Health-Benefiting Components in Rapeseed Oil

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Rapeseed oil is the third most consumed culinary oil in the world. It is well-known for its high content of unsaturated fatty acids, especially polyunsaturated fatty acids, which make it of great nutritional value. Apart from unsaturated fatty acids, there are nine functional components (vitamin E, flavonoids, squalene, carotenoids, glucoraphanin, indole-3-Carbinol, sterols, phospholipids, and ferulic acid) in rapeseed oil that contribute to its anti-microbial, anti-inflammatory, anti-obesity, anti-diabetic, anti-cancer, neuroprotective, and cardioprotective, among others.

Keywords: rapeseed oil ; unsaturated fatty acid ; functional components

1. Introduction

Rapeseed oil originates from the seeds of brassica plants, which include *Brassica Rapa*, *Brassica napus*. The brassica plant is a significant cash crop because of the high oil content of its seeds [1]. During the year 1975 to 2016, more than 1.9 billion adults were overweight, which can lead to a series of diseases, such as obesity, cardiovascular diseases, hypertension, and hyperlipidemia [2]. Thus, nutritious and digestible foods are urgently needed. Rapeseed oil contains lots of USFAs and bioactive compounds, which makes it beneficial to human health. These components can be classified as antioxidants; however, most rapeseeds have low erucic acid and low glucosinolate content [3]. The nutrients of the phytochemical compound are either water soluble or lipid soluble. This makes lipids of great importance to health. The bioactive compounds in rapeseed consist of phenolic acids, phytosterols, diglycerides, flavones, vitamin E, and flavonols. Both α-linolenic acid and linoleic acid fatty acids are essential fatty acids for humans since they must be consumed from the diet. They cannot be synthesized in the human body due to the lack of specific enzymes [4]. Obviously, the advantage of rapeseed oil is rich in unsaturated fatty acids and especially famous for its high content of oleic acid and linoleic acid. However, the disadvantage of rapeseed oil is a few varieties of rapeseed contain not little erucic acid and glucosinolate which are harmful to people [5][6][7].

2. Unsaturated Fatty Acids

It is well-known that USFAs have a lot of health benefits since polyunsaturated fatty acids (PUFAs) cannot be synthesized in the human body and must be obtained from the diet [1]. Many people make their choice of culinary oils based on their nutritional value, and oils containing rich amounts of PUFA are preferred. Rapeseed oil is rich in oleic, linoleic, and γ-linolenic acids. Specifically, many kinds of rapeseed contain 75% oleic acid. All USFAs in rapeseed account for approximately 90% of the total fatty acids composition. Rapeseed oil has a higher proportion of oleic acid than mustard oil and peanut oil; meanwhile, rapeseed oil has a lower proportion of SFAs than soybean oil and sunflower oil. Perrier et al. reported that rapeseed oil is composed of monounsaturated fatty acids (MUFAs), which account for the largest proportion, SFAs, and polyunsaturated fatty acids (PUFAs) [8]. Lewinska et al. found that MUFAs in rapeseed oil account for 62.9% of the total fatty acids, which is the highest content. Among the PUFAs, oleic acid possesses the highest amount, followed by linoleic and γ-linolenic acids. It is found that people from the Mediterranean region consuming high MUFAs have a low risk of cancers of the skin, breast, and colon, as well as coronary heart diseases [4]. Oleic acid is more heat-stable and oxidation-stable than linoleic acid, and it accounts for 46–66.03% of rapeseed oil [1][9][10][11]. Oleic acid is considered as a phytochemical compound that can ameliorate cardiovascular diseases [12]. Since linoleic acid has one more olefinic bond than oleic acid, the antioxidant effect of linoleic is better than that of oleic acid. Linoleic acid is a nutritional component since it is an essential fatty acid that is important to the human body's maintenance. Linoleic acid is useful to the human skin's integrity, immune system, cell membrane, and eicosanoid constitution [1]. Omega-6 fatty acids are famous for their healthcare action, of which linoleic acid and its derivatives, such as γ-linolenic acid, are abundantly constituents in rapeseed oil. It has been revealed that a diet rich in γ-linolenic acid could attenuate high blood lipid, high blood pressure, and skin perspiration [13][14]. γ-linolenic acid also has certain physiological functions, including anti-cancer, anti-thrombotic cardio-cerebrovascular, and anti-diabetic functions, whereas α-linolenic possesses physiological functions, such as anti-atherosclerotic, weight loss, blood lipid-lowering, and cardiovascular and cerebrovascular disease-preventing functions [15]

[16][17]. The special content of fatty acids in rapeseed oil could lead to a variety of biological functions, which are beneficial for human health.

