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Review of Literature

The literature pertaining to the present study entitled **"Formulation of Blended Vegetable Oils and Investigation of their Fatty Acid Profile in Cooked Products"**is reviewed under the following headings:

2.1 Dietary Fat and Health

2.2Edible Oils and their Consumption

2.3. Role of Fats and Oils

2.4Fatty Acids and their Functional Benefits

2.5 Benefits of Blended Vegetable Oils

2.6 Fatty Acids Profile in Blended Vegetable Oil

2.7Oxidative Stability of Blended Oils

2.1 Dietary Fat and Health

Nutrition stands out as a potent and highly adaptable environmental factor capable of alleviating the burden of disease across an individual's lifespan (Bailey *et al*., 2015).The global burden of disease (NCD) accounts for almost 70% of all fatalities, which has a significant financial impact (WHO, 2021).

A healthy diet is defined by an appropriate calorie intake that primarily emphasizes the consumption of plant-based foods; additionally, it promotes the consumption of unsaturated fats rather than saturated fats, low amounts of foods derived from animals and minimal amounts of highly processed foods, refined grains and free sugars (Caprara., 2018: Hankey *et al*., 2019).

One major factor influencing health is nutrition. While poor food and improper eating habits and excess use of oil can contribute to a number of diseases, proper nutritious food intake can help in avoiding diseases. In many nations around the world, improper eating patterns and the ensuing ailments like diabetes, obesity and cancer are regarded as serious problems (Salehzadeh *et al*., 2019).

Edible vegetable fats and oils are a crucial component of the human diet because they provide critical fatty acids and energy, in addition to their sensory qualities. They also act as a precursor for the manufacture of prostaglandins and steroid hormones, as well as a transporter for fat-soluble vitamins (Liu *et al*., 2016).The consumption of edible oil has been continuously increasing globally. Increased oil and fat intake is linked to a number of causes, including global shifts to obesogenic diets, urbanization and rising per capita income (Kojima *et al*., 2016).

Cooking oils and fats have become increasingly controversial due to their potential link to the occurrence of chronic illnesses, such as cardiovascular disease (CVD). It's important to note that the well-established benefits of cooking oils and fats do not seem to correspond to the cardio metabolic health effects of saturated fatty acids (SFAs), monounsaturated fatty acids (MUFAs) and polyunsaturated fatty acids (PUFAs) (Forouhi *et al*., 2018).

Saturated and trans fatty acids, which are found in solid oils, have both been demonstrated to raise cholesterol. Angina, myocardial infarction, and stroke symptoms are linked to a number of health problems, including elevated cholesterol, the formation of atheroma plaques and stenosis in the arteries. Reducing the consumption of solid oils through awareness-raising, encouraging the use of liquid oils, and cross-sectoral coordination is the first step in changing these consumption patterns. This will increase access to these types of oils, alter lifestyles, and enhance the quality of cooking oils (Salehzadeh *et al*., 2019).

The FAO/WHO recommendations on fat were taken into account for (i) total fat, individual fatty acids and health promoting non-glyceride components (ii) sources of dietary fats in Indians (iii) availability of fat and (iv) energy requirements set on the basis of age, physiological status and physical activity. The recommendations are directed towards meeting the requirements for optimal foetal and infant growth and development, maternal health and combating chronic energy deficiencyand Diet Related Non-Communicable Diseases (DR-NCD) in adults. Diet recommendations based on physical activity is stated by the organization. The visible fat intake for sedentary, moderate and heavy activity has been set at 25, 30 and 40 g/day for adult man and 20, 25 and 30 g/day for adult women as against the single level recommended earlier.

To achieve intakes of individual fatty acids in Indians that are consistent with FAO/WHO 2008 recommendations the types of visible fats and correct combination of vegetable oils to be used for different food applications has been also emphasized. There is a realization that effort to increase the dietary levels of total fat and n-3 PUFAs would contribute to lifelong health and well-being. Inclusion of foods which provide LCn-3 PUFAs is also recommended for the prevention of DR-NCD (RDA, 2020).

2.2 Edible Oils and their Consumption

India is a significant producer of oilseeds; of the several oilseed-producing nations, it possesses the most area and yield of three oilseed crops: groundnut, rapeseed, mustard, and sesame. India is the country that produces the second-most castor seeds, behind Brazil. Among all the necessary goods available on the market, edible oils are among the most significant and widely utilized goods. One of the fundamental and significant substances that is commonly utilized by all people for all food items is edible oil, which is necessary for cooking. Various types of edible oils flooded the market, like coconut oil, sunflower oil, mustard oil, groundnut oil, gingili oil, etc. Unrefined oils like coconut oil, groundnut oil, and gingelly oil have been used long by mankind. Ground oils have become more widely available as a result of consumers' increased awareness of quality and health concerns in recent years. As a result, several brands of refined oils have entered the edible oil industry and sold in consumer packs and unpacked forms. Hence, oils such as gingelly, sunflower, groundnut can be purchased with refined oil (Arya., 2021).

Indian cuisine uses a variety of oils, including rapeseed, mustard, niger, soybean, sunflower, sesame, and groundnut. Mustard oil is expected to dominate the market by 2027 because of its widespread use and health advantages. In India, soybean oil is still gaining traction in the market. The Indian edible oil market is segmented into four zones: North, South, East, and West India (Yadav *et al*., 2022).

India is a large country, and people living in many of its regions have come to have particular tastes in oils. This preference is mostly influenced by the oils that are available where they live. For instance, people in the East and North use mustard or rapeseed oil, people in the South and West prefer groundnut oil. Similar preferences for coconut and sesame oil are seen in the South. According to the respondents, when asked which brand of edible oil they liked, refined edible oil came in first place (48.50%), followed by filtered edible oil (30.50%).

The consumption of mustard oil was reported to be 61.1% in the North region (Delhi, Punjab, Jammu and Kashmir, Himachal Pradesh, and Uttar Pradesh), with sunflower oil (12%), rice bran (9%), olive oil (7%) and other oils (11%). 44% of people in the southern states (Andhra Pradesh, Telangana, Tamil Nadu, Karnataka, Kerala, and Goa) used sunflower oil, with groundnuts coming in second at 29%, rice bran at 7%, palm oil at 9%, and other states at 14%. The primary oil consumed in the western zone (Gujarat, Maharashtra, Rajasthan, and Madhya Pradesh) was soybean (28%) and was followed by sunflower (25%) and mustard (25%). Similar to North India, mustard oil (29%) and sunflower oil (19%) were consumed by the majority of respondents in the eastern zone (Yadav *et al*., 2022).

