmi et al., 2022). Furthermore, lycopene levels in OO varied from 0.47 to 15 μg/g (Zhang et al., 2019). The enzyme protochlorophyllide oxidoreductase reduces protochlorophyllide to produce chlorophyllide (Heyes et al., 2021). Dark green OO contains more chlorophyllide and tastes better. When olive fruits ripen, chlorophyllide breakdown (chlorophyll a and a′, pheophytins a and a′) is accompanied by anthocyanin synthesis. As a result, the oil's chlorophyllide concentration is higher in green olive fruit than in mature olive fruit (Martakos et al., 2020; Quiles et al., 2022).

4.6 | Triterpenoids

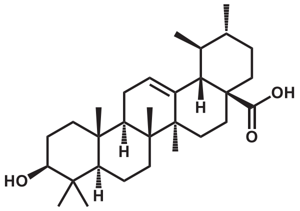
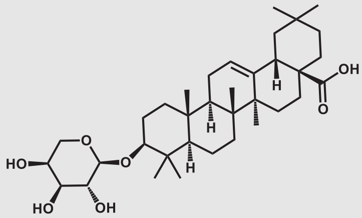
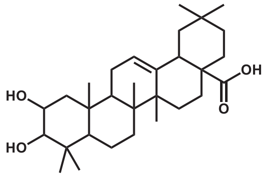
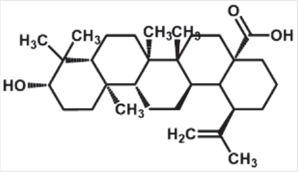
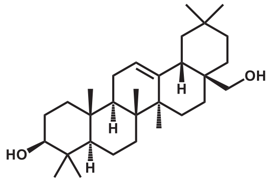
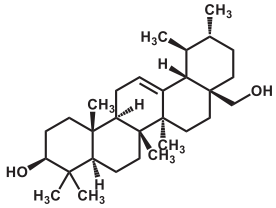
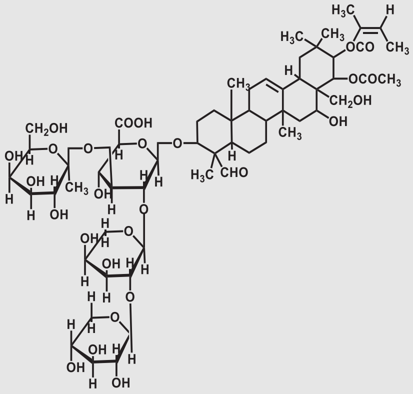
Plant pentacyclic triterpenoids, which are made up of three terpene units, exhibit antiviral, anti-tumor, and anti-inflammatory properties (Xiao et al., 2018). The polyvalent pentacyclic triterpene–cyclodextrin conjugates had a high affinity for influenza HA protein (KD at the μM level) and disrupted the connections between HA and the monosaccharide SA receptor, blocking viral attachment to host cells. These conjugates show potent anti-influenza virus activity while exhibiting modest cytotoxicity (Xiao et al., 2016). Table 5 shows the main

TABLE 4 Contents of different sterols in six woody edible oil.

Compounds	TPSO (mg/kg)	SIO (mg/kg)	ATSO (mg/kg)	VOO (mg/kg)	EVOO (mg/kg)	OPO (mg/kg)	TSO (mg/kg)	CSO (mg/kg)
Cholesterol	ND	ND	ND	0.66–1.28	ND	2.84	ND	ND
Brassicasterol	ND	ND	ND	0.26–1.93	ND	<2.84	ND	ND
24-Methylcholesterol	ND	ND	ND	1.05–1.61	ND	5.68	ND	ND
Campesterol	30.30	74–153	106.10	34.96–43.54	31.50	90.85	ND	27.50–60.45
Campestanol	ND	ND	57.60	0.79–1.71	ND	2.84	ND	ND
Stigmasterol	ND	219–1129	381.80	13.13–14.70	7.60	34.07	196–456	ND
Δ7-Campesterol	ND	ND	ND	0.66–1.43	ND	<2.84	ND	ND
Δ5,23-Stigmastadienol	ND	ND	ND	0.64–2.03	ND	22.71	ND	ND
β-Sitosterol	1454.75	452–1274	1065.90	961.14–1180.00	ND	2444.38	147–334	106.96–240.12
Sitosterol	ND	ND	ND	ND	978.80	ND	ND	ND
Fucosterol	677.24	ND	ND	ND	ND	ND	ND	ND
Sitostanol	ND	ND	ND	2.03–2.25	ND	48.26	ND	ND
Cycloartenol	ND	ND	ND	ND	218.20	ND	ND	578.87–1093.67
Δ5-Avenasterol	117.98	ND	ND	29.00–50.52	179.10	45.42	ND	ND
Δ5,24-Stigmastadienol	ND	ND	ND	3.53–4.34	ND	56.78	ND	ND
Δ7-Stigmastenol	ND	ND	1034.10	2.14–2.75	ND	11.36	ND	ND
Δ7-Avenasterol	33.73	ND	181.50	2.63–3.29	ND	28.39	ND	ND
Lanosterol	ND	ND	ND	ND	ND	ND	1133–1222	715.19–1029.67
Total sterols	2455.79	2229.92	3274.10	1070.19–1315.50	1471.80	2839.00	ND	ND
Reference	Wang, Zheng et al. (2021)	Norhazlindah et al. (2023), Ramos-Escudero et al. (2019)	Liang et al. (2019)	Aydin et al. (2022)	Gutiérrez-Luna et al. (2022)	González-Rámila et al. (2022)	Shao et al. (2015)	Wang, Zeng, Verardo et al. (2017)

Abbreviations: ATSO, *Acer truncatum* seed oil; CSO, *Camellia oleifera* seed oil; EVOO, extra virgin olive oil; OPO, olive pomace oil; SIO, sacha inchi oil; TPSO, tree peony seed oil; TSO, tea (*Camellia sinensis*) seed oil; VOO, virgin olive oil.

TABLE 5 The main triterpenoids and their efficacy.

Compounds	Chemical structures	Functions	Reference
Ursolic acid (*Olea europaea*)		Lipid and body weight↓ Endogenous glucose↓ Glucose absorption↓ Insulin sensitivity↑ Intercellular adhesion molecule-1 expression↓	Nakano et al. (2022), Silva et al. (2016)
Oleanolic acid (*Olea europaea, Paeonia suffruticosa*)		Glucose tolerance↑ Regulate fat and carbohydrate metabolism IL-1β, IL-6, lipid-promoting genes (PPARα, SREBP1, FAS, ChREBP, G6Pase) expression in liver and adipose tissue↓ Cognitive impairment↓	Djeziri et al. (2018)
Maslinic acid (*Olea europaea*)		Cognitive dysfunction↓	Bae et al. (2020)
Betulinic acid (*Paeonia suffruticosa*)		Inhibition of AGS and HepG2 cells	Tian et al. (2020)
Erythrodiol (*Olea europaea*)		Antioxidant, Anti-inflammatory, neuroprotective, Cardiovascular protective	Montenegro et al. (2021)
Uvaol (*Olea europaea*)			
Tea saponin (*Camilla Oleifera*)		Destroy (*C. Albicans, Penicillium*) fungi cell membrane structure, Downregulate biofilm-related genes and hyphae-related genes (ALS3, EFG1, ECE1, UME6, and HWP1) expressions, Inhibit mycelium growth, Cell adhesion and aggregation↓	Yu, Wu et al. (2022)

triterpenoids and their efficacy. Ursolic and oleanolic acids can increase insulin sensitivity by promoting lipid and body weight balance, decreasing endogenous glucose synthesis and absorption, and improving insulin sensitivity (Silva et al., 2016). Ursolic acid significantly reduces intercellular adhesion molecule-1 cell surface expression, which is linked to pro-inflammatory cytokines. This function of ursolic acid is related to the presence of carboxyl functional groups and the quantity of hydroxyl functional groups (Nakano et al., 2022).

By modulating fat and carbohydrate metabolism, oleanolic acids may increase glucose tolerance in obese rats. In the liver and adipose tissue of obese mice, oleanolic acids also reduced the expression of IL-1 and IL-6 pro-inflammatory factor mRNA as well as several lipid-promoting genes (Djeziri et al., 2018). Furthermore, oleanolic acid may help with cognitive impairment. Maslinic acid promotes brain-derived neurotrophic factors and its downstream pathway signaling in the hippocampus of the mouse brain to alleviate cognitive impairment caused by cholinergic blockade (Bae et al., 2020). The principal triterpenes found in OO and olive pomace oil are oleanolic acids and maslinic acids, which are generated from the oleanane molecule. The quantity of oleanolic acids and maslinic acids in OO varies according to olive tree type, fruit age, and processing conditions. Maslinic acids vary from oleanolic acids in that they have an OH group at carbon position 2. Maslinic acids and oleanolic acids can both be excreted as glucuronide, whereas oleanolic acid can also be excreted as sulfate (Pozo et al., 2017). Maslinic acids had a bioavailability that was seven times that of oleanolic acids. The decreased oral bioavailability of oleanolic acids may be due to gastrointestinal malabsorption and impaired hepatic microsomal metabolism (de la Torre et al., 2020). The pomace left behind after extracting VOO can be used to make olive pomace oil. Olive pomace oil contains higher triterpene components than VOO (the triterpenoid acid level was less than 100 mg/kg oil). By centrifugation and hexane extraction, the concentrations of pentacyclic triterpene acids (mostly oleanolic acids and maslinic acids) in crude OO residue were 850–980 and 510–900 g/kg, respectively (Velasco et al., 2018). In obese mice, olive pomace oil high in triterpenic acids (POCTA) might decrease the expression of pro-inflammatory genes in the liver and adipose tissue. Furthermore, a POCTA-diet for 10 weeks enhanced vascular function, lowered insulin resistance, and decreased body weight in obese rats (Claro-Cala et al., 2020).

Olive pomace oils include triterpenoid alcohols (erythrodiol and uvaol) in addition to triterpenoid acids (Ruiz-Méndez et al., 2021). Both erythrodiol and uvaol exhibit antioxidant and anti-inflammatory properties, as well as neuroprotective and cardiovascular protective properties (Suárez Montenegro et al., 2021).

Triterpenoids found in peony seeds (*P. ostii*) include oleanolic acid and betulinic acid, with betulinic acid having a substantial depressive impact on AGS (IC50 5.4 μM) and HepG2 (IC50 6.6 μM) cells (Tian et al., 2020).

Tea saponin, a complex pentacyclic triterpenoid consisting of saponins, organic acids, and sugar bodies, is abundant in *C. sinensis* and CSO (Liu, Geng, et al., 2022). The seeds of tea tree (*C. sinensis*) contain about 11%–15% of saponin. The saponin content of extracted Assam tea seed oil samples was in the range of 23,075.6–28,434.8 mg/kg (Uoonlue & Muangrat, 2019). *C. oleifera* seed contains 7.28%–16.24% tea saponin (Wu et al., 2018). Tea saponin has the ability to degrade the cell membrane structure of *Saccharomyces cerevisiae*, *Candida albicans*, *Penicillium*, and other fungi. It has been shown to impede mycelium development, diminish cell adhesion and aggregation, and downregulate the expression of many biofilm and hyphae-related genes (ALS3, EFG1, ECE1, UME6, and HWP1) (Yu, Wu, et al., 2022).

5 | PHYSIOLOGICAL EFFECTS OF SIX WOODY OILSEED CROPS

The oils of *P. suffruticosa*, *P. volubilis*, *A. truncatum*, *O. europaea*, *C. sinensis*, and *C. oleifera* are abundant in beneficial components with a high nutritional value. For example, the oil from tree peonies is high in ALA, γ-tocopherol, and squalene. SIO contains a high concentration of ALA, LA, γ-tocopherol, δ-tocopherol, and carotenoids. LA, oleic acid, nervonic acid, and γ-tocopherol are all found in *A. truncatum* seed oil. OO contains a high concentration of oleic acid, α-tocopherol, squalene, β-carotene, and lutein. CSO and tea seed oil have a high concentration of oleic acid, tea saponin, β-amyrin, cycloartenol, lanosterol, α-tocopherol, and phenolic acid. The presence of these active components confers antioxidant, anti-inflammatory, hypoglycemic, and cardiovascular disease-preventive characteristics on TPSO, SIO, *A. truncatum* seed oil, OO, tea seed oil, and CSO.

5.1 | Peony seed oil

PSO possesses antioxidant properties. A daily dose of 4 g/kg of PSO stabilizes antioxidant enzyme activity in the liver and protects it from oxidative damage (Yang et al., 2017). PSO can regulate lipid and cholesterol metabolism. PSO (high in ALA) can increase FA β-oxidation and inhibit adipogenesis (downregulation of FA synthase, sterol regulatory element-binding proteins 1C, and acetyl-CoA carboxylase expression) to lower liver lipid concentrations and regulate cholesterol metabolism (Su et al., 2016). Furthermore, it might reduce male hamster triacylglycerols, total plasma cholesterol, and non-HDL cholesterol by 14%–34%, 9%–14%, and 7%–18%, respectively. In comparison to a high cholesterol diet, dietary PSO substantially inhibited the formation of hepatic lipids and plaque lesions ($p < .01$) (Kwek et al., 2022). In addition, PSO has neuroprotective characteristics. Large levels of pro-inflammatory mediators generated by excessive microglia activation in the nervous system are related with altered synapse and neuronal function and consequent memory impairment. PSO suppresses microglia activation and neuroinflammation-induced cognitive impairments in Alzheimer's disease-like phenotypic mice by de-regulating pro-inflammatory mediators in the hippocampus and prefrontal cortex (Gao et al., 2021).