3. Bioactive Compounds

3.1. Vitamin E

Vitamin E exists widely in many plants and is abundant in many kinds of plant seeds; it is a fat-soluble vitamin [15]. In plant seeds, vitamin E is found in high concentrations in the seed coat and embryo. In rapeseed oil, it is revealed that the concentration of vitamin E is up to 608.90 mg/Kg [18]. It is reported that both γ-tocotrienol and δ-tocotrienol have great antioxidant activity, which can inhibit the spoilage of rapeseed oils during storage, thus prolonging the shelf life. Furthermore, tocotrienols have been identified to possess anti-inflammatory and anti-cancer effects [19][20][21][22]. However, the concentration of γ- or δ-tocopherol that can kill half of the cancer cells, thus reaching IC50, would be a much higher concentration (25 μM or 50 μM) [23][24][25]. There are controversies over whether vitamin E can suppress Alzheimer's disease. It is considered that supplementations with vitamins E and C can prevent cognitive decline [26]. Thus, it is proposed as a treatment for Alzheimer's disease [27][28].

3.2. Flavonoids

Flavonoids are small phenolic molecules that possess a 2-phenyl chromogen ketone parent nucleus. They belong to a diverse class of plant phytochemical metabolites and are abundant in rapeseed [29][30][31]. They are categorized according to the position of the hydroxyl group and exist in the form of a bound flavonoid glycoside or a free flavonoid anhydride [32][33]. In general, flavonoids consist of flavonols, flavan-3-ols, flavanones, isoflavones, and anthocyanidins, among others [34]. They harbor several physiological functions, such as preventing UV, pigmentation, stimulation of nitrogen-fixing nodules, and other health-improving functions [35]. These include the isomers of flavonoids and their hydrogenation and reduced products, most of which exist in the form of glycosides or carbohydrate groups combined with sugars in plants, and a few of them exist in the free form [36]. In rapeseed oil, it has been reported that the total flavonoids are around 164.1 mg/Kg [37].

Quercetin and kaempferol are the most common flavonoids in the human diet and are present as complex glycosides in Brassica species [36][37][38]. Flavonoids act as antioxidants [39] and shielding components [40] in plants and are of special interest due to their antioxidant activity, as well as anti-inflammatory and anti-carcinogenic effects in humans [32][41][42][43][44][45]. Flavonols from copigments with anthocyanins contribute to the seed color, and the oxidation of proanthocyanidins with seed maturation forms oxidized tannins and brown color [43].

3.3. Squalene

Squalene, as a precursor of other sterols, exists in various vegetable oils. The content differs with the vegetable type, cultivar, agronomic factors, and extraction methods, among others [46][47]. In rapeseed oil, the content of squalene is reported to be approximately 47.8 mg/Kg, which is far less than that in refined olive oil (4784.28 mg/Kg).

The antioxidant activity of squalene is not strong; however, they are difficult to inhibit unless primary antioxidants are present [48][49]. Squalene, a biofunctional lipid compound, is reported to have diverse bioactivities ranging from cardioprotective, antioxidant, chemopreventive, anti-cancerous, anti-lipidemic, and membrane-stabilizing properties, among others [50]. A previous study showed that squalene could enhance serum high-density lipoprotein cholesterol levels and reduce oxidative stress [51].

3.4. Carotenoids

Carotenoids are red, yellow, and orange tetraterpenoid pigments that are universally synthesized by various plants, animals, and microorganisms, especially in rapeseed [52]. In a previous study, it was found that β-carotene not only exists in cold-press rapeseed oil, but also in rapeseed oil acquired through other processes, such as hot-press, leaching, and aqueous enzymatic extraction [53]. Carotenoids are powerful antioxidants, particularly for neutralizing superoxide anions [54]. It is recognized that carotenoids could inhibit the synthesis of tumor necrotic factor (TNF)-α in monocytes and macrophages and suppress the expression of Toll-like receptors 2 and 4 in human monocytes [55]. Carotenoids play different significant functions in the brain and have several medicinal properties, including neuroplasticity enhancement, antioxidant, anti-inflammatory, anti-diabetes, and anti-apoptotic potentials [56][57]. It also protects against UV damage [58].