Vegetable oils rich in ω-6 polyunsaturated fatty acids, like canola or rapeseed oil, soybean oil, sunflower oil, and corn oil, have gained popularity as healthy and affordable options for frying food. At the moment, the most popular cooking oils used in homes and restaurants across the globe are ω-6 PUFA-rich vegetable oils like canola and soybean oils, but very little information is known regarding the precise risk of daily use on human health (Lauretti *et al*., 2017).

An important factor in determining the community's health state is the assessment of families based on their consumption of fats and oils.Triglycerides make up over 90% of edible oils, and the kinds of fatty acids present have a significant impact on consumers' health (Nagpal *et al*., 2021).Investigations show that the percentage of people using solid cooking oils has increased to 55% due to recent changes in culture and taste (Salehzadeh *et al*., 2019).

2.3. Role of Fats and Oils

Cooking oils are the integral part of diets. Therefore, selection of healthy edible oil is very important. Edible oils can be classified in various ways. A)On basis of fatty acid contents are classified in to Saturated fatty acids (SFA), Monounsaturated (MUFA), polyunsaturated (PUFA) (Further classified as omega-3; alpha-linolenic acid, omega-6; linolenic acid), trans fatty acids (TFA) which are produced by hydrogenation of vegetable oils (vanaspati ghee). B) as essential (cannot be synthesized in liver e.g. omega-3 and omega-6) and non-essentials fats e.g. saturated and monounsaturated fats. C) can be based on extraction process as cold or heat pressed oils. D) on basis of smoke points and heat stability (Sadiqa *et al*., 2019).

Cooking oils are derived from animal fat, as butter, lard and other types,or plant oils from the olive, maize, sunflower and many other species. Different types of cooking oil include: olive oil, soybean oil, palmoil, canola oil (rapeseed oil), corn oil, pumpkin seed oil, sunflower oil, safflower oil, groundnut oil, grape seed oil, sesame oil, rice bran oil and other vegetable oils, as well as animal-based oils like butter and lard (Kaleem *et al*., 2015).

Cooking oil of plant and animal origin or synthetic fat is used in frying, baking, and other types of cooking. It is also used in food preparation as flavoring agent not involving heat, such as salad dressings and bread dips. Cooking oils are liquid, although some oils that contain a high amount of saturated fat, such as coconut oil, palm oil and palm kernel oil, are solid at room temperature.

During cooking, phenolic compounds present in oils and foods are subjected to different chemical reactions that obviously depend on the method of cooking namely: deep-fat frying, sautéing (shallow/pan frying of vegetables in little amount of oil), roasting (air-baking of superficially oiled vegetables), air-frying (with a small amount or no oil at all) and microwaving (cooking with water/oil mixes). Oil cooking reduces vegetable content in phytosterols, and reduction was linked to several variables, from length and type of technique used to oil unsaturation (Ambra *et al*., 2022).

Different cooking procedures are also related to the level of production of fried items: home, restaurant and industry. While domestic choices mainly favors tradition and health efficiency and shelf life, industries are mainly oriented towards efficiency and price, while restaurateurs' choices are more variable due to the huge diversity in the quality of food offered and the type of consumers targeted. For example, detrimental repeated frying is avoided in shallow frying as oil is used just once, with consequences on oil uptake. On the other hand, while restaurants tend to reuse and/or partially replenish deep-fat frying after oil cooling due to economic reasons, with effects on oil quality, industries mainly perform deep-fat frying in a continuous, but controlled manner, in order to implement frying for consecutive hours or even days (Ambra *et al*.,2022).

Vegetable oils have many uses, most importantly, they are a food product and use for the preparation and seasoning of food. Oil and fats are both triglycerides that are liquid or clear at room temperature; however, the degree of solubility determines their chemistry. Fats are triglycerides that are solid or semi-solid at room temperature. Following carbohydrates and proteins, fat and oil are the major three categories of food. In a metabolic pool, they can provide approximately 9 kcal of energy and are a rich source of nutrients.

However, fat and oil also contain other polymeric structures like monomers, dimers, and trimmers derived from free fatty acids, sterol, phospholipids, tocopherol, pigments, and lipoprotein moieties. Triglycerides, the functional unit of fat and oil are derived from fatty acid (3 units) and glycerol (1 unit) (Potter *et al*., 2012).

Depending on the structural location of the fatty acid group, they can be categorized as saturated, monounsaturated, or polyunsaturated (Lund *et al*., 2020). Oils and fats contribute largely to enhance the taste, flavor, and overall quality of food, making them essential food components. Saturated fats and oils are one of two types of fats and oils, and they are thought to be harmful to consumers' health, whereas unsaturated fatty acids have been shown to be beneficial to health in recent decades of scientific studies. On the other side, consumer awareness of healthier options has grown and so have the research efforts by the food industry covering these fields are expanded. Oils and fats can be classified as polyunsaturated (more than one double bond) or monounsaturated (a single double bond) (more than one double bond). According to the Food and Agriculture Organization of the United Nations and the World Health Organization (FAO/WHO), boosting dietary intake of polyunsaturated fatty acids (PUFAs) reduces risk of cardiac illnesses (Huang *et al*., 2016).

Major fatty acids include palmitic, oleic, stearic, lauric, and linoleic acid; plant sources are primarily polyunsaturated and saturated, primarily derived from animal origin. The functions of oil and fat in the body or food systems through fatty acid reconfiguration or mediations include sensory palatability, satiation mechanisms, hormone effects, organ protection, system regulation, carrying of soluble vitamins, and posing cholesterol density such as HDL and LDL in cells. Aeration, moisture retention, efficient cooking when frying, and other functional and physiochemical qualities of food and food systems are all improved by fats and oils (Ogori *et al*., 2020).

Nowadays edible oils have become much popular because of the high content of polyunsaturated fatty acids (PUFAs) and are commonly used for cooking purposes. Among these, Sunflower oil is considered to be the most preferred one. But it is highly susceptible to thermal oxidation as it is rich in polyunsaturated fatty acids (PUFA), particularly linoleic acid (48.3–74.0%) (Sharma *et al*., 2017).

Physical and chemical changes of oil during cooking and storage. Oxidation may cause undesirable flavors and taste, decomposing the nutritional quality, and leading to production of toxic compounds. Oxidation of oils may be influenced by different factors such as the degree of unsaturation, heat, light, oil processing, antioxidants and transition metals (Kaleem *et al*., 2015).

Oils with a higher degree of unsaturation are highly susceptible to autoxidation. The best test for autoxidation (oxidative rancidity) is determination of the peroxide value (PV). Peroxides are intermediated in the autoxidation reaction. In contrast it is not always useful in quality control, especially in the absence of sensory evaluation and other tests. As soon as the food, feed or product is manufactured, it begins to go through a variety of chemical and physical changes.

