BIOCHEMICAL ANALYSIS AND NUTRITIONAL BENEFITS OF VARIOUS EDIBLE OILS – A COMPREHENSIVE REVIEW

Abstract

The use of edible oil is an integral part of daily cooking. Different people have different opinions about selecting edible oils globally; however, regions, family trends, individual choice, taste, flavor, availability, and affordability are the factors in choosing such oils. There is a growing scenario of such edible oils as palm oil, followed by canola and soybean oil in the global market. Indian cooking practices exhibit notable variations compared to other regions worldwide. One key distinction is in the frequent heating of oils during the process of stir-frying, which leads to the degradation of essential antioxidants such as vitamins E, A, B vitamins, folate, etc. To mitigate exposure to harmful substances, it is recommended to refrain from consuming refined oils and low-smoke-point- based oils as they tend to undergo rapid degradation and possess elevated levels of polyunsaturated fatty acids. The edible oils with MUFA or PUFA are also considered suitable for consumption. Finally, blended oils have notable thermal and oxidative stability, rendering them indispensable in preserving the optimal dietary balance of fatty acids. Overall, every oil has significance, but blended oils would perform better in the kitchen and keep health sound. This study comprehensively reviewed all the common cooking oils, particularly popular and available in India. Every oil has significance, but selecting the right oil for cooking would be wise.

Keywords: Edible oils, Indian culinary system, Benefits of edible oils, Fatty acids, Daily diet, Blended oils

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I. INTRODUCTION

Edible oils provide energy and serve as natural reservoirs of bioactive chemicals and phytonutrients. Bioactive lipids are present in olive, palm, and fish oils and are known to offer noteworthy nutritional and physiological advantages. The health advantages and preventive properties of lipids, such as prenol cum polar lipids, and polyunsaturated fatty acids (PUFA), have been documented in scientific literature. The oils contain bioactive components to develop innovative biotechnological applications, including functional foods, cosmetics, and pharmaceuticals, to enhance human health and well-being [1]. Dietary fats and oils are associated with positive, negative, and unfavorable associations. Healthy fats have a crucial role in transporting preformed fat- soluble vitamins, improving the absorption of micronutrients, and facilitating metabolic processes. Unhealthy fats can accumulate harmful substances, as well as contribute to the presence of saturated and trans fatty acids, as well as cholesterol. Adipose tissue, commonly called bad fats, is a concentrated source of metabolic fuel. It plays a significant role in developing atherosclerotic plaque, a primary factor in heart disease, stroke, and phlebitis [2]. The prevalence of fast-paced lifestyles globally can be attributed to the demands of jobs and the need to prioritize children's education. Consequently, many persons who are engaged in earning activities find themselves dependent on readily available meal options. The increasing demand for fast food can be attributed to various factors, including disposable money, taste preferences, work-related stress, and psychological resilience.

According to projections, the convenience food market on a global scale is anticipated to achieve a compound annual growth rate more than four percent by 2025, with India playing a substantial role in this rise [3]. Therefore, lifestyle disorders like metabolic syndrome have become more common in advanced countries. The metabolic syndrome encompasses a cluster of metabolic abnormalities, including dyslipidemia, hypertension, decreased glucose tolerance, compensatory hyperinsulinemia, and the accumulation of belly fat. The presence of this condition heightens the susceptibility to atherosclerosis and cardiovascular ailments.

Research indicates that implementing comprehensive lifestyle improvements, which encompass alterations in food patterns and increased engagement in physical activity, may provide advantageous outcomes for those diagnosed with the syndrome. Edible oil and fats in the daily diet significantly manage lifestyle disorders, including metabolic syndrome, as discussed [4]. Maintaining a proper diet is of utmost importance in healthcare, where dietitians play a vital role in prescribing tailored dietary regimens for patients in both hospital and private settings.