5.2 | Sacha inchi oil

SIO, which is high in ALA, can ameliorate the metabolic abnormality of intestinal flora and minimize the metabolic abnormalities of lipids such as glycerophospholipid and glycerolipid in mice (Li, Huang, et al., 2020). At a particular dosage (0.5 g $\omega - 3$/day), SIO emulsion can boost hepatic catalase activity, antioxidant capacity, and serum adiponectin level in the liver of obese rats while also lowering oxidative stress and inflammation (Ambulay et al., 2020). AIA-rich oils, such as sacha inchi (*P. volubilis*), improve omega-3 LCPUFA accumulation while also increasing antioxidant enzyme and desaturase activity and decreasing FA biosynthetic activity (Rincón-Cervera et al., 2016). SIO plays an active role in glycemic control. When SIO is taken with high-fat meals, it improves insulin sensitivity ($r = 0.636$; $p = 0.035$) and sirtuin-1 expression in those who have a greater glycemic response after fat loading and a higher basal triglyceridaemia (Alayón et al., 2018). Many amino acids are found in sacha inchi seeds, including tyrosine, tryptophan, cysteine, and threonine. These amino acids are usually made up of albumin, glutelin, globulin, and other proteins (Sathe et al., 2012). Immunomodulatory effect of albumin fractions derived from Inca peanut seeds. It mostly manifests itself by increasing tumor necrosis factor-secretion and encouraging splenic lymphocyte proliferation, as well as promoting H_2O_2 and NO production in mouse monocyte macrophage leukemia cells (Li et al., 2018).

5.3 | *Acer truncatum* seed oil

A. truncatum seed oil has been shown to improve mouse memory and cognitive function by regulating sphingolipid and glycerophospholipid metabolism. This might be due to the synergistic action of omega-9 MUFAs such nervonic acid (Song et al., 2022). *A. truncatum* seed oil has been shown to increase memory and learning ability in elderly rats. In aged mice, this edible oil may stimulate the expression of postsynaptic density protein-95, *N*-methyl-D-aspartate-receptor 1, and other proteins while decreasing mRNA transcripts of inflammatory markers like as interleukin-1β and interleukin-6 (Li et al., 2021).

5.4 | Olive oil

EVOO contains significant quantities of oleuropein aglicone, oleacin, and hydroxytyrosol, allowing it to exhibit antioxidant effects in patients' bodies. EVOO use by patients with chronic kidney disease is connected with high oleocanthal content, allowing EVOO to have anti-inflammatory actions in the body (Noce et al., 2021). By modulating gene expression, the phenolic compounds in EVOO protect proteins involved in processes, such as inflammation, lipid metabolism, and oxidative stress (Jimenez-Lopez et al., 2020). EVOO can reduce lipid oxidation. It not only raises HDL cholesterol, but it also lowers triglycerides and LDL cholesterol (Bartolomei et al., 2022). At 45 g/day, three oils (olive pomace oil, sunflower oil, and high oleic sunflower oil) were consumed. In comparison to the other two oils, olive pomace oil can lower total cholesterol and LDL cholesterol levels in the body, as well as blood lipid oxidation in healthy persons (González-Rámila et al., 2022). OO can also modulate blood sugar levels. For 24 weeks, mice with type 2 diabetes on a high-fat diet were fed EVOO, phenolic-rich EVOO, and lard. EVOO has been demonstrated to improve insulin sensitivity and normalize glucose-induced insulin production (raising the number and enhancing the function of pancreatic β-cells) (Jurado-Ruiz et al., 2019). OO can also reduce the risk of some diseases. Increased use of OO can lower the risk of mortality from neurological disorders, cardiovascular disease, respiratory illness, and cancer by 29%, 19%, 18%, and 17%, respectively. Substituting 10 g/day of OO for 10 g/day of mayonnaise, butter, margarine, and dairy fat resulted in an 8%–34% decrease in overall and cause-specific mortality (Guasch-Ferré et al., 2022). Two prospective cohorts of men and women in the United States discovered that increasing OO intake (>1/2 tablespoon/day or >7 g/day) reduced the incidence of coronary heart disease and overall cardiovascular disease (Guasch et al., 2020). VOO, especially EVOO, can help reduce the formation of atherosclerotic plaques and coronary artery calcification. When ingested in levels of 20–30 g/day, OO is most helpful in lowering the risk of cardiovascular disease (Donat-Vargas et al., 2022). A prospective cohort research found that VOO is the best form of cooking OO for preventing frailty in (community older adults) (Donat-Vargas et al., 2021). EVOO containing oleuropein aglycone may prevent cytotoxicity caused by human islet amyloid polypeptide aggregates by shielding more of the cell membrane against permeabilization and death (Chaari, 2020).

5.5 | *Camellia sinensis* seed oil

Tung et al. (2019) showed that TSO rich in MUFA could prevent obesity, reduce physical fatigue, and improve exercise performance compared with either soybean oil or lard oil-rich diets in this HFD-induced obese ovariectomized mice model. Studies have shown that tea seed oil is rich in UFAs and that prolonged dietary intake of tea seed oil can lower cholesterol levels in the body (Suealek et al., 2021). Pinthong and Suanarunsawat (2020) showed that tea seed oil decreased the AUC of glucose and serum lipid profile, whereas it suppressed serum insulin level and HOMA-IR. The tea kernel oil has lower pour point and lower viscosity compared with common vegetable oils (Demirbas & Kinsara, 2017). Tea seed oil is rich in squalene, and studies have shown that the inhibition effect of extracted squalene on angiogenesis was investigated in chick chorioallantoic membrane (Hataminia et al., 2018). A number of studies have shown that tea seed oils are a good source of emollients for skin care, and possess antioxidant activity (Fattahi-far et al., 2006; Kim et al., 2008).

5.6 | *Camellia oleifera* seed oil

CSO possesses anti-inflammatory, microbiota-modulating, antioxidant, immune-regulating, and blood lipid–lowering properties (Duan et al., 2021; Gao et al., 2022; Lin et al., 2022). *Camellia* oil has been

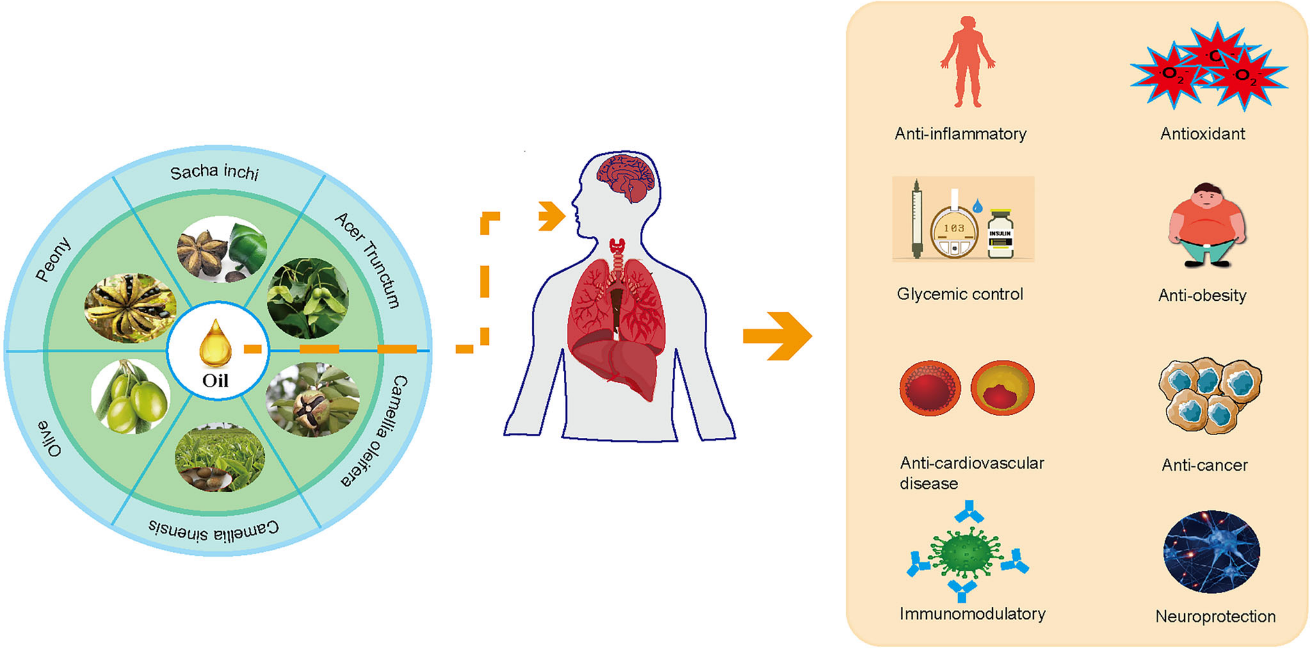


FIGURE 3 The biological effects of six woody oils.

shown to inhibit the production of inflammatory cytokines while increasing the amount of *Ruminococcaceae UCG014* antioxidant capacity (Chen, Weng, et al., 2022). The phenolic extract of *camellia* seed oil has been shown to boost the activities of glutathione peroxidase and superoxide dismutase in vivo, as well as the antioxidant capacity (101.05 ± 6.70 μmol QE/100 g of oil) and free radical scavenging. It can help lower malondialdehyde levels and increase organ index (Liu, Zhu, et al., 2022). A high-fat diet rich in camellia oil was more successful in lowering LDL cholesterol and serum total cholesterol levels than a high-fat diet rich in soybean oil (Chou et al., 2018). A high-fat diet rich in tea seed oil can minimize lipid droplet formation in the liver of mice. Adipocyte size was also reduced in brown adipose tissue and the uterine fat periphery (Tung et al., 2019). A high-fat diet rich in CSO has been shown to inhibit the expression of the PPARγ gene, which is associated with serum lipid biomarkers and branched-chain amino acids, as well as to regulate steroid biosynthesis and ARA metabolism, thereby regulating high-fat diet-induced dyslipidemia in mice (Gao et al., 2022). Tea seed oil can increase endurance and anti-fatigue activities by lowering blood urea nitrogen, creatine kinase, and ammonia levels (Tung et al., 2019). *Camellia* oil consumption may preserve neurons in rats with moderate cognitive impairment through gut microbiota-brain contact. *Camellia* oil consumption is superior to OO consumption, and it can significantly increase rats' learning and memory abilities. CSO has been shown to efficiently boost the CD19$^+$ humoral immune response. Primary peritoneal macrophages and RAW 264.7 macrophages may be stimulated to phagocytose by the oil. It can also trigger and enhance the production of interleukin-10 by BALB/c splenic macrophages (Lin et al., 2022).

Figure 3 and Table 6 show the mechanism of action and biological effects in six woody edible oils.

6 | FUTURE AND PERSPECTIVE

At present, OO and CSO are already relatively popular in the domestic market, while the industry and market prospects of other oil types need further in-depth research and development. All of these oils are rich in a variety of UFAs and other nutrients and have certain health benefits and market prospects. In the future, these woody edible oils may be more widely used in health care products, food additives, beauty products, and other fields. However, to be successful in both domestic and international markets, these woody edible oils still need to meet consumer demand in terms of quality, nutritional content, price, and so on. In addition, there is a need to strengthen marketing and promotion to increase consumer awareness and acceptance of these woody edible oils. At present, there are still some shortcomings in the research work on these woody edible oils. For future research, the following outlooks are proposed: (1) In-depth research on the active ingredients in these woody edible oils, such as a variety of UFAs, tocopherols, polyphenols and other antioxidant substances, phytosterols and other nutritional components, as well as their health benefits and mechanisms of action. Further strengthen applied research in the field of medicine. (2) Improve cultivation techniques for oilseeds to improve the yield and quality of woody edible oils, develop more efficient and environmentally friendly production techniques, and reduce nutrient losses. (3) To explore the effects and mechanisms of the application of these woody edible oils in different fields such as health products, food additives, and cosmetic products. (4) To further study the demand and trends of these woody edible oils in the domestic and international markets, and how to meet the needs of consumers and improve market competitiveness.

TABLE 6 Mechanism of action and biological effects in six woody edible oils.