Oxidation of lipids is one more common and often undesirable chemical change that may influence flavor aroma nutritional quality and, in some cases, even the fineness of the product. The tertiary oxidation products; dimers and polymers are formed as a result of polymerization of secondary oxidation products. These products cause darkening of the oil color, formation of foam on the oil surface and an increase in viscosity of the oil (Kaleem *et al*., 2015).

As per our research, it was found that longer exposure at frying temperature caused more oil deterioration compared to high temperature heating. The fast formation of lipid peroxides in sunflower oil have recognized deleterious effects to human health. Several suggestions targeting to enhance its resistance to oxidation, such as hydrogenation, interesterification, the addition of natural or synthetic antioxidants, have been attempted (Aleena *et al*, 2020).

Although it has already been noted that deep-frying, a widely used food preparation technique worldwide, alters the fatty acid composition of oils cooked to high temperatures, investigation on how commonly used edible vegetable oils changes in terms of their fatty acid composition under regular household conditions is also the need of the hour (Szabo *et al*., 2022).

2.4 Fatty Acids and their Functional Benefits

Fatty acids are the primary building blocks of healthy lipids and are frequently formed from triglycerides and phospholipids. The majority of the natural sources of FAs consist of an even number (4–28) of carbon atoms in a linear polymer chain.

Fatty acids are monocarboxylic acids of different lengths with double bonds in acids: if they have at least one double bond, they are unsaturated fatty acids. In vegetable oils, the fatty acids have an even number of C- atoms in cis configuration. In contrast to animal fats, vegetable oils contain predominantly unsaturated fatty acids, often over 80%. In nutritional physiology, the substitution of vegetable oils for animal fats is recommended, as they supply the human organism with polyunsaturated fatty acids, so called essential fatty acids.

Saturated fatty acids (SFAs),monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids are all included in the FA inventory based on the quantity of the double bonds (PUFA) (Rahim *et al*., 2023: Wu *et al*., 2019: Marangoni *et al*.,2020).

In the chains of saturated fatty acids, there are no double bonds (Zhou *et al*., 2020). According to recent UK National Institute for Health and Care Excellence (NICE) recommendations, individuals who are at high risk of developing or already have CVD should "eat a diet in which total fat intake is 30% or less, total energy intake from saturated fats is 7% or less and intake of dietary cholesterol is less than300 mg/day where possible saturated fats are modified by monounsaturated and polyunsaturated fats." (Owen *et al*.,2019).

Those fatty acids that are monounsaturated have only one double bond (Wade *et al*.,2020).Despite not being essential, monounsaturated fats have been shown to have a neutral or marginally favorable impact on serum cholesterol levels, depending on the nutrient they are replacing. Monounsaturated fats may cause a rise in elevated lipoprotein cholesterol and a decrease in low-density lipoprotein when substituted for saturated fatty acids, trans fats, or processed carbs. These fatty acids can be found in canola, sunflower and safflower oils as well as in olives, avocados, macadamia nuts, hazelnuts, pecans and their corresponding oils (Hever., 2016). Monounsaturated fatty acid holds oleic acids. Major sources of monounsaturated fatty acids are nuts, olive oil, canola oil and red meat (Temple, 2018).

In fatty acids families' main idol is Polyunsaturated Fatty Acids (PUFA) it is good fat and it holds with omega-3, omega-6 fatty acids along with Linolenic acids which is essential fatty acid for humans but it cannot be synthesized in our body, because of shortage of essential long-chain fatty acids. There is a need to switch over the intake of saturated fatty acids to polyunsaturated fatty acids to prevent chronic disease such as heart disease especially cardiovascular disease (Ghani *et al*., 2019).

Oleic acid is not essential fatty acids, but it is nevertheless of great importance since it is found in every fat in various quantities. Chemically, oleic acid is an 18:1, omega-9 fatty acids, which means that is a monounsaturated fatty acid. Polyunsaturated fatty acids are generally regarded as being more valuable in nutritional physiology, but oleic acid also has cholesterol-lowering properties. Research has shown that a diet rich in monounsaturated fatty acids as oleic acid lowers the cholesterol level of the blood and strengthens the immune system.

When compared to polyunsaturated fatty acids, oleic acid is more effective in suppressing atherosclerotic developments and reduces the local accumulation of oxidized Low-Density Lipoprotein (LDL), which is involved in the development of arteriosclerotic plaque. In addition, oleic acid is certain to play an important part in the cell structure of small children and has a positive effect on their learning aptitude.

Depending on where the first double bond is located, polyunsaturated fatty acids can have two or more double bonds. The third carbon atom from the methyl end is where the initial double bond of an omega-3 polyunsaturated fatty acid is found. The initial double bond in omega-6 polyunsaturated fatty acids is situated on the carbon atom sixth in the chain from the methyl end (Abbott, 2020). The fatty acids omega-3(n-3) and omega-6 belong to two significant families of PUFAs (n-6).

Among omega-6 fatty acids are linoleic acid (18:2, omega-6) and α- linolenic acid is formed from linolenic acid by the enzyme 6-desaturase. An absence of the enzyme results in a lack of α - linolenic acid and the corresponding metabolites, which are important for the organism. The enzyme's activity is inhibited by saturated fatty acids, alcohol, stress and cholesterol levels that are too high. Inactivity of the enzyme can be circumvented by a selective supply of α - linolenic acid from vegetable oils (Krist, 2020).

Since the human body is unable to produce Essential Fatty Acids (EFAs),it must be obtained from food ALA and LA, accordingly, among them -3 and n-6PUFA. PUFAs have vital functions in a number of biological activities that are crucial to health (Calder., 2015). The most common -6 PUFA in our diet is LA. All n-6 PUFA, including AA and-linolenic acid, can be produced from LA by lengthening and desaturating other n-6

PUFA. Arachidonic acid has a significant role in the development of the CNS and retina in particular (Angelo *et al*.,2019). In fact, the human body produces very little Omega -3 PUFA. Only 8–20 percent of the total of a consumed quantity of ALA is thought to be trans formed into EPA and there after only 0.5–9% into DHA (Saini *et al*., 2018).