The SOAP model, which is grounded in four fundamental nutritional functions known as ADIME, encompasses the processes of assessment, diagnosis, interventions, and monitoring. The initial phase entails evaluating and examining health concerns, leading to a nutritional diagnostic determined by the identified problem, underlying causes, and the exhibited symptoms. Interventions are implemented using diet programs incorporating revisions and prioritizing a progressive recovery process. Monitoring is paramount to achieving optimal outcomes and enhancing patient motivation [5].

II. RESEARCH METHODS

This article primarily focuses on the biochemical structures and nutritional benefits of all the major edible oils available in India and other advanced countries. Edible oils have been considered here as significant keywords for detailed analysis and review. Edible oil cum fats is always essential in diet planning for mainly lifestyle disorders. This is an integral part of preparing all the recipes because oils and fats give energy and an incredible feeling of flavor and taste.

The aim is to look into the nutritional benefits and suggest including them in diet and nutrition care for patients and ordinary people. Google Scholar, National Center for Biotechnology Information Pubmed, Pubmed Central, Directory of Open Access Journals (DOAJ), and Free Medical Journals were accessed to search relevant scientific literature based on the keywords. 'Edible oils,' 'Structures of edible oils,' 'Role of biochemical compounds in edible oils, 'Nutritional benefits of cooking oils,' etc. keywords and phrases used for online searches. The articles published from 2000 till 2022 have been considered for reviewing and making this comprehensive.

III. DISCUSSIONS

This study aims to provide a complete approach to reviewing the nutritional value of the most common edible oils. The study also focused on physical and chemical properties based on fatty acids.

1. **Oil Composition:** There are many studies on oil compositions and their utilizations. A study assessed the properties and characteristics of thirteen edible vegetable oils in China. The oils under evaluation include soybean oil, low erucic acid rapeseed oil, peanut oil, flaxseed oil, sunflower seed oil, olive oil, edible mix oil, palm oil, camelliaoil, corn oil, sacha inchi oil, peony seed oil, and sesame oil. Seven evaluation indices were identified: total saturated fatty acids, atherogenic fatty acids, monounsaturated fatty acids, polyunsaturated fatty acids, vitamin E, and phytosterol. Flax seed oil, Peony seed oil, edible mix oil, and low erucic acid rapeseed oil demonstrated the highest ratings, while palm oil scored the lowest 2 points [6].

   In a study, the authors mentioned that the relationship between diet and the inflammatory response was intricately intertwined, with considerable attention devoted to investigating the potential health benefits and impact on chronic diseases associated with consuming edible fats and oils.

   For therapeutic purposes, fish oil comprises polyunsaturated fatty acids (PUFAs) that can transform into oxygenated bioactive lipids, which include anti-inflammatory and pro-resolving qualities. Edible oils are known to possess phenolic chemicals and vitamins, which have the potential to impede the progression of chronic diseases. An elevated concentration of monounsaturated fatty acids can enhance the lipid profiles in the bloodstream while concurrently reducing oxidized lipoproteins and free radicals [7]. However, our article reviewed the related content of the referred articles.

Table 1: A Summary of Various Edible Oil Production and their uses, Smoke Points, and Quality [8].

Edible oils	Output in a million metric ton	Usage as edible oil	Smoke point	Quality
Canola oil*	67.0	A variety of rapeseed sourced from cultivar plants.	225	General
Coconut oil	4.0	It is widely used as cooking oil in coastal and south India and for cosmetics and soap preparation.	177	Virgin and unrefined, dry expeller pressed.
Corn oil	3.0	It is highly used for salad dressing, margarine, mayonnaise, potato chips, and French fries.	235	Refined
Linseed oil*	0.70	Widely used and sourced from flax.	107	Unrefined
Olive oil [extra virgin]	4.0	Extra virgin oil for cooking and a few varieties for massage.	207	High-quality extra virgin causes low acidity,
Palm oil	76.0	Tropical oil is used for biofuel.	230	Fractionated
Peanut oil	5.0	It is one of the best oils with MUFA and is used for medicine.	232	Refined
Rice Bran oil	2.0	Widely used cooking oil in India is sourced from rice grains.	232	Refined
Soyabean oil	59.0	Highly used edible oil in India.	240	General
Sunflower oil	21.0	One of the most used edible oils used for biodiesel.	253	Neutralized, dewaxed, bleached, deodorized
Safflower oil	.08	One of the most common uses is having no color or taste.	266	Refined
Sesame oil	1.0	Medium-demanding cooking oil is used as a massage oil.	232	Semirefined
Walnut oil	5.0	Suitable for pan frying and used as a finishing oil for flavor	204	Semi-refined