Oil types	Action mechanism	Biological effect	Reference
PSO	Fatty acid β-oxidation↑, Fatty acid synthase, sterol regulatory element-binding proteins 1C, Acetyl-CoA carboxylase expression↓	Liver lipid concentration↓, Regulate cholesterol metabolism	Su et al. (2016)
	Triacylglycerols, plasma total cholesterol, and non-HDL-C↓	Hepatic lipids and plaque lesions production↓, Regulate intestinal microbiota	Kwek et al. (2022)
	Stabilizes the antioxidant enzyme activity Protects hepatic cells from oxidative damage	Regulate liver lipid metabolism	Yang et al. (2017)
	Pro-inflammatory mediators (TNF-α, iNOS, IL-1β, and COX-2) in the hippocampus and prefrontal cortex↓	Microglia activation and neuroinflammation-induced cognitive deficits↓	Gao et al. (2021)
SIO	Intestinal flora metabolic disorder↓ Glycerophospholipid and glycerolipid metabolic abnormalities↓	Improve lipid dysmetabolism	Li, Huang et al. (2020)
	Insulin sensitivity and sirtuin-1 expression↑	Regulate blood sugar level	Alayón et al. (2018)
	Hepatic catalase activity↑, antioxidant capacity↑ Serum adiponectin content↑, oxidative stress and inflammation↓	Regulate liver lipid metabolism	Ambulay et al. (2020)
	Antioxidant enzyme and desaturase activities↑	Fatty acid biosynthetic activity↓, $n-3$ LCPUFA accumulation↑	Rincón-Cervera et al. (2016))
	Tumor necrosis factor-α secretion↑ Splenic lymphocyte proliferation↑ H_2O_2 and NO generations in mouse monocyte macrophage leukemia cells↑	Immunomodulatory activity↑	Li et al. (2018)
ATSO	Regulate sphingolipid and glycerophospholipid metabolism	Memory and cognitive function↑	Song et al. (2022)
	Postsynaptic density protein-95, *N*-methyl-D-aspartate-receptor 1, and other proteins expression↑ mRNA horizontal of inflammatory factors interleukin-1β and interleukin-6↓	Memory and learning ability of aging mice↑	Li et al. (2021)
EVOO	Oxidative stress and lipid oxidation↓, HDL-C↑ Triglycerides and LDL-C↓, atherosclerotic plaque formation and coronary artery calcification↓	Coronary heart disease↓, cardiovascular disease↓ Neurodegenerative diseases↓, cardiovascular diseases↓, respiratory diseases↓ Cancer↓	Bartolomei et al. (2022), Donat-Vargas et al. (2022), Guasch-Ferré et al. (2022)
	Insulin sensitivity↑ Normalizing glucose-induced insulin secretion The number and function of pancreatic β-cells↑	Glycemic control and homeostasis↑	Jurado-Ruiz et al. (2019)
	Anti-inflammatory↑ antioxidant↑	Chronic kidney disease↓	Noce et al. (2021)
OPO	TC↓ LDL-C↓ Serum lipid oxidation↓ eNOS expression↑	Coronary heart disease↓, cardiovascular disease↓ Mesenteric arteries, aorta endothelial function↑	González-Rámila et al. (2022)
CSO	Serum HDL-C↑ Serum TC, LDL-C/ HDL-C↓ Liver triacylglycerol↓ Liver fatty acid synthase, glucose 6-phosphate dehydrogenase, and malic enzymes↓	Obesity prevention Cardiovascular protection Antioxidant activity↑	Chou et al. (2018)

(Continues)

TABLE 6 (Continued)

Oil types	Action mechanism	Biological effect	Reference
	Liver lipid droplet accumulation↓ Adipocyte size↓ Blood urea nitrogen, creatine kinase, and ammonia↓	Obesity prevention Endurance and anti-fatigue↑	Tung et al. (2019)
	Regulate gut microbiota–brain communication Inflammatory cytokines expression↓ *Ruminococcaceae_UCG014* abundance↑	Neuroprotection Memory and cognitive function↑	Chen, Weng et al. (2022)
	$CD19^+$ humoral immune response↑ Interleukin-10↑ RAW 264.7 macrophage phagocytosis↑	Immunomodulatory↑	Lin et al. (2022)
	PPARγ gene expression↓ Regulate steroid biosynthesis and arachidonic acid metabolism	Regulating dyslipidemia	Gao et al. (2022)
TSO	AUC of glucose↓ Serum lipid profile↓ Antioxidant enzymes (liver)↑	Anti-hyperglycemic and anti-hyperlipidemic	Pinthong and Suanarunsawat (2020)
	Free radical scavenging	Organ protection↑	Pinthong and Suanarunsawat (2020)
	Ammonia, blood urea nitrogen, and creatine kinase levels↓	Endurance↑, antifatigue	Tung et al. (2019)
	Low-density lipoprotein cholesterol↓	Plasma lipids↓	Suealek et al. (2021)

Abbreviations: ATSO, *Acer truncatum* seed oil; CSO, *Camellia oleifera* seed oil; EVOO, extra virgin olive oil; OPO, olive pomace oil; PSO, peony seed oil; SIO, sacha inchi oil; TSO, tea (*Camellia sinensis*) seed oil.

7 | CONCLUSION

This review provides a systematic overview of the seed resources, active ingredients, and health benefits of six woody oil crops, namely, *P. suffruticosa*, *P. volubilis*, *A. truncatum*, *O. europaea*, *C. sinensis*, and *C. oleifera*. This study focuses on the FAs and lipid concomitants of the six woody oils and their efficacy mechanisms and provides an outlook on the application prospects of the six woody oils, with a view to providing ideas and references for exploring the active ingredients in woody oils and their efficacy mechanisms, further expanding the market of high-quality edible oils and developing high value-added functional products.

AUTHOR CONTRIBUTIONS

Lili Xu: Conceptualization; data curation; formal analysis; investigation; methodology; validation; writing—original draft. **Wei Wang**: Conceptualization; data curation; formal analysis; investigation; methodology; validation; writing—original draft; funding acquisition; supervision. **Kaiwen Bai**: Writing—review and editing. **Yi Wu**: Writing—review and editing. **Yilin Ling**: Writing—review and editing. **Xiaoyue Kong**: Writing—review and editing. **Romero Agusti**: Writing—review and editing. **Qianhui Qi**: Conceptualization; investigation. **Zhaisheng Zheng**: Conceptualization; investigation. **Ming'an Yuan**: Writing—review and editing. **Le Chen**: Conceptualization; investigation. **Lianliang Liu**: Writing—review and editing. **Peifang Weng**: Writing—review and editing. **Yu Zhang**: Conceptualization; funding acquisition; supervision.

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CONFLICT OF INTEREST STATEMENT

The authors confirm that they have no conflicts of interest to declare for this publication.

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REFERENCES

Aggarwal, B. B., Sundaram, C., Prasad, S., & Kannappan, R. (2010). Tocotrienols, the vitamin E of the 21st century: Its potential against cancer and other chronic diseases. *Biochemical Pharmacology*, *80*(11), 1613–1631. https://doi.org/10.1016/j.bcp.2010.07.043

Ahmadi, A., Shahidi, S.-A., Safari, R., Motamedzadegan, A., & Ghorbani-Hasansaraei, A. (2022). Evaluation of stability and antibacterial properties of extracted chlorophyll from alfalfa (*Medicago sativa* L.). *Food and*

Chemical Toxicology, *163*, 112980. https://doi.org/10.1016/j.fct.2022.112980

Alayón, A. N., Ortega Avila, J. G., & Echeverri Jiménez, I. (2018). Carbohydrate metabolism and gene expression of sirtuin 1 in healthy subjects after sacha inchi oil supplementation: A randomized trial. *Food & Function*, *9*(3), 1570–1577. https://doi.org/10.1039/C7FO01956D

Alu'datt, M. H., Rababah, T., Alhamad, M. N., Al-Mahasneh, M. A., Almajwal, A., Gammoh, S., Ereifej, K., Johargy, A., & Alli, I. (2017). A review of phenolic compounds in oil-bearing plants: Distribution, identification and occurrence of phenolic compounds. *Food Chemistry*, *218*, 99–106. https://doi.org/10.1016/j.foodchem.2016.09.057

Alves, E., Rey, F., da Costa, E., Moreira, A. S. P., Pato, L., Pato, L., Domingues, M. R. M., & Domingues, P. (2018). Olive (*Olea europaea* L. cv. *Galega vulgar*) seed oil: A first insight into the major lipid composition of a promising agro-industrial by-product at two ripeness stages. *European Journal of Lipid Science and Technology*, *120*(4), 1700381. https://doi.org/10.1002/ejlt.201700381

Ambulay, J. P., Rojas, P. A., Timoteo, O. S., Barreto, T. V., & Colarossi, A. (2020). Effect of the emulsion of sacha inchi (*Plukenetia huayabambana*) oil on oxidative stress and inflammation in rats induced to obesity. *Journal of Functional Foods*, *64*, 103631. https://doi.org/10.1016/j.jff.2019.103631

Anselmi, C., Portarena, S., Baldacchini, C., Proietti, S., Leonardi, L., & Brugnoli, E. (2022). One drop only. Easy and rapid Raman evaluation of β-carotene in olive oil and its relevance as an index of olive fly attack. *Food Chemistry*, *393*, 133340. https://doi.org/10.1016/j.foodchem.2022.133340

Arenas-Castro, S., Gonçalves, J. F., Moreno, M., & Villar, R. (2020). Projected climate changes are expected to decrease the suitability and production of olive varieties in southern Spain. *Science of the Total Environment*, *709*, 136161. https://doi.org/10.1016/j.scitotenv.2019.136161

Aydin, S., Ozkan, G., & Yorulmaz, A. (2022). Sterols and triterpene dialcohols in virgin olive oil: A comprehensive study on their transition from fruits depending on malaxation conditions and ripening degree. *European Journal of Lipid Science and Technology*, *124*(6), 2100232. https://doi.org/10.1002/ejlt.202100232

Azzi, A. (2007). Molecular mechanism of α-tocopherol action. *Free Radical Biology and Medicine*, *43*(1), 16–21. https://doi.org/10.1016/j.freeradbiomed.2007.03.013

Azzi, A. (2018). Many tocopherols, one vitamin E. *Molecular Aspects of Medicine*, *61*, 92–103. https://doi.org/10.1016/j.mam.2017.06.004

Azzi, A. (2019). Tocopherols, tocotrienols and tocomonoenols: Many similar molecules but only one vitamin E. *Redox Biology*, *26*, 101259. https://doi.org/10.1016/j.redox.2019.101259

Azzi, A., Atkinson, J., Ozer, N. K., Manor, D., Wallert, M., & Galli, F. (2023). Vitamin E discussion forum position paper on the revision of the nomenclature of vitamin E. *Free Radical Biology and Medicine*, *207*, 178–180. https://doi.org/10.1016/j.freeradbiomed.2023.06.029

Babu, S., Krishnan, M., Rajagopal, P., Periyasamy, V., Veeraraghavan, V., Govindan, R., & Jayaraman, S. (2020). Beta-sitosterol attenuates insulin resistance in adipose tissue via IRS-1/Akt mediated insulin signaling in high fat diet and sucrose induced type-2 diabetic rats. *European Journal of Pharmacology*, *873*, 173004. https://doi.org/10.1016/j.ejphar.2020.173004

Bae, H. J, Kim, J., Kim, J., Goo, N., Cai, M., Cho, K., Jung, S. Y., Kwon, H., Kim, D. H., Jang, D. S., & Ryu, J. H. (2020). The effect of maslinic acid on cognitive dysfunction induced by cholinergic blockade in mice. *British Journal of Pharmacology*, *177*(14), 3197–3209. https://doi.org/10.1111/bph.15042

Balić, A., & Mokos, M. (2019). Do we utilize our knowledge of the skin protective effects of carotenoids enough? *Antioxidants*, *8*(8), 259. https://www.mdpi.com/2076-3921/8/8/259

Barreiro, R., Rodríguez-Solana, R., Alonso, L., Salinero, C., López Sánchez, J. I., & Pérez-Santín, E. (2021). Fast 1H-NMR species differentiation method for camellia seed oils applied to Spanish ornamentals plants. comparison with traditional gas chromatography. *Plants*, *10*(10), 1984. https://www.mdpi.com/2223-7747/10/10/1984

Bartolomei, M., Bollati, C., Li, J., Arnoldi, A., & Lammi, C. (2022). Assessment of the cholesterol-lowering effect of MOMAST® Biochemical and Cellular Studies. *Nutrients*, *14*(3), 493. https://www.mdpi.com/2072-6643/14/3/493

Ben Hammouda, I., Triki, M., Matthäus, B., & Bouaziz, M. (2018). A comparative study on formation of polar components, fatty acids and sterols during frying of refined olive pomace oil pure and its blend coconut oil. *Journal of Agricultural and Food Chemistry*, *66*(13), 3514–3523. https://doi.org/10.1021/acs.jafc.7b05163

Bidooki, S. H., Alejo, T., Sánchez-Marco, J., Martínez-Beamonte, R., Abuobeid, R., Burillo, J. C., Lasheras, R., Sebastian, V., Rodríguez-Yoldi, M. J., Arruebo, M., & Osada, J. (2022). Squalene loaded nanoparticles effectively protect hepatic AML12 cell lines against oxidative and endoplasmic reticulum stress in a TXNDC5-dependent way. *Antioxidants*, *11*(3), 581. https://www.mdpi.com/2076-3921/11/3/581

Brown, T. J., Brainard, J., Song, F., Wang, X., Abdelhamid, A., & Hooper, L. (2019). Omega-3, omega-6, and total dietary polyunsaturated fat for prevention and treatment of type 2 diabetes mellitus: Systematic review and meta-analysis of randomised controlled trials. *BMJ*, *366*, l4697. https://doi.org/10.1136/bmj.l4697

Cao, W., Wang, Y., Shehzad, Q., Liu, Z., & Zeng, R. (2022). Effect of different solvents on the extraction of oil from peony seeds (*Paeonia suffruticosa* Andr.): Oil yield, fatty acids composition, minor components, and antioxidant capacity. *Journal of Oleo Science*, *71*(3), 333–342. https://doi.org/10.5650/jos.ess21274

Chaari, A. (2020). Inhibition of human islet amyloid polypeptide aggregation and cellular toxicity by oleuropein and derivatives from olive oil. *Alzheimer's & Dementia*, *16*(S3), e047624. https://doi.org/10.1002/alz.047624

Chang, M., Wang, Z., Zhang, T., Wang, T., Liu, R., Wang, Y., Jin, Q., & Wang, X. (2020). Characterization of fatty acids, triacylglycerols, phytosterols and tocopherols in peony seed oil from five different major areas in China. *Food Research International*, *137*, 109416. https://doi.org/10.1016/j.foodres.2020.109416

Chen, C.-C., Li, M.-S., Chen, K.-T., Lin, Y.-H., & Ko, S.-S. (2022). Photosynthetic and morphological responses of sacha inchi (*Plukenetia volubilis* L.) to waterlogging stress. *Plants*, *11*(3), 249. https://www.mdpi.com/2223-7747/11/3/249