Although the ideal Omega-3/Omega-6 ratio is unknown, evidence from a number of sources suggests that our ancestors thrived on a diet with an Omega-6 / Omega-3 ratio of 1-4:1, as opposed to the typical western diet, where this ratio exceeds 15:1 (Mashavave *et al*., 2016: Patterson *et al*., 2012). Polyunsaturated fats are required for the mind, vision and overall central nervous system to work effectively and to lower the risk of cardiovascular illnesses. Oils high in polyunsaturated fatty acids assist-inflammatory processes, lower the likelihood of thrombotic hypertension or cardiovascular disease and aid in the prevention of neurodegenerative disorders (Saidaiah *et al*.,2024). Polyunsaturated fatty acid-rich oils support anti-inflammatory mechanisms, lower the risk of cardiovascular artery or angiogenic hypertensive and help avoid neurological illnesses (Orsavova *et al*.,2015 and Thomas *et al*.,2019).

Additionally, certain phytohormones come from omega-3 fatty acids (Cholewski *et al.*, 2018). Sunflower oil, corn oil and soybean oil have own amounts of polyunsaturated fatty acids. Non-vegetarian foods like fish are rich sources of omega-3 fatty acids (salmon, herring, mackerel and sardines) it contains eicosatetraenoic acid, docosapentaenoic acid and docosahexaenoic acid (Temple,2018).Vegetarian foods like soybean, rapeseed, canola oil, walnuts and green leafy vegetables are low in omega-3 fatty acids.

Alpha linoleic acids lower occurrence of cardiovascular disease and more intakes of alpha linoleic acids lower the coronary heart disease (CHD).Consumption of low High Density Lipoprotein (HDL) leads to higher risk of developing cardiovascular disease. High Density Lipoprotein helps to remove cholesterol from cells and also prevents atherosclerosis (Sacks *et al*., 2017).

Vegetable oil and their fatty acid profile

Groundnut oil

The fatty acid profile of groundnut oil plays a major role in determining its quality. Over 80% of the oil content in groundnuts is made up of two Unsaturated Fatty Acids

(UFA), linoleic acids and oleic acid, a Monounsaturated Fatty Acids (MUFA).Groundnuts have historically had a fatty acid content that is roughly 50% oleic acid and 30% linoleic acid. The remaining 20% of total fatty acid is made up of six Saturated Fatty Acids (SFA), of which 10% are contributed by palmitic acid alone. The remaining 10% are made up of stearic, arachidic, gadoleic, behenic, and lignoceric acids combined (Janila *et al*., 2016).

Gingelly oil

An herbaceous annual plant belonging to the order *Tubiflorae* and family *Pedaliacea*, sesame is cultivated for its flavor, oil, and edible seeds. Gingelly oil have healthful fats, protein, fiber, minerals, antioxidants, B vitamins, and other beneficial plant elements in reasonable levels. Rich in fiber, protein, and healthy fats, sesame plants produce seeds. In popular culture, it's sometimes called the "King of Oil crops" because of its remarkable resistance to rancidity and oxidation. The high-quality oil included in sesame seeds is composed of tocopherol homologs, sesamolin, and sesamin, which are naturally occurring antioxidants (Ji *et al*., 2019). The monounsaturated fatty acids in sesame oil (45–49%) and polyunsaturated fatty acids (37%–41%) are more likely to undergo auto-oxidation and hydrolytic reactions while frying. On the other hand, the oil's thermally stable lignans provide oxidation prevention (Tiwari *et al*., 2014).

Sunflower oil

The physicochemical properties of oils are influenced by several factors, including the degree of unsaturation, carbon chain length, and the type, quantity, and distribution of fatty acids (FA) on the triglyceride molecule, as well as their isomeric forms. Sunflower oils, which are high in unsaturated fatty acids, are particularly prone to oxidative rancidity. This form of rancidity can develop over extended storage periods and is exacerbated under unsuitable storage conditions, adversely affecting the quality of sunflower seed oil.

Sunflower oil includes a variety of nutrients that are beneficial to healthy growth, including manganese, vitamins, phytosterols, dietary fiber, tocopherols, triterpene glycosides, phenolic acids, peptides, flavonoids, carotenoids, caffeine, tannins, chlorogenic acid, saponins, and alkaloids.

Sunflower oil is also rich source of tocopherols and phytosterols as well as copper, folate, vitamin B, iron, and zinc with calming, anticancer, and antibacterial properties

(Adeleke *et al*., 2020). According to Rahim *et al*., (2023), sunflower oil has 59% linolenic acid (polyunsaturatedomega-6), 30% oleic acid (monounsaturated omega-9), 6% stearic acid and 5% palmitic acid.

Safflower oil

The safflower is among the earliest oil crops in existence. With a composition of stearic, linoleic, oleic, and palmitic acids, safflower oil has the highest concentration of linoleic acid of any industrial oil (Guneser *et al*., 2022). Safflower oil's high tocopherol content which makes it an excellent dietary source of vitamin E, but its low thermo stability makes it unsuitable for high-temperature applications like deep-frying or lubricating (Ergönül *et al*., 2020).

Flaxseed oil

Due to its special chemical constitution, flaxseed oil is widely known for its health benefits. It is one of the best plant-based sources of polyunsaturated omega-3 fatty acids. The primary components of flaxseed oil are rich in linoleic and α-linolenic fatty acids (Madhagy *et al*., 2023).

2.5. Benefits of Blended Vegetable Oils

Saturated oils are less prone to oxidation as compared to unsaturated oils and thus more stable, but more consumption of these oils is related to CVDs and many other health issues. Hence it is required to encourage the consumption of oils that have high unsaturated fatty acids (UFAs), and moderate SFAs content that are stable under frying conditions.

A combination of polyunsaturated oil with more saturated or monounsaturated oil is the best option for creating a healthy oil that can help treat ailments brought on by fatty acids imbalance (Mostafa *et al*., 2013: Naghshineh *et al*., 2010).

This can be achieved by blending traditional oils (Sohu *et al*., 2020), such as combining high oleic SFO with SBO, mustard (MO) and groundnut oil (GNO) [Kumar *et al*., 2018] mixing CCO, PO, GNO and peanut oil (PNO) (Sura *et al*., 2020). SBO blended with camellia seed oil (CAO) in varying proportions (Wang *et al*., 2016), SFO, SBO, POO with canola oil (CO) [Siddique *et al*., 2015] and CO with PO to balance the FA level and increase the oxidative stability of the blend during frying (Choi *et al*., 2014).

Two simple and alternative approaches to achieve this are to create a physical mixture of different oils in the appropriate proportions or to create structural lipids (SLs) from diverse oils. The Indian government has officially approved the mixing of edible oils. Companies are allowed to combine any two oils in a blend, provided that one oil makes up at least 20% of the mixture FSSAI Act 2006. Blending diverse vegetable fats and oils can be an easy method to generate novel products with desirable textural and oxidative characteristics. The physical and chemical properties of various fats and oils vary. One unmixed vegetable oil may have inadequate nutritional, chemical, physical, and oxidative stability. Pure sesame oil or olive oil, for instance, has certain disadvantages, such as low levels of linolenic acid (ω3 essential fatty acid).