3.5. Glucoraphanin (GRN)

GRN, a member of the glucosinolate family, is a well-known nutritional compound and the precursor of sulforaphane (SFN). Both the content of GRN and SFN in rapeseed oil have anti-cancer effects [59][60]. GRN is found in trace amounts in rapeseed oil, specifically within the range of 0–1.53 µmol/g [61]. SFN, the isothiocyanate derivative of GRN, has attracted much attention in recent years because of its significant health-improving effects [62]. It has been shown that SFN could modulate phase I and phase II detoxifying enzymes, blocking cancer and autoimmune diseases [63].

3.6. Indole-3-Carbinol

Indole-3-carbinol (I3C) is an important anti-cancer and chemopreventive phytochemical that acts via further hydrolysis of indol-3-methyl isothiocyanate found in rapeseed [64]. The I3C compound has been revealed to inhibit the proliferation of cancer cells by regulating genes involved in growth, signal transduction, and carcinogenesis. It suppresses the expression of drug resistance-related genes and induces apoptosis [65][66][67][68]. Preliminary clinical trials revealed that I3C could be used to protect against hormone-mediated human cancers [69]. 3′3-diindolylmethane is derived from acid-catalyzed condensation of I3C, which has a biological function [70].

3.7. Sterols

Phytosterols occur in many plants and therefore exist in various edible oils. Among all the identified phytosterols, β-sitosterol is the most commonly reported. Other significant phytosterols existing in edible plants include campesterol, brassicasterol, cycloartenol, and stigmasterol [71]. Phytosterols have been reported to exhibit anti-inflammatory, anti-microbial, and anti-cancer activities [72][73]. These compounds are structurally similar to cholesterol, which exist in animal cells, whereas sterols exist in plants. It is indicated that phytosterols reduce intestinal cholesterol absorption by regulating several transporters [74][75].

3.8. Phospholipids

In rapeseed, phospholipids are very abundant, and they include glycerolphosphatidic acid and phosphatidylinositol, among others [76]. There are differences in the form of phospholipids in rapeseed in terms of different storage conditions, even in the form of hemolysis compounds. In general, phospholipids in rapeseed oil are extracted by physical or chemical extraction. The simple method is to select various organic solvents for multiple extractions [77].

3.9. Ferulic Acid (FA)

FA is a health-benefit trace compound found in rapeseed oil, which is a hydroxycinnamic acid. A previous study showed that dietary FA attenuated metabolism syndrome-associated hyperuricemia in rats [78]. It was also reported that FA could ameliorate aflatoxin B1-induced duodenal barrier damage in rats [79]. FA effectively prevents high-fat diet-induced fatty liver disease by activating the PPARα signaling pathway to decrease the accumulation of triacylglycerol in the liver and increase the consumption of energy [80]. FA acid has a cardioprotective effect induced by severe endoplasmic reticulum stress [81].

4. Conclusions

Rapeseed is globally known as a huge source of valuable nutrients. A significant advantage of rapeseed oil is that it is rich in unsaturated fatty acids. Thus, rapeseed oil has health-promoting effects on diabetes, metabolic syndrome, and type 2 diabetes. Furthermore, it can promote lipid metabolism in healthy people and patients. Each content of rapeseed has its unique biological functions; thus, it can be inferred that rapeseed oil has a series of biological functions. The rapeseed processing technology should be improved to ensure the good retention of its nutrients. To sum up, in order to preserve the functional components as much as possible the cold-pressed process is proposed. Some of the nutrients are lost during the deodorization process, while some are lost during color removal. In addition, the refining processes may cause the loss of vitamin E, flavonoids, carotenoids, and major phospholipids. Therefore, to maintain the nutrients, high temperature and chemical refining should be replaced by physical refining. The rapeseed oil not only supplies vitamin E directly, but it also includes vitamin E derived from carotenoids. Flavonoids are well-known phytochemicals that can be made for drug and healthcare products, which exert antioxidant, anti-inflammatory, and anti-carcinogenic effects in humans. Phospholipids are often used to improve brain supplements, which are very popularly used for adolescents and children. Thus, the optimization of rapeseed processing for maximum retention of nutrients is very crucial, considering its potential benefits to food processing industries and consumers.

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