Chen, S.-Y., Weng, M.-H., Li, Z.-Y., Wang, G.-Y., & Yen, G.-C. (2022). Protective effects of camellia and olive oils against cognitive impairment via gut microbiota-brain communication in rats. *Food & Function*, *13*(13), 7168–7180. https://doi.org/10.1039/D1FO04418D

Chen, Y.-Y., Liu, K., Zha, X.-Q., Li, Q.-M., Pan, L.-H., & Luo, J.-P. (2021). Encapsulation of luteolin using oxidized lotus root starch nanoparticles prepared by anti-solvent precipitation. *Carbohydrate Polymers*, *273*, 118552. https://doi.org/10.1016/j.carbpol.2021.118552

Chou, T.-Y., Lu, Y.-F., Inbaraj, B. S., & Chen, B.-H. (2018). Camelia oil and soybean-camelia oil blend enhance antioxidant activity and cardiovascular protection in hamsters. *Nutrition*, *51–52*, 86–94. https://doi.org/10.1016/j.nut.2017.12.011

Chtourou, F., Valli, E., Ben Mansour, A., Bendini, A., Gallina Toschi, T., & Bouaziz, M. (2021). Characterization of virgin olive oils obtained from minor Tunisian varieties for their valorization. *Journal of Food Measurement and Characterization*, *15*(6), 5060–5070. https://doi.org/10.1007/s11694-021-01066-7

Claro-Cala, C. M., Quintela, J. C., Pérez-Montero, M., Miñano, J., Alvarez De Sotomayor, M., Herrera, M. D., & Rodríguez-Rodríguez, R. (2020). Pomace olive oil concentrated in triterpenic acids restores vascular function, glucose tolerance and obesity progression in mice. *Nutrients*, *12*(2), 323. https://www.mdpi.com/2072-6643/12/2/323

Cornelio-Santiago, H. P., Bodini, R. B., Mazalli, M. R., Gonçalves, C. B., Rodrigues, C. E. C., & Lopes De Oliveira, A. (2022). Oil extraction from pequi (*Caryocar brasiliensis* Camb.) and sacha inchi (*Plukenetia huayllabambana* sp. Nov.) almonds by pressurized liquid with intermittent purge: The effects of variables on oil yield and composition. *The Journal of*

Supercritical Fluids, *182*, 105527. https://doi.org/10.1016/j.supflu.2022.105527

De La Torre, R., Carbó, M., Pujadas, M., Biel, S., Mesa, M.-D., Covas, M.-I., Expósito, M., Espejo, J.-A., Sanchez-Rodriguez, E., Díaz-Pellicer, P., Jimenez-Valladares, F., Rosa, C., Pozo, O., & Fitó, M. (2020). Pharmacokinetics of maslinic and oleanolic acids from olive oil – Effects on endothelial function in healthy adults. A randomized, controlled, dose–response study. *Food Chemistry*, *322*, 126676. https://doi.org/10.1016/j.foodchem.2020.126676

De Leo, E., Elmonem, M. A., Berlingerio, S. P., Berquez, M., Festa, B. P., Raso, R., Bellomo, F., Starborg, T., Janssen, M. J., Abbaszadeh, Z., Cairoli, S., Goffredo, B. M., Masereeuw, R., Devuyst, O., Lowe, M., Levtchenko, E., Luciani, A., Emma, F., & Rega, L. R. (2020). Cell-based phenotypic drug screening identifies luteolin as candidate therapeutic for nephropathic cystinosis. *Journal of the American Society of Nephrology*, *31*(7), 1522–1537. https://doi.org/10.1681/asn.2019090956

Demirbas, A., & Kinsara, R. A. (2017). Cost analysis of biodiesel from kernel oil of tea seed. *Energy Sources, Part B: Economics, Planning, and Policy*, *12*(5), 480–486. https://doi.org/10.1080/15567249.2016.1198846

Deniz, C., Ramos, R., Macía, I., Rivas, F., Ureña, A., Rosado, G., Rodriguez-Taboada, P., Aso-González, S., Padrones-Sánchez, S., & Escobar, I. (2019). P2.17-10 effects of the omega-6/omega-3 ratio on postoperative complications after lung resection: Preliminary results. *Journal of Thoracic Oncology*, *14*(10), S887. https://doi.org/10.1016/j.jtho.2019.08.1921

Dianatinasab, M., Wesselius, A., Salehi-Abargouei, A., Yu, E. Y. W., Fararouei, M., Brinkman, M., Van Den Brandt, P., White, E., Weiderpass, E., Le Calvez-Kelm, F., Gunter, M. J., Huybrechts, I., & Zeegers, M. P. (2022). Dietary fats and their sources in association with the risk of bladder cancer: A pooled analysis of 11 prospective cohort studies. *International Journal of Cancer*, *151*(1), 44–55. https://doi.org/10.1002/ijc.33970

Dierge, E., Debock, E., Guilbaud, C., Corbet, C., Mignolet, E., Mignard, L., Bastien, E., Dessy, C., Larondelle, Y., & Feron, O. (2021). Peroxidation of n-3 and n-6 polyunsaturated fatty acids in the acidic tumor environment leads to ferroptosis-mediated anticancer effects. *Cell Metabolism*, *33*(8), 1701–1715.e5. https://doi.org/10.1016/j.cmet.2021.05.016

Dini, I., Graziani, G., Fedele, F. L., Sicari, A., Vinale, F., Castaldo, L., & Ritieni, A. (2020). Effects of *Trichoderma* biostimulation on the phenolic profile of extra-virgin olive oil and olive oil by-products. *Antioxidants*, *9*(4), 284. https://www.mdpi.com/2076-3921/9/4/284

Djeziri, F. Z., Belarbi, M., Murtaza, B., Hichami, A., Benammar, C., & Khan, N. A. (2018). Oleanolic acid improves diet-induced obesity by modulating fat preference and inflammation in mice. *Biochimie*, *152*, 110–120. https://doi.org/10.1016/j.biochi.2018.06.025

Donat-Vargas, C., Domínguez, L. J., Sandoval-Insausti, H., Moreno-Franco, B., Rey-Garcia, J., Banegas, J. R., Rodríguez-Artalejo, F., & Guallar-Castillón, P. (2021). Olive oil consumption is associated with lower frailty risk: A prospective cohort study of community-dwelling older adults. *Age and Ageing*, *51*(1), afab198. https://doi.org/10.1093/ageing/afab198

Donat-Vargas, C., Sandoval-Insausti, H., Peñalvo, J. L., Moreno Iribas, M. C., Amiano, P., Bes-Rastrollo, M., Molina-Montes, E., Moreno-Franco, B., Agudo, A., Mayo, C. L., Laclaustra, M., De La Fuente Arrillaga, C., Chirlaque Lopez, M. D., Sánchez, M.-J., Martínez-Gonzalez, M. A., & Guallar-Castillón, P. (2022). Olive oil consumption is associated with a lower risk of cardiovascular disease and stroke. *Clinical Nutrition*, *41*(1), 122–130. https://doi.org/10.1016/j.clnu.2021.11.002

Dong, W.-P., Sun, J.-H., Liu, Y.-L., Xu, C., Wang, Y.-H., Suo, Z.-L., Zhou, S.-L., Zhang, Z.-X., & Wen, J. (2022). Phylogenomic relationships and species identification of the olive genus *Olea* (Oleaceae). *Journal of Systematics and Evolution*, *60*(6), 1263–1280. https://doi.org/10.1111/jse.12802

Duan, D., Huang, Y., Zou, Y., He, B., Tang, R., Yang, L., Zhang, Z., Su, S., Wang, G., Zhang, D., Zhou, C., Li, J., & Deng, M. (2021). Discrimination of Camellia seed oils extracted by supercritical CO_2 using electronic tongue technology. *Food Science and Biotechnology*, *30*(10), 1303–1312. https://doi.org/10.1007/s10068-021-00973-1

Dugo, L., Russo, M., Cacciola, F., Mandolfino, F., Salafia, F., Vilmercati, A., Fanali, C., Casale, M., De Gara, L., Dugo, P., Mondello, L., & Rigano, F. (2020). Determination of the phenol and tocopherol content in Italian high-quality extra-virgin olive oils by using LC-MS and multivariate data analysis. *Food Analytical Methods*, *13*(5), 1027–1041. https://doi.org/10.1007/s12161-020-01721-7

Elisia, I., & Kitts, D. D. (2013). Modulation of NF-κB and Nrf2 control of inflammatory responses in FHs 74 Int cell line is tocopherol isoform-specific. *American Journal of Physiology-Gastrointestinal and Liver Physiology*, *305*(12), G940–G949. https://doi.org/10.1152/ajpgi.00269.2013

Espínola, F., Vidal, A. M., Espínola, J. M., & Moya, M. (2021). Processing effect and characterization of olive oils from Spanish wild olive trees (*Olea europaea* var. *sylvestris*). *Molecules*, *26*(5), 1304. https://www.mdpi.com/1420-3049/26/5/1304

Fan, H., Sun, L., Yang, L., Zhou, J., Yin, P., Li, K., Xue, Q., Li, X., & Liu, Y. (2018). Assessment of the bioactive phenolic composition of *Acer truncatum* seed coat as a byproduct of seed oil. *Industrial Crops and Products*, *118*, 11–19. https://doi.org/10.1016/j.indcrop.2018.03.030

Fan, Y., Lin, F., Zhang, R., Wang, M., Gu, R., & Long, C. (2022). *Acer truncatum* Bunge: A comprehensive review on ethnobotany, phytochemistry and pharmacology. *Journal of Ethnopharmacology*, *282*, 114572. https://doi.org/10.1016/j.jep.2021.114572

Farha, A. K., Gan, R.-Y., Li, H.-B., Wu, D.-T., Atanasov, A. G., Gul, K., Zhang, J.-R., Yang, Q.-Q., & Corke, H. (2022). The anticancer potential of the dietary polyphenol rutin: Current status, challenges, and perspectives. *Critical Reviews in Food Science and Nutrition*, *62*(3), 832–859. https://doi.org/10.1080/10408398.2020.1829541

Fattahi-Far, E., Sahari, M. A., & Barzegar, M. (2006). Interesterification of tea seed oil and its application in margarine production. *Journal of the American Oil Chemists' Society*, *83*(10), 841–845. https://doi.org/10.1007/s11746-006-5035-9

Ferri, P., Angelino, D., Gennari, L., Benedetti, S., Ambrogini, P., Del Grande, P., & Ninfali, P. (2015). Enhancement of flavonoid ability to cross the blood–brain barrier of rats by co-administration with α-tocopherol. *Food & Function*, *6*(2), 394–400. https://doi.org/10.1039/C4FO00817K

Finno, C. J., Peterson, J., Kang, M., Park, S., Bordbari, M. H., Durbin-Johnson, B., Settles, M., Perez-Flores, M. C., Lee, J. H., & Yamoah, E. N. (2019). Single-cell RNA-seq reveals profound alterations in mechanosensitive dorsal root ganglion neurons with vitamin E deficiency. *iScience*, *21*, 720–735. https://doi.org/10.1016/j.isci.2019.10.064

Gao, J., Ma, L., Ma, J., Xia, S., Gong, S., Yin, Y., & Chen, Y. (2022). Camellia (*Camellia oleifera* Abel.) seed oil regulating of metabolic phenotype and alleviates dyslipidemia in high fat-fed mice through serum branch-chain amino acids. *Nutrients*, *14*(12), 2424. https://www.mdpi.com/2072-6643/14/12/2424

Gao, J., Wang, L., Zhao, C., Wu, Y., Lu, Z., Gu, Y., Ba, Z., Wang, X., Wang, J., & Xu, Y. (2021). Peony seed oil ameliorates neuroinflammation-mediated cognitive deficits by suppressing microglial activation through inhibition of NF-κB pathway in presenilin 1/2 conditional double knockout mice. *Journal of Leukocyte Biology*, *110*(6), 1005–1022. https://doi.org/10.1002/JLB.3MA0821-639RR

Gao, L.-L., Li, Y.-Q., Wang, Z.-S., Sun, G.-J., Qi, X.-M., & Mo, H.-Z. (2018). Physicochemical characteristics and functionality of tree peony (*Paeonia suffruticosa* Andr.) seed protein. *Food Chemistry*, *240*, 980–988. https://doi.org/10.1016/j.foodchem.2017.07.124

Gardner, K. G., Gebretsadik, T., Hartman, T. J., Rosa, M. J., Tylavsky, F. A., Adgent, M. A., Moore, P. E., Kocak, M., Bush, N. R., Davis, R. L., Lewinn, K. Z., Wright, R. J., & Carroll, K. N. (2020). Prenatal omega-3 and omega-6 polyunsaturated fatty acids and childhood atopic dermatitis. *The Journal of Allergy and Clinical Immunology: In Practice*, *8*(3), 937–944. https://doi.org/10.1016/j.jaip.2019.09.031

Gonzalez-Ramila, S., Garcia-Cordero, J., Sarria, B., Bravo, L., & Mateos, R. (2020). Consuming nutritional doses of olive pomace oil fulfils recommended dietary allowances of alpha-tocopherol. Results from a randomized clinical trial. *Proceedings of the Nutrition Society*, *79*, E256. https://doi.org/10.1017/S0029665120002049

González-Rámila, S., Mateos, R., García-Cordero, J., Seguido, M. A., Bravo-Clemente, L., & Sarriá, B. (2022). Olive pomace oil versus high oleic sunflower oil and sunflower oil: A comparative study in healthy and cardiovascular risk humans. *Foods*, *11*(15), 2186. https://www.mdpi.com/2304-8158/11/15/2186