Nutritionists suggested that a correct balance of fatty acids in Triacylglycerol (TAG) of oils/fats cannot always be accomplished by a single oil (Mostafa *et al.*, 2013). Some oils like corn oil (COO), sunflower oil (SFO), soybean oil (SBO) and olive oil (OO) are good for human consumption, but due to their high content of unsaturation they are unstable at cooking temperature. Therefore, blending oils with saturated oils like coconut oil (CCO), palm oil (PO), palm olein oil (POO), palm kernel oil (PKO), etc. is a good practice to balance the FA profile (Gulla *et al*., 2010).

Blending has long been applied to redesign oils and fats for modification of their nutritional values and consequently optimize their application in foodstuffs. It improves the quality of oils without changing their chemical composition (Dhyani, 2018). Furthermore, the chemical reactions that frying oil goes through can also significantly contribute to the colour, texture, aroma and flavour of fried food. When edible oil is used for deep frying it turns into markedly degraded, which affects the resulting quality of food as it may become overcooked, greasy and burned (Patil, 2013).

The functional, sensory, and economical qualities of food and food products are significantly influenced by the distinct composition of different types of vegetable oil or fat (Upadhyay *et al*., 2015). The fatty acid composition of several widely used vegetable oils is unbalanced, and their composition deviates from the committee's expert recommendations (Nagaraju *et al*., 2007). Nutritionists recommend that the ideal ratio of fatty acids in triacylglycerol (TG) of oils and fats cannot always be obtained from a single oil.

Therefore, blending two or more oils is a well-known practice to widen the functionalities of oils/fats with characteristics that are often not adequate in single pure oil, such as low chemical stability, poor melting behaviour, lowering of the smoke point (SP) and high solid fat content (SFC). The poor chemical and physical properties have led to the limited applications of oils/fats in the industry (Norazlina *et al*., 2021).

In this growing world, the concerns over the application of natural products and prominence on nutritional status enhancement, blending of vegetable oils/fats has come forward as an efficient means to generate edible oils devoid of any treatment of chemicals but having natural characteristics and flavors along with dietary products (Lee *et al*., 2017). The main concern of vegetable oils is the degree of SFAs which may cause CVD, inflammation, obesity, and immunological diseases (Olagunju *et al*., 2022).

Demand for cooking oils has led food technologists to study the knowledge and benefits of blended vegetable oils, as well as its application in cooking practices. Sunflower oil (SFO) with high concentrations of monounsaturated fatty acids (MUFA) (oleic acid, 14%–40%) and polyunsaturated fatty acids (PUFA) (linoleic acid, 48%– 74%) can improve human health (Hashemi *et al*., 2015). However, SFO is very easy to be oxidized due to the heat-sensitive content of ω-6 fatty acids. Early rancidity of SFO is always the limitation of the application of SFO in cooking. Roasted sesame (*Sesamumindicum L.*) seed oil (SO) is more stable in terms of lipid oxidation than unroasted SO because of the high concentrations of unsaturated fatty acids (85%), lignans (sesamin, sesamolin, and sesamol), and tocols. The prolonged production of sesamol from the deterioration of sesamolin during frying may enhance the oils' oxidative stability (Amin *et al*., 2023).

Roiaini *et al*., (2015) stated that ingesting the right amount of ω-3/ω-6 FAs plays a major role in the maintenance of health-related problems. The ω-3/ω-6 ratio is closely related to and deals with inflammatory and homeostatic processes of the human body. Shifting this ratio also can alter the body’s inflammatory rate and metabolic activity (Norazlina *et al*., 2021). Fats containing ω-3, ω-6, and ω-9 FAs are of particular nutritional importance. The ω-3 is recommended for the following diseases: diabetes, CVD, vision problems, immune disorders, overweight and underweight, osteoarthritis and rheumatoid arthritis.

Whereas ω-6 is an important FA, the only one that can be converted into other acids and protect the body from their deficiency. Only ω-6 is the basis for the synthesis of arachidonic acid, which guarantees the correct fat metabolism and the correct synthesis of prostaglandins (Nehdi *et al*., 2019). Prior investigations have demonstrated that using an optimized blend of oils can aid in the reduction of triacylglycerol (TAG) and cholesterol contents in the liver and serum (Jan *et al*., 2016).

Healthy edible oil blends were developed from red palm oil, rice bran oil, and sesame seed oil in 10 different ratios. The blends were formulated using mixture designs within the ranges 20%–50% red palm oil 30%–60% rice bran oil and 10%–50% sesame seed oil. The blends were stored at 30°C for 120 days. The physicochemical analysis revealed that the blend of Palm oil: Rice bran oil: Sesame seed oil with the ratio of 33:35:32 was richly filled with antioxidants, including carotenoids, gamma-oryzanol, sesamin, and tocopherols with good sensory characteristics (Chompoo *et al*., 2019).

Conversely, the linolenic acid levels in canola and soybean oils are modest, but their oxidative stability is poor. Low in essential fatty acids and abundant in saturated fatty acids, palm oil has great oxidative stability. Thus, one easy approach to benefit from this can be to use a blended vegetable oil (Roiaini *et al*., 2015). Blending vegetable oil has been a well-accepted method in many nations. There are numerous reports on the edible oil industry's use of blending. Common combinations include blending sunflower oil with canola or palm oil, as well as soybean oil with hydrogenated soybean oil or corn oil with high-oleic sunflower oil. It is now acceptable to combine standard edible oil with non-traditional oils, like rice bran oil, to accomplish several goals, including cost reduction and industry requirements (Farag *et al*., 2010).

Choudhary *et al*., (2013) reported that by combining several fats and oils with diverse qualities, a new oil with enhanced functional qualities and applications in the final product is created. For example, when cooled, certain oils have a tendency to crystallize and lose their clarity. Research indicates that combining these oils with higher and more unsaturated oils results in a clearer, more stable mixture that holds up better over time (Roiaini *et al*., 2015).

It is worth noting that the characteristics of pure oils exhibit variations dependent on the particular type of oil or fat involved, such as olive oil, coconut oil, sesame, palm oil, canola, sunflower, soybean, rice bran oil, flaxseed, palm olein, butter, among others. Blended oils, a mixture of different oil types, undergo alterations in their properties influenced by multiple factors. Key reasons behind the transformation in properties of blended oils encompass the composition of fatty acids, the point at which smoke arises, the infusion of flavour and aroma, changes in viscosity and texture, storage durability, considerations of cost and availability, as well as nutritional content. Industries strategically formulate blended oils, considering the nutritional profile (saturated and unsaturated fats, ω-3 and ω-6 fatty acids, and other nutritional factors).