Canola is the same as rapeseed; linseed oil is also as flaxseed oil

2. **Smoke Point:** A comprehensive grasp of the smoke point temperatures of cooking oils and fats is necessary to maximize nutritional value, enhance flavor, and ensure safety within culinary settings. These oils are crucial for the process of deep frying and serve the

purpose of keeping food from adhering to pans. Nevertheless, these entities possess some constraints as a result of their composition. The selection of appropriate oil for various cooking purposes is a matter of objectivity, considering factors such as functionality, health implications, and safety. The smoke point is the specific temperature at which oil undergoes thermal degradation, releasing free fatty acids and generating visible smoke. The safety threshold of oils varies and might pose risks if exceeded. The appropriateness of oils, namely free fatty acids, for high-temperature frying, is contingent upon their structural composition. Fats exhibit a solid state at ambient temperature, whereas oils retain a liquid form. A higher proportion of unsaturated fats characterizes plant-based oils, conferring enhanced health advantages, but animal fats are known for their more pronounced flavor profile [9].

3. **Production:** Edible oils are essential commodities for everyone globally. Here is a glimpse of the production (million tons) of commonly available edible oils, mainly vegetable oils. In Figure 1, palm oil shows the highest presentation globally, followed by canola, soybean, rapeseed, and sunflower oil.

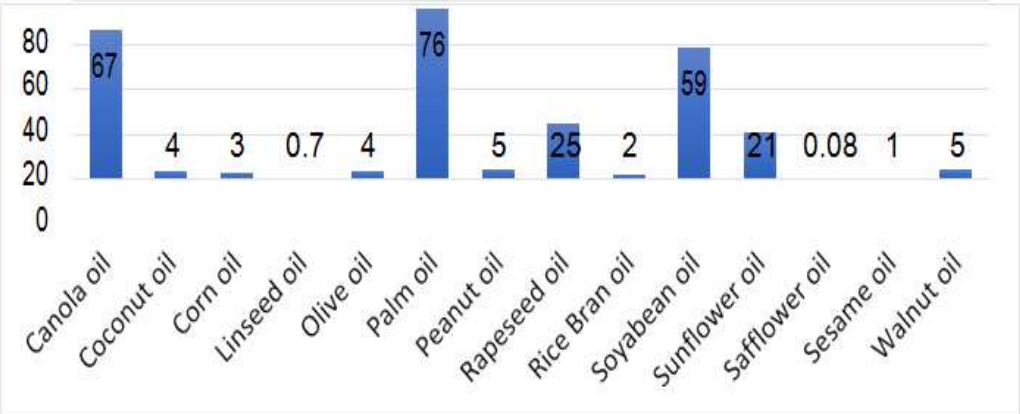

Figure 1: Production of Various Edible Oils Globally in Million-Ton [11]
[Source: https://ourworldindata.org/grapher/vegetable-oil-production]

4. **Varieties of oils:** There are similar types of oils but different names. Both rapeseed oil and mustard oil serve the same purpose. In South Asia, both are referred to by the same name, Sarson-with no differentiation. Canola is a hybrid plant developed from rapeseed or mustard. Mustard, rapeseed, soy, rice bran, and sunflower oils benefit health only when used as a base. Mustard or coconut oil alone is helpful for the scalp. Although selenium is useful in the event of hypothyroidism, it is absent from mustard. Nuts, cereals, mushrooms, fish, eggs, and so on are all natural sources used in nutritional supplements [10]. According to world data records, Figure 2 shows the relevant percentage of edible oil production from 2006 to 2021. It denoted the consistent growth of the common edible oil production globally, reaching almost 99% in 2021.