Gu, R.-H., Morcol, T., Liu, B., Shi, M.-J., Kennelly, E. J., & Long, C.-L. (2019). GC–MS, UPLC-QTOF-MS, and bioactivity characterization of *Acer truncatum* seeds. *Industrial Crops and Products*, *138*, 111480. https://doi.org/10.1016/j.indcrop.2019.111480

Guasch-Ferré, M., Li, Y., Willett, W. C., Sun, Q., Sampson, L., Salas-Salvadó, J., Martínez-González, M. A., Stampfer, M. J., & Hu, F. B. (2022). Consumption of olive oil and risk of total and cause-specific mortality among U.S. adults. *Journal of the American College of Cardiology*, *79*(2), 101–112. https://doi.org/10.1016/j.jacc.2021.10.041

Guasch, M., Liu, G., Li, Y., Sampson, L., Manson, J. E., Salas-Salvado, J., Martinez-Gonzalez, M. A., Stampfer, M. J., Willett, W., Sun, Q., & Hu, F. B. (2020). Abstract P509: Olive oil consumption and risk of cardiovascular disease. *Circulation*, *141*(1), AP509. https://doi.org/10.1161/circ.141.suppl_1.P509

Günç Ergönül, P., & Aksoylu Özbek, Z. (2018). Identification of bioactive compounds and total phenol contents of cold pressed oils from safflower and camelina seeds. *Journal of Food Measurement and Characterization*, *12*(4), 2313–2323. https://doi.org/10.1007/s11694-018-9848-7

Guo, Z., Jia, X., Zheng, Z., Lu, X., Zheng, Y., Zheng, B., & Xiao, J. (2018). Chemical composition and nutritional function of olive (*Olea europaea* L.): A review. *Phytochemistry Reviews*, *17*(5), 1091–1110. https://doi.org/10.1007/s11101-017-9526-0

Gutiérrez-Luna, K., Ansorena, D., & Astiasarán, I. (2022). Fatty acid profile, sterols, and squalene content comparison between two conventional (olive oil and linseed oil) and three non-conventional vegetable oils (echium oil, hempseed oil, and moringa oil). *Journal of Food Science*, *87*(4), 1489–1499. https://doi.org/10.1111/1750-3841.16111

Hataminia, F., Farhadian, N., Karimi, M., & Ebrahimi, M. (2018). A novel method for squalene extraction from pumpkin seed oil using magnetic nanoparticles and exploring the inhibition effect of extracted squalene on angiogenesis property. *Journal of the Taiwan Institute of Chemical Engineers*, *91*, 1–9. https://doi.org/10.1016/j.jtice.2018.05.017

He, J., Dong, Y., Liu, X., Wan, Y., Gu, T., Zhou, X., & Liu, M. (2019). Comparison of chemical compositions, antioxidant, and anti-photoaging activities of *Paeonia suffruticosa* flowers at different flowering stages. *Antioxidants*, *8*(9), 345. https://www.mdpi.com/2076-3921/8/9/345

Heinzl, G. C., Mota, D. A., Martinis, V., Martins, A. S., Soares, C. M. F., Osório, N., Gominho, J., Madhavan Nampoothiri, K., Sukumaran, R. K., Pereira, H., & Ferreira-Dias, S. (2022). Integrated bioprocess for structured lipids, emulsifiers and biodiesel production using crude acidic olive pomace oils. *Bioresource Technology*, *346*, 126646. https://doi.org/10.1016/j.biortech.2021.126646

Henderson, G., Crofts, C., & Schofield, G. (2018). Linoleic acid and diabetes prevention. *The Lancet Diabetes & Endocrinology*, *6*(1), 12–13. https://doi.org/10.1016/S2213-8587(17)30404-7

Heyes, D. J., Zhang, S., Taylor, A., Johannissen, L. O., Hardman, S. J. O., Hay, S., & Scrutton, N. S. (2021). Photocatalysis as the 'master switch' of photomorphogenesis in early plant development. *Nature Plants*, *7*(3), 268–276. https://doi.org/10.1038/s41477-021-00866-5

Hu, P., Xu, X., & Yu, L. (2017). Physicochemical properties of *Acer truncatum* seed oil extracted using supercritical carbon dioxide. *Journal of the American Oil Chemists' Society*, *94*(6), 779–786. https://doi.org/10.1007/s11746-017-2983-1

Isanejad, M., Tajik, B., Mcardle, A., Tuppurainen, M., Sirola, J., Kröger, H., Rikkonen, T., & Erkkilä, A. (2022). Dietary omega-3 polyunsaturated fatty acid and alpha-linolenic acid are associated with physical capacity measure but not muscle mass in older women 65-72 years. *European Journal of Nutrition*, *61*(4), 1813–1821. https://doi.org/10.1007/s00394-021-02773-z

Iuliano, L., Mauriello, A., Sbarigia, E., Spagnoli, L. G., & Violi, F. (2000). Radiolabeled native low-density lipoprotein injected into patients with carotid stenosis accumulates in macrophages of atherosclerotic plaque. *Circulation*, *101*(11), 1249–1254. https://doi.org/10.1161/01.CIR.101.11.1249

Jimenez-Lopez, C., Carpena, M., Lourenço-Lopes, C., Gallardo-Gomez, M., Lorenzo, J. M., Barba, F. J., Prieto, M. A., & Simal-Gandara, J. (2020). Bioactive compounds and quality of extra virgin olive oil. *Foods*, *9*(8), 1014. https://www.mdpi.com/2304-8158/9/8/1014

Jurado-Campos, N., Rodríguez-Gómez, R., Arroyo-Manzanares, N., & Arce, L. (2023). Instrumental techniques to classify olive oils according to their quality. *Critical Reviews in Analytical Chemistry*, *53*, 139–160. https://doi.org/10.1080/10408347.2021.1940829

Jurado-Ruiz, E., Álvarez-Amor, L., Varela, L. M., Berná, G., Parra-Camacho, M. S., Oliveras-Lopez, M. J., Martínez-Force, E., Rojas, A., Hmadcha, A., Soria, B., & Martín, F. (2019). Extra virgin olive oil diet intervention improves insulin resistance and islet performance in diet-induced diabetes in mice. *Scientific Reports*, *9*(1), 11311. https://doi.org/10.1038/s41598-019-47904-z

Kageyama, Y., Kasahara, T., Nakamura, T., Hattori, K., Deguchi, Y., Tani, M., Kuroda, K., Yoshida, S., Goto, Y.-I., Inoue, K., & Kato, T. (2017). Plasma nervonic acid is a potential biomarker for major depressive disorder: A pilot study. *International Journal of Neuropsychopharmacology*, *21*(3), 207–215. https://doi.org/10.1093/ijnp/pyx089

Kamei, Y., Otsuka, Y., & Abe, K. (2009). Comparison of the inhibitory effects of vitamin E analogues on melanogenesis in mouse B16 melanoma cells. *Cytotechnology*, *59*(3), 183–190. https://doi.org/10.1007/s10616-009-9207-y

Ketenoglu, O., Sahin Ozkan, K., Yorulmaz, A., & Tekin, A. (2018). Molecular distillation of olive pomace oil—Multiobjective optimization for tocopherol and squalene. *LWT*, *91*, 198–202. https://doi.org/10.1016/j.lwt.2018.01.051

Khan, N., & Mukhtar, H. (2007). Tea polyphenols for health promotion. *Life Sciences*, *81*(7), 519–533. https://doi.org/10.1016/j.lfs.2007.06.011

Kim, J. D., Khan, M. I., Shin, J. H., Lee, M. G., Seo, H. J., Shin, T. S., & Kim, M. Y. (2015). HPLC fractionation and pharmacological assessment of green tea seed saponins for antimicrobial, anti-angiogenic and hemolytic activities. *Biotechnology and Bioprocess Engineering*, *20*(6), 1035–1043. https://doi.org/10.1007/s12257-015-0538-6

Kim, N.-H, Choi, S.-K., Kim, S.-J, Moon, P.-D., Lim, H.-S., Choi, I.-Y, Na, H.-J, An, H.-J., Myung, N.-Y., Jeong, H.-J., Um, J.-Y., Hong, S.-H., & Kim, H.-M. (2008). Green tea seed oil reduces weight gain in C57BL/6J mice and influences adipocyte differentiation by suppressing peroxisome proliferator-activated receptor-γ. *Pflügers Archiv—European Journal of Physiology*, *457*(2), 293–302. https://doi.org/10.1007/s00424-008-0537-y

Kodahl, N., & Sørensen, M. (2021). Sacha inchi (*Plukenetia volubilis* L.) is an underutilized crop with a great potential. *Agronomy*, *11*(6), 1066. https://www.mdpi.com/2073-4395/11/6/1066

Kohlschütter, A., Finckh, B., Nickel, M., Bley, A., & Hübner, C. (2020). First recognized patient with genetic vitamin E deficiency stable after 36 years of controlled supplement therapy. *Neurodegenerative Diseases*, *20*(1), 35–38. https://doi.org/10.1159/000508080

Kumar, V. P., Stone, S., Biswas, S., Sharma, N., & Ghosh, S. P. (2020). Gamma tocotrienol protects mice from targeted thoracic radiation injury [Original Research]. *Frontiers in Pharmacology*, *11*, 587970. https://doi.org/10.3389/fphar.2020.587970

Kwek, E., Zhu, H., Ding, H., He, Z., Hao, W., Liu, J., Ma, K. Y., & Chen, Z.-Y. (2022). Peony seed oil decreases plasma cholesterol and favorably modulates gut microbiota in hypercholesterolemic hamsters. *European Journal of Nutrition*, *61*, 2341–2356. https://doi.org/10.1007/s00394-021-02785-9

Lekshmi, R. G. K, Rahima, M., Chatterjee, N. S., Tejpal, C. S., Anas, K. K., Vishnu, K. V., Sarika, K., Asha, K. K., Anandan, R., & Suseela, M. (2019). Chitosan – Whey protein as efficient delivery system for squalene: Characterization and functional food application. *International Journal of Biological Macromolecules*, *135*, 855–863. https://doi.org/10.1016/j.ijbiomac.2019.05.153

Lewkowicz, N., Piątek, P., Namiecińska, M., Domowicz, M., Bonikowski, R., Szemraj, J., Przygodzka, P., Stasiolek, M., & Lewkowicz, P. (2019). Naturally occurring nervonic acid ester improves myelin synthesis by human oligodendrocytes. *Cells*, *8*(8), 786. https://www.mdpi.com/2073-4409/8/8/786

Li, G., Ma, L., Yan, Z., Zhu, Q., Cai, J., Wang, S., Yuan, Y., Chen, Y., & Deng, S. (2022). Extraction of oils and phytochemicals from *Camellia oleifera* seeds: Trends, challenges, and innovations. *Processes*, *10*(8), 1489. https://www.mdpi.com/2227-9717/10/8/1489

Li, G., Wang, X., Yang, H., Zhang, P., Wu, F., Li, Y., … Li, J. (2020). α-Linolenic acid but not linolenic acid protects against hypertension: Critical role of SIRT3 and autophagic flux. *Cell Death & Disease*, *11*(2), 83. https://doi.org/10.1038/s41419-020-2277-7

Li, P., Huang, J., Xiao, N., Cai, X., Yang, Y., Deng, J., … Du, B. (2020). Sacha inchi oil alleviates gut microbiota dysbiosis and improves hepatic lipid dysmetabolism in high-fat diet-fed rats. *Food & Function*, *11*(7), 5827–5841. https://doi.org/10.1039/D0FO01178A

Li, P., Wen, J., Ma, X., Lin, F., Jiang, Z., & Du, B. (2018). Structural, functional properties and immunomodulatory activity of isolated Inca peanut (*Plukenetia volubilis* L.) seed albumin fraction. *International Journal of Biological Macromolecules*, *118*, 1931–1941. https://doi.org/10.1016/j.ijbiomac.2018.07.046

Li, S., Zhang, L., Sun, M., Lv, M., Yang, Y., Xu, W., & Wang, L. (2022). Biogenesis of flavor-related linalool is diverged and genetically conserved in tree peony (*Paeonia × suffruticosa*). *Horticulture Research*, *10*(2), uhac253. https://doi.org/10.1093/hr/uhac253

Li, T., Liu, G.-S., Zhou, W., Jiang, M., Ren, Y.-H., Tao, X.-Y., Liu, M., Zhao, M., Wang, F.-Q., Gao, B., & Wei, D.-Z. (2020). Metabolic engineering of *Saccharomyces cerevisiae* to overproduce squalene. *Journal of Agricultural and Food Chemistry*, *68*(7), 2132–2138. https://doi.org/10.1021/acs.jafc.9b07419

Li, X., Li, T., Hong, X. Y., Liu, J. J., Yang, X. F., & Liu, G. P. (2021). *Acer Truncatum* seed oil alleviates learning and memory impairments of aging mice [Original Research]. *Frontiers in Cell and Developmental Biology*, *9*, 680386. https://doi.org/10.3389/fcell.2021.680386

Li, Y., Bharath, L. P., Qian, Y., Ruan, T., Anandh Babu, P. V., Bruno, R. S., Symons, J. D., & Jalili, T. (2016). γ-Carboxyethyl hydroxychroman, a metabolite of γ-tocopherol, preserves nitric oxide bioavailability in endothelial cells challenged with high glucose. *Experimental Biology and Medicine*, *241*(18), 2056–2062. https://doi.org/10.1177/1535370216661780