Bordon *et al*. (2019) reported that blending two or more seed oils with different chemical properties has become increasingly popular. This technique modifies the fatty acid profiles, enhances natural antioxidants, improves oxidative properties, and boosts the nutritional value and industrial usability of the oils at a relatively low cost. While seed oil blending is a traditional method, the emergence of new seed oils in the market has rejuvenated this practice, leading to the integration of various specialty oils into conventional vegetable oils. Factors such as the concentration of lipid-soluble antioxidant compounds, fatty acid composition, and processing can influence lipid oxidation. Additionally, conventional seed oil often loses its functional and nutritional properties and oxidative stability due to refining processes.

Memon *et al*., (2023) said that blending technology proved itself as an economical approach to get advantageous chemical and physical characteristics along with a suitable amount of SFA:MUFA:PUFA ratio, vitamins, and antioxidants in a particular oil blend. Single vegetable oil has very limited uses in its original form due to its specific physicochemical properties. To further extend the commercial applications, vegetable oils can be blended with suitable oils to explore new fields.

A study conducted by Memon *et al*. (2023) collected data on different blended oils are gathered for food, cosmetics, pharmaceuticals, and other industries to improve the oil quality and stability as well as to produce various industrial products. The above article attracted many researchers to work on the new blends of vegetable oils that are not yet been explored especially in the prevention of cardiovascular or health issues and improvements of a healthy diet and enhancement of biological activities that need the entire population in broad-spectrum.

Ahmadi *et al*. (2019) reported that recently, various blends of palm, rapeseed, sunflower, and soybean oils have been widely utilized for several purposes including enhancing nutritional value, reducing costs, and meeting the food industry's demands in numerous countries. There is extensive documentation on the use of these blends in the edible oil industry.

2.6. Fatty Acids Profile of Blended Vegetable Oils

Based on the American Heart Association (AHA) guiding principle, healthy oil contains a ratio of 1.0:1.3:1.0 for saturated fatty acid (SFA), Monounsaturated Fatty Acid (MUFA), And Polyunsaturated Fatty Acids (PUFA) (Chompoo *et al*., 2019).

Another recommendation by the World Health Organization (WHO) for the ratio of essential fatty acids (EFAs) i.e. ω–6/ω–3 FAs should be (4–10:1). These EFAs facilitate to reduce of the risk factors of inflammation, cardiovascular diseases (CVD), high levels of blood pressure, clot formation, and muscle breakdown, enhance thermogenesis, hormones like eicosanoids and help to improve brain functions, vision, mood, behaviour, and intelligence (Mostafa *et al*.,2013).

However, there is no such oil that is up to these standards and meets consumers' fulfilment in terms of the stability of the food products and their physicochemical along nutritional properties. Healthy and stable oil with high functional value is always a challenging design. To improve the stability, shelf life, nutritional value, and utility, fats/ oils could be chemically modified by various methods such as microencapsulation, interesterification (IE), hydrogenation, fractionation, and blending (Kouame *et al*., 2021).

The polyunsaturated fatty acid (PUFA) content of the blends increased with a higher proportion of linseed oil, while the saturated fatty acid (SFA) and monounsaturated fatty acid (MUFA) levels varied based on the unique fatty acid composition of each oil. For a blend of linseed oil and soybean oil, the 20:80 ratio yielded an SFA: MUFA: PUFA ratio of 1:1.4:4.6, which closely aligned with recommended intake levels. In contrast, the 80:20 ratio produced a ratio of 1:1.4:6.4. In the case of linseed oil and sunflower oil blends, the MUFA and PUFA levels exceeded recommended values due to the high PUFA content (linoleic and linolenic acids) in both oils. None of these blends were deemed suitable based on their fatty acid composition (Grover *et al.*, 2021).

The blend of linseed oil and coconut oil was an interesting combination because both oils have opposite properties. Linseed oil is rich in PUFA content; on the other hand, coconut oil contained a high amount of SFA. Coconut oil shows SFA: MUFA: PUFA ratio as 35.1:3.1:1, while linseed oil has 1:1.2:4.3. When both the oils were blended, the fatty acid composition was affected drastically. In blend of 20:80, SFA: MUFA: PUFA ratio was 5.9:1:1 followed by 4.9:1:1.6, 4.4:1:2.2, 3.5:1:2.6, 2.7:1:2.8, 1.9:1:3 and 1.5:1:3.1

respectively for remaining blends. As mentioned above, a blend of 80:20 showed SFA: MUFA:PUFA content close to the recommended level. Linseed oil and olive oil blends also showed good compositional balance.

Olive oil has a high smoking point, so it can be a good choice as a frying medium, but the economic value of this oil is comparatively high. Therefore, the blending of olive oil with any low-priced oil could be a better economical option. Blend of linseed oil and olive oil in ratio 80:20 showed SFA:MUFA:PUFA content in ratio 1:1.9:3.4, which was found close to the suggested ratio. In a blend of linseed oil and mustard oil, none of the proportions were observed to be near the recommended level (Grover *et al*., 2021).

Rudzińska *et al*. (2016) found that a blend of 80:20 rapeseed oil and rice bran oil contain a high level of monounsaturated fatty acids, including methyl palmitate C16:0 7.7%, while a blend of 95:5% rapeseed oil and rice bran oil contains a considerable number of monounsaturated fatty acids. Rapeseed oil blended with black cumin oil has the highest levels of C18:1 n-9 (61.2%), C18:2 n-6 (28.2%), and C18:3 n-3 (9.0%).

According to Simakova *et al*. (2019), when safflower, camelina, and milk thistle oils are combined 50:13.5:36.5, they contain a large amount of monounsaturated fatty acids C18:1 oleic acid (28.7%) and polyunsaturated fatty acids C18:3 linolenic acid (9.9%). Safflower, milk thistle and mustard oil are combined in a 30:11:59 ratio and it contains the most polyunsaturated fatty acids, specifically C18:2 linoleic acid (57.2%).

In the experiment conducted by Sharayei *et al*., (2016), canola oil, palm oilein oil, and olive oil were blended in the ratio of 75:15:10, and the largest amounts of monounsaturated fatty acids C16:0 methyl palmitate (14.12%) and polyunsaturated fatty acids C18:2 methlylenoleate (21.02%) were found.