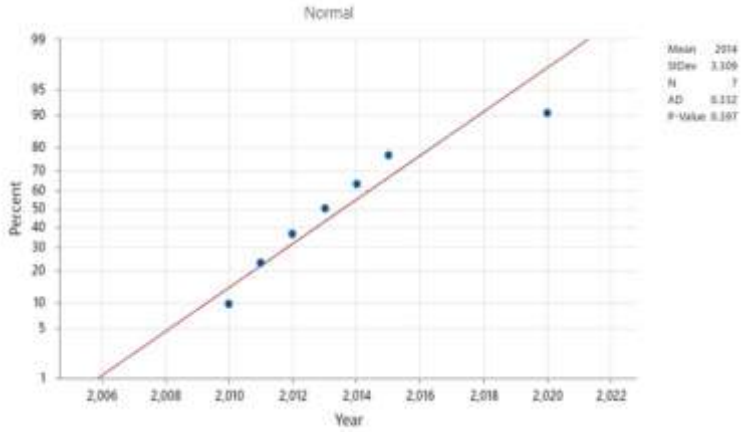

Figure 2: Percentage-wise Global Production of Vegetable Oils from 2006-2021 [11]
[Source: https://ourworldindata.org/grapher/vegetable-oil-production]

5. **Effect of Heating:** The applications of heat, along with the use of a heating vessel, induce swift alterations in the properties of cooking oil. Certain oils considered beneficial for human health when consumed at room temperature may lose their health benefits and become potentially harmful when exposed to high temperatures, mainly through repeated heating. The association between hazardous risk and the oxidation of fatty acids has been established, whereby fatty acids possessing more elevated levels of unsaturation exhibit a heightened oxidation rate when subjected to heating in an oxygen-rich environment [12]. When selecting a cooking oil, it is imperative to ensure that the oil's heat tolerance aligns with the intended cooking temperature, and it is advisable to replace the frying oil regularly, preferably multiple times within a week. Deep-fat frying temperatures typically average 180 °C. In some cases, although this is unusual, 130 °C may be considered [13].

Table 2: Various Edi ble Oils and their Chemical Structures and Total SA, MUFA, PUFA

Edible oils	Palmitoleic acid C16:1	Oleic C18:1n9	Eicosenoic C20:1n9	Erucic C22:1n9	Linoleic C18:2n6	Alpha-Linolenic C18:3n3	Total Saturated Fatty Acid (TSFA)	Total Poly Unsaturated Fatty Acid (TPUFA)	Total Mono-Unsaturated Fatty Acid (TMUFA)
Coconut oil		7.24			1.90		90.86	1.90	7.24
Corn oil	1.70	31.97			48.97	0.76	16.60	49.74	33.67
Mustard oil	0.16	10.18	5.45	51.30	15.55	11.64	5.72	27.19	67.09
Palm oil	0.27	43.26			11.18	0.30	44.98	11.49	43.53
Rice Bran oil	0.28	43.84			31.56	0.56	23.76	32.12	44.12
Soyabean oil		24.06			54.78	5.20	15.96	59.98	24.06
Sunflower oil		25.96			62.65		11.39	62.65	25.96
Safflower oil	0.24	13.80	0.17		76.58	0.13	9.19	76.78	14.04

Note: C here carbon with 16 or 18 or more carbon chains with one/two/three double bonds at specific positions as mentioned, followed by n.

IV. NUTRITIONAL BENEFITS OF EDIBLE OILS [10,14]

1. **Rapeseed oil**, or Canola oil, is processed oil derived from rapeseed plants' seeds, necessitating elevated temperatures, pressure, and chemical agents during refining. The oil contains less than 7% saturated fatty acids but is high in monounsaturated fatty acids. The food item under consideration exhibits a notable abundance of monounsaturated and polyunsaturated fats while demonstrating a comparatively low presence of saturated fats and a substantial concentration of omega-3 fats. Nevertheless, this substance exhibits a deficiency in inherent antioxidants, an elevated concentration of polyunsaturated fat, and diminished heat stability, generating deleterious polar compounds. This raises questions about the nutritional suitability of canola oil for culinary use.