Liang, M.-H., He, Y.-J, Liu, D.-M., & Jiang, J.-G. (2021). Regulation of carotenoid degradation and production of apocarotenoids in natural and engineered organisms. *Critical Reviews in Biotechnology*, *41*(4), 513–534. https://doi.org/10.1080/07388551.2021.1873242

Liang, Q., Wang, W., Yuan, F., Liu, X., Li, D., & Yang, K. Q. (2019). Characterization of yuanbaofeng (*Acer truncatum* Bunge) samaras: Oil, fatty acid, and phytosterol content. *Industrial Crops and Products*, *135*, 344–351. https://doi.org/10.1016/j.indcrop.2019.04.032

Lin, C.-Y., Chen, S.-Y., Lee, W.-T., & Yen, G.-C. (2022). Immunomodulatory effect of camellia oil (*Camellia oleifera* Abel.) on CD19+ B cells enrichment and IL-10 production in BALB/c mice. *Journal of Functional Foods*, *88*, 104863. https://doi.org/10.1016/j.jff.2021.104863

Lin, P., Wang, K., Zhou, C., Xie, Y., Yao, X., & Yin, H. (2018). Seed transcriptomics analysis in *Camellia oleifera* uncovers genes associated with oil content and fatty acid composition. *International Journal of Molecular Sciences*, *19*(1), 118. https://www.mdpi.com/1422-0067/19/1/118

Liu, G., Zhu, W., Zhang, J., Song, D., Zhuang, L., Ma, Q., Yang, X., Liu, X., Zhang, J., Zhang, H., Wang, J., Liang, L., & Xu, X. (2022). Antioxidant capacity of phenolic compounds separated from tea seed oil in vitro and in vivo. *Food Chemistry*, *371*, 131122. https://doi.org/10.1016/j.foodchem.2021.131122

Liu, P., Zhang, L.-N., Wang, X.-S., Gao, J.-Y., Yi, J.-P., & Deng, R.-X. (2019). Characterization of *Paeonia ostii* seed and oil sourced from different cultivation areas in China. *Industrial Crops and Products*, *133*, 63–71. https://doi.org/10.1016/j.indcrop.2019.01.054

Liu, W., Zhang, T., Yin, D.-X., Song, P., Hou, X.-G., Qi, Q., & Qi, Z.-H. (2020). Major fatty acid profiles and bioactivity of seed oils from ten tree peony cultivars as a potential raw material source for the cosmetics and healthy products. *Chemistry & Biodiversity*, *17*(10), e2000469. https://doi.org/10.1002/cbdv.202000469

Liu, Y., Geng, Y., Zhang, S., Hu, B., Wang, J., & He, J. (2022). Quantitative analysis and screening for key genes related to tea saponin in *Camellia Oleifera* Abel. Seeds. *Food Bioscience*, *49*, 101901. https://doi.org/10.1016/j.fbio.2022.101901

Loffredo, L., Perri, L., Di Castelnuovo, A., Iacoviello, L., De Gaetano, G., & Violi, F. (2015). Supplementation with vitamin E alone is associated with reduced myocardial infarction: A meta-analysis. *Nutrition, Metabolism and Cardiovascular Diseases*, *25*(4), 354–363. https://doi.org/10.1016/j.numecd.2015.01.008

Lou-Bonafonte, J. M., Martínez-Beamonte, R., Sanclemente, T., Surra, J. C., Herrera-Marcos, L. V., Sanchez-Marco, J., … Osada, J. (2018). Current insights into the biological action of squalene. *Molecular Nutrition & Food Research*, *62*(15), 1800136. https://doi.org/10.1002/mnfr.201800136

Lu, Y., Li, H., & Geng, Y. (2018). Analysis of the effects of δ-tocopherol on RAW264.7 and K562 cells based on 1H NMR metabonomics. *Journal of Agricultural and Food Chemistry*, *66*(4), 1039–1046. https://doi.org/10.1021/acs.jafc.7b04667

Luo, S.-Z., Chen, S.-S., Pan, L.-H., Qin, X.-S., Zheng, Z., Zhao, Y.-Y., Pang, M., & Jiang, S.-T. (2017). Antioxidative capacity of crude camellia seed oil: Impact of lipophilization products of blueberry anthocyanin. *International Journal of Food Properties*, *20*(2), 1627–1636. https://doi.org/10.1080/10942912.2017.1350974

Ma, Q., Sun, T., Li, S., Wen, J., Zhu, L., Yin, T., Yan, K., Xu, X., Li, S., Mao, J., Wang, Y.-N., Jin, S., Zhao, X., & Li, Q. (2020). The *Acer truncatum* genome provides insights into nervonic acid biosynthesis. *The Plant Journal*, *104*(3), 662–678. https://doi.org/10.1111/tpj.14954

Maestri, D., Barrionuevo, D., Bodoira, R., Zafra, A., Jiménez-López, J., & Alché, J. D. (2019). Nutritional profile and nutraceutical components of olive (*Olea europaea* L.) seeds. *Journal of Food Science and Technology*, *56*(9), 4359–4370. https://doi.org/10.1007/s13197-019-03904-5

Mao, Y., Han, J., Tian, F., Tang, X., Hu, Y., & Guan, Y. (2017). Chemical composition analysis, sensory, and feasibility study of tree peony seed. *Journal of Food Science*, *82*(2), 553–561. https://doi.org/10.1111/1750-3841.13593

Martakos, I., Kostakis, M., Dasenaki, M., Pentogennis, M., & Thomaidis, N. (2020). Simultaneous determination of pigments, tocopherols, and squalene in Greek olive oils: A study of the influence of cultivation and oil-production parameters. *Foods*, *9*(1), 31. https://www.mdpi.com/2304-8158/9/1/31

Mateos, R., Sarria, B., & Bravo, L. (2020). Nutritional and other health properties of olive pomace oil. *Critical Reviews in Food Science and Nutrition*, *60*(20), 3506–3521. https://doi.org/10.1080/10408398.2019.1698005

Moral, R., & Escrich, E. (2022). Influence of olive oil and its components on breast cancer: Molecular mechanisms. *Molecules*, *27*(2), 477. https://www.mdpi.com/1420-3049/27/2/477

Mousavi, S., Stanzione, V., Mariotti, R., Mastio, V., Azariadis, A., Passeri, V., Valeri, M. C., Baldoni, L., & Bufacchi, M. (2022). Bioactive compound profiling of olive fruit: The contribution of genotype. *Antioxidants*, *11*(4), 672. https://www.mdpi.com/2076-3921/11/4/672

Mu, H. (2004). The digestion of dietary triacylglycerols. *Progress in Lipid Research*, *43*(2), 105–133. https://doi.org/10.1016/S0163-7827(03)00050-X

Muhammad, N., Ruiz, F., Stanley, J., Rashmi, R., Cho, K., Jayachandran, K., Zahner, M. C., Huang, Y., Zhang, J., Markovina, S., Patti, G. J., & Schwarz, J.

K. (2022). Monounsaturated and diunsaturated fatty acids sensitize cervical cancer to radiation therapy. *Cancer Research*, *82*(24), 4515–4527. https://doi.org/10.1158/0008-5472.Can-21-4369

Nakano, K., Sasaki, S., & Kataoka, T. (2022). Bioactive evaluation of ursane-type pentacyclic triterpenoids: β-Boswellic acid interferes with the glycosylation and transport of intercellular adhesion molecule-1 in human lung adenocarcinoma A549 cells. *Molecules*, *27*(10), 3073. https://www.mdpi.com/1420-3049/27/10/3073

Nishizaki, Y., Shimada, K., Tani, S., Ogawa, T., Ando, J., Takahashi, M., Yamamoto, M., Shinozaki, T., Miyazaki, T., Miyauchi, K., Nagao, K., Hirayama, A., Yoshimura, M., Komuro, I., Nagai, R., & Daida, H. (2020). Association between the ratio of serum n-3 to n-6 polyunsaturated fatty acids and acute coronary syndrome in non-obese patients with coronary risk factor: A multicenter cross-sectional study. *BMC Cardiovascular Disorders*, *20*(1), 160. https://doi.org/10.1186/s12872-020-01445-w

Noce, A., Di Daniele, F., Marrone, G., Pietroboni Zaitseva, A., Urciuoli, S., Di Lauro, M., Di Daniele, N., & Romani, A. (2021). MO594 potential beneficial effect of extra virgin olive oil with high minor polar compounds contents in nephropathic patients: Preliminary data. *Nephrology Dialysis Transplantation*, *36*(1), gfab089.007. https://doi.org/10.1093/ndt/gfab089.007

Norhazlindah, M. F, Jahurul, M. H. A., Norliza, M., Shihabul, A., Islam, S., Nyam, K. L, & Zaidul, I. S. M (2023). Techniques for extraction, characterization, and application of oil from sacha inchi (*Plukenetia volubilis* L.) seed: A review. *Journal of Food Measurement and Characterization*, *17*, 904–915. https://doi.org/10.1007/s11694-022-01663-0

Oi-Kano, Y., Iwasaki, Y., Nakamura, T., Watanabe, T., Goto, T., Kawada, T., Watanabe, K., & Iwai, K. (2017). Oleuropein aglycone enhances UCP1 expression in brown adipose tissue in high-fat-diet-induced obese rats by activating β-adrenergic signaling. *The Journal of Nutritional Biochemistry*, *40*, 209–218. https://doi.org/10.1016/j.jnutbio.2016.11.009

Olmo-García, L., & Carrasco-Pancorbo, A. (2021). Chromatography-MS based metabolomics applied to the study of virgin olive oil bioactive compounds: Characterization studies, agro-technological investigations and assessment of healthy properties. *TrAC, Trends in Analytical Chemistry*, *135*, 116153. https://doi.org/10.1016/j.trac.2020.116153

Pacetti, D., Scortichini, S., Boarelli, M. C., & Fiorini, D. (2019). Simple and rapid method to analyse squalene in olive oils and extra virgin olive oils. *Food Control*, *102*, 240–244. https://doi.org/10.1016/j.foodcont.2019.03.005

Palomares-Rius, J. E., Belaj, A., León, L., De La Rosa, R., Rapoport, H. F., & Castillo, P. (2019). Evaluation of the phytopathological reaction of wild and cultivated olives as a means of finding promising new sources of genetic diversity for resistance to root-knot nematodes. *Plant Disease*, *103*(10), 2559–2568. https://doi.org/10.1094/pdis-02-19-0322-re

Pastor, R., Bouzas, C., & Tur, J. A. (2021). Beneficial effects of dietary supplementation with olive oil, oleic acid, or hydroxytyrosol in metabolic syndrome: Systematic review and meta-analysis. *Free Radical Biology and Medicine*, *172*, 372–385. https://doi.org/10.1016/j.freeradbiomed.2021.06.017

Petruccelli, R., Bartolini, G., Ganino, T., Zelasco, S., Lombardo, L., Perri, E., Durante, M., & Bernardi, R. (2022). Cold stress, freezing adaptation, varietal susceptibility of *Olea europaea* L.: A review. *Plants*, *11*(10), 1367. https://www.mdpi.com/2223-7747/11/10/1367

Pinthong, W., & Suanarunsawat, T. (2020). Tea seed oil alleviates metabolic derangement and oxidative stress in rats fed with high fat and high fructose diet. *Chiang Mai University Journal of Natural Sciences*, *19*(4), 665.

Pokkanta, P., Sookwong, P., Tanang, M., Setchaiyan, S., Boontakham, P., & Mahatheeranont, S. (2019). Simultaneous determination of tocols, γ-oryzanols, phytosterols, squalene, cholecalciferol and phylloquinone in rice bran and vegetable oil samples. *Food Chemistry*, *271*, 630–638. https://doi.org/10.1016/j.foodchem.2018.07.225

Pozo, O. J., Pujadas, M., Gleeson, S. B., Mesa-García, M. D., Pastor, A., Kotronoulas, A., Fitó, M., Covas, M.-I., Navarro, J. R. F., Espejo, J. A., Sanchez-Rodriguez, E., Marchal, R., Calleja, M. A., & De La Torre, R. (2017). Liquid chromatography tandem mass spectrometric determination of triterpenes in human fluids: Evaluation of markers of dietary intake of olive oil and metabolic disposition of oleanolic acid and maslinic acid in humans. *Analytica Chimica Acta*, *990*, 84–95. https://doi.org/10.1016/j.aca.2017.07.041

Prasad, M., Jayaraman, S., Eladl, M. A., El-Sherbiny, M., Abdelrahman, M. A. E., Veeraraghavan, V. P., Vengadassalapathy, S., Umapathy, V. R., Jaffer Hussain, S. F., Krishnamoorthy, K., Sekar, D., Palanisamy, C. P., Mohan, S. K., & Rajagopal, P. (2022). A comprehensive review on therapeutic perspectives of phytosterols in insulin resistance: A mechanistic approach. *Molecules*, *27*(5), 1595. https://www.mdpi.com/1420-3049/27/5/1595

Qian, L., Yao, Y., Li, C., Xu, F., Ying, Y., Shao, Z., & Bao, J. (2021). Pasting, gelatinization, and retrogradation characteristics related to structural properties of tea seed starches. *Food Hydrocolloids*, *117*, 106701. https://doi.org/10.1016/j.foodhyd.2021.106701

Qiao, Q., Wang, X., Ren, H., An, K., Feng, Z., Cheng, T., & Sun, Z. (2019). Oil content and nervonic acid content of *Acer truncatum* seeds from 14 regions in China. *Horticultural Plant Journal*, *5*(1), 24–30. https://doi.org/10.1016/j.hpj.2018.11.001