According to a study conducted by Roiaini *et al*. (2015) adding 20% palm olein to a canola-olive mix at an 80:20 ratio resulted in the best physicochemical qualities compared to other oil blend ratios. Fatty acid compositions also showed that an 80:20 canola: olive blend with 20% palm olein has a high level of unsaturated oleic acid (58.83%). The blend contained 5.25% linolenic acid (omega-3) and 16.59% linoleic acid (omega-6). Blending palm olein with canola and olive oil at an 80:20 ratio improved the oil's physicochemical qualities. Using an 80:20 ratio of canola and olive oil with 20%palmolein greatly improved storage stability and suitability for frying.

According to Mohamed *et al*.(2014), the main fatty acids in the Corn oil and Black cumin seed oil blends were linoleic, oleic, and palmitic acids, with 60.1, 26.0, and 9.46% (Corn oil); 59.8, 25.8, and 9.81% (Corn oil: Black cumin seed oil, 9:1); and 59.5, 25.6, and 10.1% (Corn oil: Black cumin seed oil, 8:2).

Sharayei *et al*. (2016) blended canola oil, palm oil and olive oil in the ratio of 75:15:10 and observed it to exhibit the maximum quantity of monounsaturated fatty acids (C16:0 methyl palmitate 14.2%) and polyunsaturated fatty acids (C18:2 methyl linoleate 21.02%).

2.7 Oxidative Stability of Blended oils

Vegetable oils are widely used in food preparation. Their oxidative stability is a key quality parameter, which depends upon the balance of different intrinsic and extrinsic factors. The main important factors are fatty acid unsaturation, the composition of minor components, environment conditions, delivery techniques, and the use of antioxidants. Lipid oxidation leads to negative effects on both the food quality and human health. In such a context, minimizing oxidation and improving the oxidative stability of lipid-based products become imperative (Shahidi *et al*., 2016).

Vegetable oils are endowed with a wide variety of endogenous antioxidants (e.g., pigments, vitamins, tocols, and phenols). However, the use of exogenous antioxidants is widely practiced to improve oxidative stability. In this optic, synthetic antioxidants such as Butylated Hydroxy Anisole (BHA), Butylated Hydroxy Toluene (BHT), Tert-Butyl Hydroquinone (TBHQ), and Propyl Gallate (PG) are commercially used to extend an oil's shelf life by delaying or even hindering lipid degradation. Such molecules were considered "Generally Recognized as Safe" (GRAS). However, some reports associated these molecules with health risks such as carcinogenesis, and their use was reduced (Taghvaei and Jafari 2015). Natural antioxidants are a good alternative to replace synthetic ones in the preservation of vegetable oils (Blasi *et al*., 2021: Odeh *et al*., 2021).

The application of preservatives, vitamins, and antioxidants (BHT, TBHQ, PG, etc.) can be one of the solutions to encounter lipid oxidation issues. However, consumers nowadays are more concerned about natural antioxidants to improve thermally stable oil blends instead of artificial additives. Lately, negative perceptions had been given to the addition of artificial antioxidants due to their related health implications (Upadhyay *et al*., 2015). In addition, natural antioxidants can inhibit oil oxidation under lower temperature, but most antioxidants lose their efficiency during frying due to their degradative nature at high temperature (Ruiz *et al*., 2014).

Thus, the oil industry starts to focus on the blending of vegetable oils to extend the storage stability and nutritional profile of cooking oil. A blending of various types of vegetable oils may help to increase the storage stability and reduce the requirement for artificial antioxidants (Kiralan *et al*., 2017: Srivastava *et al*., 2017).

The blending of two or more seed oils is an old approach employed to modify the fatty acid profile and to improve an oil's nutritional quality. The edible oil industry often uses the blending practice to produce blended oils with enhanced oxidative stability and improved functional characteristics. This practice has gained renewed interest after the introduction in the market of new oils extracted from unconventional oil-bearing seeds. The blending with this kind of oils has economic and functional advantages, changing the physico-chemical and nutritional properties of the blends (Baltork *et al*., 2016).

Natural extracts from various plant parts (e.g., peel, fruit, leaf, flower, and root) belonging to different herbs, agri-food residues, and by-products were investigated for their antioxidant power as well as their use for the enrichment of edible oils, with an emphasis on enhancing oxidative stability. Such natural extracts were proven to possess a wide range of bioactive compounds, which were identified as belonging mainly to carotenoids and phenols (Blasi *et al*., 2021).

Oxidation occurring at the double bond sites of fatty acid molecule which is the primary route of deterioration of oil quality. The deterioration process proceeds through initiation, propagation and termination steps. The deterioration process can be broadly classified into two types, viz., autoxidation and photosensitised oxidation. In case of autoxidation, unsaturated fatty acid molecules lose a hydrogen atom and thereby produce lipid alkyl radical in the presence of certain initiators such as heat, light/ionising radiation and metal ions/metalloproteins (Mishra *et al*., 2021).

Lipids in edible oils are susceptible to photo-oxidation and auto-oxidation during processing and storage (Hong *et al*., 2021), which is a major problem for the oil industry. Oxidation may cause undesirable flavours and taste, decomposing the nutritional quality, and leading to production of toxic compounds. Oxidation of oils may be influenced by different factors such as the degree of unsaturation, heat, light, oil processing, antioxidants and transition metals. Another important issue is the reusing of fried oils. This practice is not only restricted to roadside food stalls, and reputable food outlets in large cities also use this technique to lower their costs (Lužaić *et al*., 2021).

Auto-oxidation, where peroxide is the main product that gives rise to objectionable flavour in food products, proceeds through the free radical chain reaction, where it attacks on the double bond at room temperatures. Photo-oxidation is a much faster reaction that involves attack at double bond (Kaleem *et al*.,2015). Rancidity of food items can be the result of auto and photo-oxidation, which are natural oxidation and chemical degradation processes of edible oils, where fatty acid esters of oils are converted into FFA giving a smell observed in many vegetable oils (Anwar *et al*., 2016). Indicators of poor oil quality include elevated FFA, low smoke point, change of colour, low iodine value, peroxide value, total polar material, high foaming properties and increased viscosity (Kheang *et al*., 2012). The double bonds found in fats and oils play an essential role in autoxidation.

Since oil oxidation occurs by different routes, influenced by extrinsic (light and temperature) and intrinsic (degree of saturation, free fatty acids, phospholipids, pigments, etc) parameters which are different for each oil, no single antioxidant can meet the expectations. In view of the huge diversity in oil composition and its varying degree of oxidative stability, it is imperative to find antioxidants which could enhance oxidative stability in every circumstance. Hence, there is an on-going effort by various research groups to find the best antioxidant for the oil of their consideration. For edible bulk oil, an antioxidant should be effective at low concentrations, should not change the colour and flavour of the oil upon addition and should not exhibit any kind of toxicity to the consumer.