2. **Rice Bran Oil** is derived from rice grains by refining techniques akin to those employed in the extraction of Canola Oil. This oil possesses oryzanol, an antioxidant compound that effectively impedes cholesterol absorption. The oil in question demonstrates a favorable distribution of mono and polyunsaturated fats, with a slightly elevated proportion of saturated fats (20%) compared to Canola Oil. Rice Bran Oil exhibits lower stability despite its favorable attributes, such as a high smoke point and cooking compatibility. It generates deleterious by-products due to its refining techniques, elevated polyunsaturated fat composition, and diminished presence of inherent antioxidants.

3. **Coconut oil,** derived from the matured flesh of coconuts, possesses a notable saturated fat concentration of 92%. The main constituent of this substance is predominantly lauric acid, which has been found to enhance high-density lipoprotein (HDL) cholesterol levels while concurrently elevating low-density lipoprotein (LDL) cholesterol levels. Compared to extra virgin olive oil (EVOO), this oil exhibits stability and safety when used for culinary purposes. However, it is essential to note that its antioxidant content is negligible. While it may be a comparatively superior option to oils such as Canola Oil, it is not advised as a substitute for unsaturated fats like Extra Virgin Olive Oil (EVOO).

4. **Palm oil:** Palm oil, derived from the fruit pulp of the oil palm, is widely utilized as a culinary component in tropical regions of Africa, Southeast Asia, and specific areas of Brazil. Due to its affordability and elevated smoke point, this substance is advantageous for frying. Numerous studies have provided evidence that using palm oil as a replacement for trans-fat in the food sector is not deemed safe, owing to its propensity to induce unfavorable alterations in LDL cholesterol and apolipoprotein B levels. Recent studies have demonstrated that saturated fats' metabolism processes in the sn-1 and -3 locations of triacylglycerol differ due to their low absorptivity. Additional research is required to comprehensively comprehend the impact of variations in the exact positioning of fatty acids on health-related results. The primary drawbacks associated with palm oil are its elevated levels of saturated fat and an unfavorable N-6: N-3 ratio of approximately 20:1.

5. **Sunflower Oil**: Derived from the seeds of the sunflower plant, is composed of around 13% saturated fat and 66% omega-6 polyunsaturated fat. Omega-6 polyunsaturated fat in sunflower oil has been associated with cholesterol-lowering effects. Nevertheless, similar

to other polyunsaturated oils, it exhibits increased vulnerability to oxidation when exposed to elevated temperatures, forming detrimental byproducts.

6. **Soybean Oil:** Comprises around 4% stearic acid and 10% palmitic acid. However, it is noteworthy that this oil possesses a significant proportion of linolenic acid, contributing to its rancidity susceptibility. Consequently, it is advisable to utilize soybean oil promptly to ensure optimal freshness.

7. **Safflower Oil:** Safflower oil has a somewhat elevated proportion of polyunsaturated fatty acids (PUFA) while demonstrating comparatively diminished monounsaturated fatty acids (MUFA) content at approximately thirteen percent. Consequently, safflower oil may not be optimal for promoting health and well-being. Consuming some substances has potentially reduced total and low-density lipoprotein (LDL) cholesterol levels while simultaneously decreasing levels of high-density lipoprotein (HDL) cholesterol. A large proportion of polyunsaturated fatty acids (PUFAs) is associated with an increased susceptibility to rancidity. Additionally, although polyunsaturated fats exhibit a high smoke point suitable for deep frying, they can become hazardous when subjected to elevated temperatures [14].

8. **Blended Oils:** The recommended PUFA: SFA ratio of 0.8-1.5 is advocated by esteemed organizations such as the World Health Organization and the American Heart Association. However, a study discovered that no individual oil possesses the essential micronutrients required to achieve a well-balanced SAFA/MUFA/PUFA composition. Blended oils have thermal and oxidative durability, rendering them indispensable for preserving the appropriate dietary fatty acid ratio.