Quiles, C., Viera, I., & Roca, M. (2022). Multiomics approach to decipher the origin of chlorophyll content in virgin olive oil. *Journal of Agricultural and Food Chemistry*, *70*(12), 3807–3817. https://doi.org/10.1021/acs.jafc.2c00031

Ramos-Escudero, F., Morales, M. T., Ramos Escudero, M., Muñoz, A. M., Cancino Chavez, K., & Asuero, A. G. (2021). Assessment of phenolic and volatile compounds of commercial sacha inchi oils and sensory evaluation. *Food Research International*, *140*, 110022. https://doi.org/10.1016/j.foodres.2020.110022

Ramos-Escudero, F., Muñoz, A. M., Ramos Escudero, M., Viñas-Ospino, A., Morales, M. T., & Asuero, A. G. (2019). Characterization of commercial sacha inchi oil according to its composition: Tocopherols, fatty acids, sterols, triterpene and aliphatic alcohols. *Journal of Food Science and Technology*, *56*(10), 4503–4515. https://doi.org/10.1007/s13197-019-03938-9

Ranard, K. M., & Erdman, J. W. (2017). Effects of dietary RRR α-tocopherol vs all-racemic α-tocopherol on health outcomes. *Nutrition Reviews*, *76*(3), 141–153. https://doi.org/10.1093/nutrit/nux067

Rave, M. C., Echeverri, J. D., & Salamanca, C. H. (2020). Improvement of the physical stability of oil-in-water nanoemulsions elaborated with sacha inchi oil employing ultra-high-pressure homogenization. *Journal of Food Engineering*, *273*, 109801. https://doi.org/10.1016/j.jfoodeng.2019.109801

Rincón-Cervera, M. Á., Valenzuela, R., Hernandez-Rodas, M. C., Barrera, C., Espinosa, A., Marambio, M., & Valenzuela, A. (2016). Vegetable oils rich in alpha linolenic acid increment hepatic n-3 LCPUFA, modulating the fatty acid metabolism and antioxidant response in rats. *Prostaglandins, Leukotrienes and Essential Fatty Acids*, *111*, 25–35. https://doi.org/10.1016/j.plefa.2016.02.002

Rocchetti, G., Luisa Callegari, M., Senizza, A., Giuberti, G., Ruzzolini, J., Romani, A., Urciuoli, S., Nediani, C., & Lucini, L. (2022). Oleuropein from olive leaf extracts and extra-virgin olive oil provides distinctive phenolic profiles and modulation of microbiota in the large intestine. *Food Chemistry*, *380*, 132187. https://doi.org/10.1016/j.foodchem.2022.132187

Rocchetti, G., Senizza, B., Giuberti, G., Montesano, D., Trevisan, M., & Lucini, L. (2020). Metabolomic study to evaluate the transformations of extra-virgin olive oil's antioxidant phytochemicals during in vitro gastrointestinal digestion. *Antioxidants*, *9*(4), 302. https://www.mdpi.com/2076-3921/9/4/302

Rodríguez-García, C., Sánchez-Quesada, C., Toledo, E., Delgado-Rodríguez, M., & Gaforio, J. (2019). Naturally lignan-rich foods: A dietary tool for health promotion? *Molecules*, *24*(5), 917. https://www.mdpi.com/1420-3049/24/5/917

Rodríguez, G., Squeo, G., Estivi, L., Quezada Berru, S., Buleje, D., Caponio, F., Brandolini, A., & Hidalgo, A. (2021). Changes in stability, tocopherols, fatty acids and antioxidant capacity of sacha inchi (*Plukenetia volubilis*) oil during French fries deep-frying. *Food Chemistry*, *340*, 127942. https://doi.org/10.1016/j.foodchem.2020.127942

Rosqvist, F., Kullberg, J., Ståhlman, M., Cedernaes, J., Heurling, K., Johansson, H.-E., … Risérus, U. (2019). Overeating saturated fat promotes fatty liver and ceramides compared with polyunsaturated fat: A randomized trial. *The Journal of Clinical Endocrinology & Metabolism*, *104*(12), 6207–6219. https://doi.org/10.1210/jc.2019-00160

Ruiz-Méndez, M.-V., Márquez-Ruiz, G., Holgado, F., & Velasco, J. (2021). Stability of bioactive compounds in olive-pomace oil at frying temperature and incorporation into fried foods. *Foods*, *10*(12), 2906. https://www.mdpi.com/2304-8158/10/12/2906

Sahari, M. A., Ataii, D., & Hamedi, M. (2004). Characteristics of tea seed oil in comparison with sunflower and olive oils and its effect as a natural antioxidant. *Journal of the American Oil Chemists' Society*, *81*(6), 585–588. https://doi.org/10.1007/s11746-006-0945-0

Saini, R. K., & Keum, Y.-S. (2018). Omega-3 and omega-6 polyunsaturated fatty acids: Dietary sources, metabolism, and significance – A review. *Life Sciences*, *203*, 255–267. https://doi.org/10.1016/j.lfs.2018.04.049

Sánchez-Rodríguez, L., Kranjac, M., Marijanović, Z., Jerković, I., Corell, M., Moriana, A., Carbonell-Barrachina, Á. A., Sendra, E., & Hernández, F. (2019). Quality attributes and fatty acid, volatile and sensory profiles of "Arbequina" hydrosostainable olive oil. *Molecules*, *24*(11), 2148. https://www.mdpi.com/1420-3049/24/11/2148

Sánchez, M., Romero, M., Gómez-Guzmán, M., Tamargo, J., Pérez-Vizcaino, F., & Duarte, J. (2019). Cardiovascular effects of flavonoids. *Current Medicinal Chemistry*, *26*(39), 6991–7034. https://doi.org/10.2174/0929867326666181220094721

Sathe, S. K., Kshirsagar, H. H., & Sharma, G. M. (2012). Solubilization, fractionation, and electrophoretic characterization of Inca peanut (*Plukenetia volubilis* L.) proteins. *Plant Foods for Human Nutrition*, *67*(3), 247–255. https://doi.org/10.1007/s11130-012-0301-5

Scicchitano, P., Cameli, M., Maiello, M., Modesti, P. A., Muiesan, M. L., Novo, S., Palmiero, P., Saba, P. S., Pedrinelli, R., & Ciccone, M. M. (2014). Nutraceuticals and dyslipidaemia: Beyond the common therapeutics. *Journal of Functional Foods*, *6*, 11–32. https://doi.org/10.1016/j.jff.2013.12.006

Seçmeler, Ö., & Güçlü Üstündağ, Ö. (2019). Partitioning of predominant lipophilic bioactives (squalene, α-tocopherol and β-sitosterol) during olive oil processing. *International Journal of Food Science & Technology*, *54*(5), 1609–1616. https://doi.org/10.1111/ijfs.14029

Shahidi, F., & Ambigaipalan, P. (2018). Omega-3 polyunsaturated fatty acids and their health benefits. *Annual Review of Food Science and Technology*, *9*(1), 345–381. https://doi.org/10.1146/annurev-food-111317-095850

Shao, P., Liu, Q., Fang, Z., & Sun, P. (2015). Chemical composition, thermal stability and antioxidant properties of tea seed oils obtained by different extraction methods: Supercritical fluid extraction yields the best oil quality. *European Journal of Lipid Science and Technology*, *117*(3), 355–365. https://doi.org/10.1002/ejlt.201400259

Shi, M., Huang, F., Deng, C., Wang, Y., & Kai, G. (2019). Bioactivities, biosynthesis and biotechnological production of phenolic acids in *Salvia miltiorrhiza*. *Critical Reviews in Food Science and Nutrition*, *59*(6), 953–964. https://doi.org/10.1080/10408398.2018.1474170

Shi, T., Zhu, M., Zhou, X., Huo, X., Long, Y., Zeng, X., & Chen, Y. (2019). 1H NMR combined with PLS for the rapid determination of squalene and sterols in vegetable oils. *Food Chemistry*, *287*, 46–54. https://doi.org/10.1016/j.foodchem.2019.02.072

Shramko, V. S., Polonskaya, Y. V., & Kashtanova, E. V., Stakhneva, E. M., Ragino, Y. I. (2020). The short overview on the relevance of fatty acids for human cardiovascular disorders. *Biomolecules*, *10*(8), 1127. https://www.mdpi.com/2218-273X/10/8/1127

Silva, F. S. G., Oliveira, P. J., & Duarte, M. F. (2016). Oleanolic, ursolic, and betulinic acids as food supplements or pharmaceutical agents for type 2 diabetes: Promise or illusion? *Journal of Agricultural and Food Chemistry*, *64*(15), 2991–3008. https://doi.org/10.1021/acs.jafc.5b06021

Silva, K. F. C. E., Da Silva Carvalho, A. G., Rabelo, R. S., & Hubinger, M. D. (2019). Sacha inchi oil encapsulation: Emulsion and alginate beads characterization. *Food and Bioproducts Processing*, *116*, 118–129. https://doi.org/10.1016/j.fbp.2019.05.001

Skulas-Ray, A. C., Wilson, P. W. F., Harris, W. S., Brinton, E. A., Kris-Etherton, P. M., Richter, C. K., Jacobson, T. A., Engler, M. B., Miller, M., Robinson, J. G., Blum, C. B., Rodriguez-Leyva, D., De Ferranti, S. D., & Welty, F. K. (2019). Omega-3 fatty acids for the management of hypertriglyceridemia: A science advisory from the American Heart Association. *Circulation*, *140*(12), e673–e691. https://doi.org/10.1161/CIR.0000000000000709

Soimee, W., Nakyai, W., Charoensit, P., Grandmottet, F., Worasakwutiphong, S., Phimnuan, P., & Viyoch, J. (2020). Evaluation of moisturizing and irritation potential of sacha inchi oil. *Journal of Cosmetic Dermatology*, *19*(4), 915–924. https://doi.org/10.1111/jocd.13099

Song, W., Zhang, K., Xue, T., Han, J., Peng, F., Ding, C., … Chen, X. (2022). Cognitive improvement effect of nervonic acid and essential fatty acids on rats ingesting *Acer truncatum* Bunge seed oil revealed by lipidomics approach. *Food & Function*, *13*(5), 2475–2490. https://doi.org/10.1039/D1FO03671H

Su, J., Ma, C., Liu, C., Gao, C., Nie, R., & Wang, H. (2016). Hypolipidemic activity of peony seed oil rich in α-linolenic, is mediated through inhibition of lipogenesis and upregulation of fatty acid β-oxidation. *Journal of Food Science*, *81*(4), H1001–H1009. https://doi.org/10.1111/1750-3841.13252

Suárez Montenegro, Z. J., Álvarez-Rivera, G., Sánchez-Martínez, J. D., Gallego, R., Valdés, A., Bueno, M., Cifuentes, A., & Ibáñez, E. (2021). Neuroprotective effect of terpenoids recovered from olive oil by-products. *Foods*, *10*(7), 1507. https://www.mdpi.com/2304-8158/10/7/1507

Suealek, N., Tharavanij, T., Hackman, R. M., Keen, C. L., Holt, R. R., Burawat, B., Chaikan, A., Tiengtip, R., & Rojpibulstit, P. (2021). Thai tea seed oil and virgin olive oil similarly reduce plasma lipids: A pilot study within a healthy adult male population. *European Journal of Lipid Science and Technology*, *123*(2), 2000126. https://doi.org/10.1002/ejlt.202000126

Sun, L., & Miao, M. (2020). Dietary polyphenols modulate starch digestion and glycaemic level: A review. *Critical Reviews in Food Science and Nutrition*, *60*(4), 541–555. https://doi.org/10.1080/10408398.2018.1544883

Tang, G., Huang, Y., Zhang, T., Wang, Q., Crommen, J., Fillet, M., & Jiang, Z. (2018). Determination of phenolic acids in extra virgin olive oil using supercritical fluid chromatography coupled with single quadrupole mass spectrometry. *Journal of Pharmaceutical and Biomedical Analysis*, *157*, 217–225. https://doi.org/10.1016/j.jpba.2018.05.025

Tardugno, R., Cicero, N., Costa, R., Nava, V., & Vadalà, R. (2022). Exploring lignans, a class of health promoting compounds, in a variety of edible oils from Brazil. *Foods*, *11*(10), 1386. https://www.mdpi.com/2304-8158/11/10/1386

Tian, X., Guo, S., Zhang, S., Li, P., Wang, T., Ho, C.-T., Pan, M.-H., & Bai, N. (2020). Chemical characterization of main bioactive constituents in *Paeonia ostii* seed meal and GC-MS analysis of seed oil. *Journal of Food Biochemistry*, *44*(1), e13088. https://doi.org/10.1111/jfbc.13088

Torres-Sánchez, J., De La Rosa, R., León, L., Jiménez-Brenes, F. M., Kharrat, A., & López-Granados, F. (2022). Quantification of dwarfing effect of different rootstocks in 'Picual' olive cultivar using UAV-photogrammetry. *Precision Agriculture*, *23*(1), 178–193. https://doi.org/10.1007/s11119-021-09832-9

Tung, Y.-T, Hsu, Y.-J., Chien, Y.-W, Huang, C.-C., Huang, W.-C., & Chiu, W.-C. (2019). Tea seed oil prevents obesity, reduces physical fatigue, and improves exercise performance in high-fat-diet-induced obese ovariectomized mice. *Molecules*, *24*(5), 980. https://www.mdpi.com/1420-3049/24/5/980

Uoonlue, N., & Muangrat, R. (2019). Effect of different solvents on subcritical solvent extraction of oil from Assam tea seeds (*Camellia sinensis* var. *assamica*): Optimization of oil extraction and physicochemical analysis. *Journal of Food Process Engineering*, *42*(2), e12960. https://doi.org/10.1111/jfpe.12960