Though synthetic antioxidants such as BHA, BHT, and TBHQ meet the first two conditions, there is still doubt about their safety (Taghvaei and Jafari 2015). Furthermore, current consumer preferences for the use of "natural products" are driving edible oil industry to look for natural antioxidants. Numerous reports have been published in last 20 years on the use of various pure antioxidants, their mixtures and plant extracts in bulk edible oil. These antioxidants (tocopherols, flavonoids, phenolic acids, polyphenols, carotenoids, lignan compounds and ascorbates) are found to exhibit anti-inflammatory, anti-carcinogenic and anti-atherosclerotic effects. Reduction in the incidence of coronary diseases and maintenance of gut health by the modulation of the gut microbial balance are also evidenced by the intake of these natural antioxidants (Oroian and Escriche, 2015).

Thus, in addition to enhancing oxidative stability, natural antioxidants and their derivatives can confer health benefits to the edible oil consumers.

Low-molecular-weight off-flavour compounds are produced during oxidation, and off-flavor compounds make oil less acceptable to consumers or for industrial use as a food ingredient. Furthermore, the oxidation of oil also destroys essential fatty acids and produces toxic compounds and oxidized polymers.

The results of the study conducted by Kaleem *et al.* (2015) showed higher percentage increase in the peroxide values over 20ºC of two brands of sunflower cooking oil namely Tullo sunflower cooking oil and Mezan sunflower cooking oil. Both oils show an increasing peroxide value at 130ºC, which decreases at 170ºC. Another study gives the same results of PV for four different brands of sunflower oil (Fatlawi, 2018) with a slight difference in value but the same trend. This difference could be due to some other factors like exposure to light, air and oil refining method.

Autoxidation is a free radical reaction involving oxygen that leads to deterioration of fats and oils which form off-odours and off- flavours. PV value is useful to assess the extent to which spoilage has taken place. Autoxidation can be inhibited or retarded by some methods such as vacuum packing, modified atmosphere packing and refrigeration/freezing. Addition of natural antioxidants and precursors of plant origin into the frying oils is the best way of enhancing oxidative and flavour stability (Kaleem *et al*., 2015).

The difference in the values is due to many factors. The peroxide value is affected by packaging also. Transparent plastic bottles are more exposed to sunlight which causes photo-oxidation. Tin packed cooking oils are safe from photo-oxidation. Another factor is due difference in conditions and climate of area where the process of refinement takes place. More over storage time also has an effect on the quality of oil (Kaleem *et al*., 2015).

Lipid oxidation involves the continuous formation of primary oxidation products that may break down to a variety of non-volatile and volatile secondary products hydroperoxides. The formation rate of hydroperoxides exceeds their rate of decomposition during the initial stage of oxidation, and this becomes reversed at later stages (Shahidi *et al*., 2015).

It is well known that hydroperoxides are primary products of oil oxidative degradation, possess no order and are highly unstable, due to instability they react with other components of oil or break down into secondary products (hydroxyl acids, aldehydes, ketones). The secondary oxidation products have a strong odour with an unlikable taste. These primary and secondary products can cause the loss of nutritious substances due to their ability to react with vitamins, lipids, and proteins of oil. Consumption of the oxidative lipid product can have many toxicological risk factors for degenerative pathologies including cancer, arteriosclerosis, etc. Therefore, it is necessary to use the right oil for cooking. Oils exhibit various properties depending upon the environmental conditions, the heat to which they are exposed while cooking, and their shelf life. These properties in turn verify the oil quality (Kaseke *et al*., 2021).

There has been an international focus in the food industry on the use of natural flavours, colorants, flavour enhancers and antioxidants. Natural antioxidants are being researched intensively due to the potential toxicological long-term effects of synthetic antioxidants (Rojo *et al*., 2012). Food companies are changing their products to adhere to the standards set by consumers. Using natural antioxidants is challenging as they do not always provide the same shelf life as a synthetic antioxidant (Chen *et al*., 2023).

Research showed that some phytochemical antioxidants have unpredictable effects and can act as antioxidants or pro-oxidants depending on their concentration (Choueiri *et al*., 2012). Pectin, a natural antioxidant, has also been reported to cause emulsion instability (Celus *et al*., 2018). This adds to the challenges of using natural antioxidants (Choueiri *et al*., 2012). Natural antioxidants often used in the food industry include proteins, tocopherols, polyphenols to name a few.

It has also been shown that primary lipid oxidation products, as well as malonaldehyde, a secondary product of lipid oxidation can cross link proteins, deactivate ribonuclease and react with DNA (Addis, 2021). There is still uncertainty whether these undesirable compounds are formed before, during or after the development of a recognisable rancid flavour (Karlsdottir *et al*., 2014), but it is clear that a high PV is associated with the significant increase in plasma lipid peroxides (Sainsbury *et al*., 2019).

Butylatedhydroxytoluene (BHT) and butylatedhydroxyanisole (BHA), but also tertiary butylhydroquinone (TBHQ), and propyl gallate are common examples of the synthetic antioxidants used in the vegetable oil industry to retard oxidation reactions.The safety concerns associated with the use of synthetic antioxidants and the consumers' increasing demand for natural food fostered the development of methods based on the employment of natural molecules to delay oil oxidation (Xu *et al*., 2020). In this context, natural antioxidants have been suggested as an alternative to synthetic additives in the prevention of oil oxidative degradation. Plants are the main source of natural antioxidants, and the ability of plant antioxidants to protect oils from lipid degradation has been the topic of several investigations (Blasi *et al*., 2020: Bodoira *et al*., 2017: Drinić *et al*., 2017: Drozłowska *et al*., 2021: Gorji *et al*.,2016: Grosshagauer *et al*., 2019).

Nosenko *et al*. (2017) reported that fats that include ω-3 polyunsaturated fatty acids (PUFAs) have a higher biological value; nevertheless, this also causes the oxidation rate to increase. The higher the PUFA content, the faster the oil oxidizes. That the studied mixes with unrestricted access to light and air increased at various rates in terms of peroxide value. When the peroxide value reached 10 mmol ½O per kg in 21 days, blended oil consist of 60% of sunflower oil and 40% camelina oil(ω-3:ω-6=1:3.3) showed the fastest rate of peroxide accumulation. Even though linolenic acid was absent, after 22 days of storage, the same peroxide value of sunflower oil was found.

According to Prescha *et al*. (2014), oil blends including flaxseed oil are not advised for long-term preservation. Low temperatures and the absence of oxygen access, on the other hand, can extend their shelf life by preventing oxidation. Furthermore, research indicates that the peroxide value of flaxseed oil barely increases even after six months of storage.