V. CONCLUSION

Indian cooking methods exhibit distinct variations compared to worldwide culinary traditions, characterized by the repeated application of heat to oils during the process of stir-frying, which has been observed to result in the degradation of crucial antioxidants. Refined oils are often advocated due to their accelerated breakdown process and elevated concentrations of polyunsaturated fatty acids. Edible oils containing monounsaturated fatty acids (MUFA) or polyunsaturated fatty acids (PUFA) are deemed appropriate for dietary consumption. Blended oils exhibit thermal and oxidative stability, effectively maintaining the desirable dietary equilibrium of fatty acids. Blended oils have superior performance in culinary applications and contribute to preserving human health.

REFERENCES

[1] Rey, Felisa, et al. Chapter 10 - Oils as a Source of Bioactive Lipids (Olive Oil, Palm Oil, Fish Oil). Edited by Manuela Pintado et al., Academic Press, 2023, pp. 231–268.
[2] Lichtenstein, A. H. FATS AND OILS. Edited by Benjamin B T - Encyclopedia of Human Nutrition (Second Edition) Caballero, Elsevier, 2005, pp. 177–186.
[3] Banerjee, Swapan. "A Comprehensive Review on the Economic Status of the Global Convenience Food Industry." International Journal of Business, Management and Economics, vol. 2, no. 1, 2021, pp. 43–52.
[4] Pitsavos, Christos, et al. "Diet, Exercise and the Metabolic Syndrome." The Review of Diabetic Studies, vol. 3, no. 3, 2006, pp. 118.
[5] Banerjee, Swapan. "Consistent Monitoring by a Dietitian Directs the Patient's Regular Follow-up for the Best Possible Dietary Outcome." Southeast Asian Journal of Health Professional, vol. 5, no. 1, 2022, pp.

17–18.
[6] Zhao, Xuemei et al. “Studying the Evaluation Model of the Nutritional Quality of Edible Vegetable Oil Based on Dietary Nutrient Reference Intake.” ACS omega vol. 6,10 6691-6698.
[7] Mazzocchi, Alessandra, et al. “Bioactive Compounds in Edible Oils and Their Role in Oxidative Stress and Inflammation.” Frontiers in physiology vol. 12 659551.
[8] Doureradjou, P.; Koner, Bidhan Chandra. "Effect of Different Cooking Vessels on Heat Induced Lipid Peroxidation of Different Edible Oils". Journal of Food Biochemistry. Vol 32, no 6,2008, pp 740–751.
[9] Schwingshackl, Lukas, and Georg Hoffmann. “Monounsaturated fatty acids and risk of cardiovascular disease: synopsis of the evidence available from systematic reviews and meta-analyses.” Nutrients vol. 4,12 1989-2007.
[10] Kathleen Alleaume. “A Guide to Common Cooking Oils” Accessed on 20th August 2023. https://olivewellnessinstitute.org/article/a-guide- to-common-cooking-oils/.
[11] Vegetable oil production, World. Ourworldindata. Accessed on 20th August,2023. https://ourworldindata.org/grapher/vegetable-oil- production
[12] Orna Izakson. "Oil Right: choose wisely for heart-healthy Cooking - Eating Right.” E: The Environmental Magazine.
[13] Jump up to a b Bouchon, Pedro. "Chapter 5 - Understanding Oil Absorption During Deep-Fat Frying". Advances in Food and Nutrition Research. 57,2009, pp 209–34.
[14] Bharti, Deepa Indoria, R.L. Solanki and Meena, B.S. “A Comparative Impact Study of Edible Oils on Health”. Int.J.Curr.Microbiol.App.Sci. vol 6, no 11, 2017,pp 601-612.
[15] Bhattacharyya S, Sen KS, Maiti A. Natural antioxidant rich dietary oil blends as healthy cooking oil. Int J Eng Res Technol., vol 2,2013, pp 1473–76.