Velasco, J., Holgado, F., Márquez-Ruiz, G., & Ruiz-Méndez, M. V. (2018). Concentrates of triterpenic acids obtained from crude olive pomace oils: Characterization and evaluation of their potential antioxidant activity. *Journal of the Science of Food and Agriculture*, *98*(13), 4837–4844. https://doi.org/10.1002/jsfa.9012

Verge-Mèrida, G., Solà-Oriol, D., Tres, A., Verdú, M., Farré, G., Garcés-Narro, C., & Barroeta, A. C. (2022). Olive pomace oil and acid oil as alternative fat sources in growing-finishing broiler chicken diets. *Poultry Science*, 102079. https://doi.org/10.1016/j.psj.2022.102079

Villacorta, L., GraçA-Souza, A. V., Ricciarelli, R., Zingg, J.-M., & Azzi, A. (2003). α-Tocopherol induces expression of connective tissue growth factor and antagonizes tumor necrosis factor-α–mediated downregulation in human smooth muscle cells. *Circulation Research*, *92*(1), 104–110. https://doi.org/10.1161/01.RES.0000049103.38175.1B

Villanueva-Corrales, S., García-Botero, C., Garcés-Cardona, F., Ramírez-Ríos, V., Villanueva-Mejía, D. F., & Álvarez, J. C. (2021). The complete chloroplast genome of *Plukenetia volubilis* provides insights into the organelle inheritance [Original Research]. *Frontiers in Plant Science*, *12*, 667060. https://doi.org/10.3389/fpls.2021.667060

Wang, M., Wu, W., Xiao, J., Li, C., Chen, B., & Shen, Y. (2022). Recent development in antioxidant peptides of woody oil plant by-products. *Food Reviews International*, *39*, 5479–5500. https://doi.org/10.1080/87559129.2022.2073367

Wang, S., Zhu, F., & Kakuda, Y. (2018). Sacha inchi (*Plukenetia volubilis* L.): Nutritional composition, biological activity, and uses. *Food Chemistry*, *265*, 316–328. https://doi.org/10.1016/j.foodchem.2018.05.055

Wang, X., Contreras, M. D. M., Xu, D., Jia, W., Wang, L., & Yang, D. (2021). New insights into free and bound phenolic compounds as antioxidant cluster in tea seed oil: Distribution and contribution. *LWT*, *136*, 110315. https://doi.org/10.1016/j.lwt.2020.110315

Wang, X., Li, C., Contreras, M. D. M., Verardo, V., Gómez-Caravaca, A. M., & Xing, C. (2020). Integrated profiling of fatty acids, sterols and phenolic compounds in tree and herbaceous peony seed oils: Marker screening for new resources of vegetable oil. *Foods*, *9*(6), 770. https://www.mdpi.com/2304-8158/9/6/770

Wang, X., Zeng, Q., Del Mar Contreras, M., & Wang, L. (2017). Profiling and quantification of phenolic compounds in Camellia seed oils: Natural tea polyphenols in vegetable oil. *Food Research International*, *102*, 184–194. https://doi.org/10.1016/j.foodres.2017.09.089

Wang, X., Zeng, Q., Verardo, V., & Contreras, M. D. M. (2017). Fatty acid and sterol composition of tea seed oils: Their comparison by the “FancyTiles” approach. *Food Chemistry*, *233*, 302–310. https://doi.org/10.1016/j.foodchem.2017.04.110

Wang, Y., Sun, D., Chen, H., Qian, L., & Xu, P. (2011). Fatty acid composition and antioxidant activity of tea (*Camellia sinensis* L.) seed oil extracted by optimized supercritical carbon dioxide. *International Journal of Molecular Sciences*, *12*(11), 7708–7719. https://www.mdpi.com/1422-0067/12/11/7708

Wang, Y., Xu, L., Shehzad, Q., Zhang, Y., Karrar, E., Zhang, H., Jin, Q., Wu, G., & Wang, X. (2023). Influence of different extraction methods on the chemical composition, antioxidant activity, and overall quality attributes of oils from peony seeds (*Paeonia suffruticosa* Andr.). *Journal of Food Measurement and Characterization*, *17*, 2953–2963. https://doi.org/10.1007/s11694-023-01838-3

Wang, Z., Zheng, C., Huang, F., Liu, C., Huang, Y., & Wang, W. (2021). Effects of radio frequency pretreatment on quality of tree peony seed oils: Process optimization and comparison with microwave and roasting. *Foods*, *10*(12), 3062. https://www.mdpi.com/2304-8158/10/12/3062

Wei, Z., Yang, K., Guo, M., Luan, X., Duan, Z., & Li, X. (2022). The effect of thermal pretreatment processing on the distribution of free and bound phenolics in virgin *Camellia oleifera* seed oil. *LWT*, *161*, 113349. https://doi.org/10.1016/j.lwt.2022.113349

Wu, D., Wang, P., Huo, Z., Yuan, X., Jiang, H., Yang, J., Tang, J., & Ma, Y. (2022). Changes in climate suitability for oil-tea (*C. oleifera* Abel) production in China under historical and future climate conditions. *Agricultural and Forest Meteorology*, *316*, 108843. https://doi.org/10.1016/j.agrformet.2022.108843

Wu, H., Li, C., Li, Z., Liu, R., Zhang, A., Xiao, Z., Ma, L., Li, J., & Deng, S. (2018). Simultaneous extraction of oil and tea saponin from *Camellia oleifera* Abel. seeds under subcritical water conditions. *Fuel Processing Technology*, *174*, 88–94. https://doi.org/10.1016/j.fuproc.2018.02.014

Wu, J., Fan, X., Huang, X., Li, G., Guan, J., Tang, X., Qiu, M., Yang, S., & Lu, S. (2021). Effect of different drying treatments on the quality of *Camellia oleifera* seed oil. *South African Journal of Chemical Engineering*, *35*, 8–13. https://doi.org/10.1016/j.sajce.2020.10.003

Wu, Y., Yang, Y., Liu, C., Hou, Y., Yang, S., Wang, L., & Zhang, X. (2021). Potential suitable habitat of two economically important forest trees (*Acer truncatum* and *Xanthoceras sorbifolium*) in east Asia under current and future climate scenarios. *Forests*, *12*(9), 1263. https://www.mdpi.com/1999-4907/12/9/1263

Xiao, S., Si, L., Tian, Z., Jiao, P., Fan, Z., Meng, K., Zhou, X., Wang, H., Xu, R., Han, X., Fu, G., Zhang, Y., Zhang, L., & Zhou, D. (2016). Pentacyclic triterpenes grafted on CD cores to interfere with influenza virus entry: A dramatic multivalent effect. *Biomaterials*, *78*, 74–85. https://doi.org/10.1016/j.biomaterials.2015.11.034

Xiao, S., Tian, Z., Wang, Y., Si, L., Zhang, L., & Zhou, D. (2018). Recent progress in the antiviral activity and mechanism study of pentacyclic triterpenoids and their derivatives. *Medicinal Research Reviews*, *38*(3), 951–976. https://doi.org/10.1002/med.21484

Xie, D., Chen, Y., Yu, J., Yang, Z., Wang, X., & Wang, X. (2022). Progress in enrichment of n-3 polyunsaturated fatty acid: A review. *Critical Reviews in Food Science and Nutrition*, 1–17. https://doi.org/10.1080/10408398.2022.2086852

Xie, H., Zhang, J., Cheng, J., Zhao, S., Wen, Q., Kong, P., Zhao, Y., Xiang, X., & Rong, J. (2023). Field plus lab experiments help identify freezing tolerance and associated genes in subtropical evergreen broadleaf trees: A case study of *Camellia oleifera* [Original Research]. *Frontiers in Plant Science*, *14*, 1113125. https://doi.org/10.3389/fpls.2023.1113125

Xuan, T., Gangqiang, G., Minh, T., Quy, T., & Khanh, T. (2018). An overview of chemical profiles, antioxidant and antimicrobial activities of commercial vegetable edible oils marketed in Japan. *Foods*, *7*(2), 21. https://www.mdpi.com/2304-8158/7/2/21

Xue, Y., Liu, R., Xue, J., Wang, S., & Zhang, X. (2021). Genetic diversity and relatedness analysis of nine wild species of tree peony based on simple sequence repeats markers. *Horticultural Plant Journal*, *7*(6), 579–588. https://doi.org/10.1016/j.hpj.2021.05.004

Yan, Z., Xie, L., Tian, Y., Li, M., Ni, J., Zhang, Y., & Niu, L. (2020). Insights into the phytochemical composition and bioactivities of seeds from wild peony species. *Plants*, *9*(6), 729. https://www.mdpi.com/2223-7747/9/6/729

Yang, L., Yin, P., Ho, C.-T., Yu, M., Sun, L., & Liu, Y. (2018). Effects of thermal treatments on 10 major phenolics and their antioxidant contributions in *Acer truncatum* leaves and flowers. *Royal Society Open Science*, *5*(6), 180364. https://doi.org/10.1098/rsos.180364

Yang, X., Zhang, D., Song, L.-M., Xu, Q., Li, H., & Xu, H. (2017). Chemical profile and antioxidant activity of the oil from peony seeds (*Paeonia suffruticosa* Andr.). *Oxidative Medicine and Cellular Longevity*, *2017*, 9164905. https://doi.org/10.1155/2017/9164905

Yang, Z., Jin, W., Cheng, X., Dong, Z., Chang, M., & Wang, X. (2021). Enzymatic enrichment of n-3 polyunsaturated fatty acid glycerides by selective hydrolysis. *Food Chemistry*, *346*, 128743. https://doi.org/10.1016/j.foodchem.2020.128743

Yin, D.-D., Li, S.-S., Shu, Q.-Y., Gu, Z.-Y., Wu, Q., Feng, C.-Y., Xu, W.-Z., & Wang, L.-S. (2018). Identification of microRNAs and long non-coding RNAs involved in fatty acid biosynthesis in tree peony seeds. *Gene*, *666*, 72–82. https://doi.org/10.1016/j.gene.2018.05.011

Yu, J., Yan, H., Wu, Y., Wang, Y., & Xia, P. (2022). Quality evaluation of the oil of *Camellia* spp. *Foods*, *11*(15), 2221. https://www.mdpi.com/2304-8158/11/15/2221

Yu, Z., Wu, X., & He, J. (2022). Study on the antifungal activity and mechanism of tea saponin from *Camellia oleifera* cake. *European Food Research and Technology*, *248*(3), 783–795. https://doi.org/10.1007/s00217-021-03929-1

Yuan, L., Zhang, F., Jia, S., Xie, J., & Shen, M. (2020). Differences between phytosterols with different structures in regulating cholesterol synthesis, transport and metabolism in Caco-2 cells. *Journal of Functional Foods*, *65*, 103715. https://doi.org/10.1016/j.jff.2019.103715

Zanqui, A. B., Da Silva, C. M., De Morais, D. R., Santos, J. M., Ribeiro, S. A. O., Eberlin, M. N., Cardozo-Filho, L., Visentainer, J. V., Gomes, S. T. M., & Matsushita, M. (2016). Sacha inchi (*Plukenetia volubilis* L.) oil composition varies with changes in temperature and pressure in subcritical extraction with n-propane. *Industrial Crops and Products*, *87*, 64–70. https://doi.org/10.1016/j.indcrop.2016.04.029

Zanqui, A. B., Da Silva, C. M., Ressutte, J. B., De Morais, D. R., Santos, J. M., Eberlin, M. N., Cardozo-Filho, L., Da Silva, E. A., Gomes, S. T. M., & Matsushita, M. (2020). Extraction and assessment of oil and bioactive compounds from cashew nut (*Anacardium occidentale*) using pressurized n-propane and ethanol as cosolvent. *The Journal of Supercritical Fluids*, *157*, 104686. https://doi.org/10.1016/j.supflu.2019.104686

Zeng, W., & Endo, Y. (2019). Lipid characteristics of camellia seed oil. *Journal of Oleo Science*, *68*(7), 649–658. https://doi.org/10.5650/jos.ess18234

Zhang, L., Wang, S., Yang, R., Mao, J., Jiang, J., Wang, X., Zhang, W., Zhang, Q., & Li, P. (2019). Simultaneous determination of tocopherols, carotenoids and phytosterols in edible vegetable oil by ultrasound-assisted saponification, LLE and LC-MS/MS. *Food Chemistry*, *289*, 313–319. https://doi.org/10.1016/j.foodchem.2019.03.067

Zhang, Q.-Y., Yu, R., Xie, L.-H., Rahman, M. M., Kilaru, A., Niu, L.-X., & Zhang, Y.-L. (2018). Fatty acid and associated gene expression analyses of three tree peony species reveal key genes for α-linolenic acid synthesis in seeds [Original Research]. *Frontiers in Plant Science*, *9*, 106. https://doi.org/10.3389/fpls.2018.00106

Zhenggang, X., Zhiru, C., Haoran, Y., Chaoyang, L., Zhao, Y., Deyi, Y., & Guiyan, Y. (2021). The physicochemical properties and fatty acid composition of two new woody oil resources: *Camellia hainanica* seed oil and *Camellia sinensis* seed oil. *CyTA—Journal of Food*, *19*(1), 208–211. https://doi.org/10.1080/19476337.2021.1879936

Zhu, G., Liu, H., Xie, Y., Liao, Q., Lin, Y., Liu, Y., Liu, Y., Xiao, H., Gao, Z., & Hu, S. (2020). Postharvest processing and storage methods for *Camellia oleifera* seeds. *Food Reviews International*, *36*(4), 319–339. https://doi.org/10.1080/87559129.2019.1649688

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