CONTROL OF THE QUALITY OF VEGETABLE OILS AND ENRICHMENT WITH BIOACTIVE SUBSTANCES

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Abstract. *The increase in the world population indicates that efficient use of food resources, and at the same time, providing people with high-quality, safe, and beneficial products that fully preserve their nutritional value, is one of the most important issues of today. Taking this issue into account, research was conducted on checking the quality of vegetable oils currently offered for public consumption. The analysis of vegetable oils offered for consumption showed that the peroxide value of every 10 analyzed samples was determined to be from 10.71 mmol/kg ½ O to 17.22 mmol/kg ½ O, respectively. This means that, despite not having expired, all analyzed samples contain primary oxidation products 2–3 times higher than the standard required by state regulation. From this, it follows that oxidation processes have already begun in the analyzed vegetable oil samples offered for consumption. Considering that oxidation in vegetable oils proceeds through a chain reaction, we can conclude that even during the valid shelf life period, these vegetable oils already contain primary and secondary oxidation products dangerous to human health. Prooxidants that triggered oxidation in vegetable oils or the causes of the beginning of oxidation in oils could have affected the product at any stage—during production, storage, delivery, or in commercial complexes. To preserve the quality and nutritional value of vegetable oils, it is necessary to introduce antioxidants into the production process to prevent oxidation, thereby preventing the appearance of primary, secondary, and tertiary oxidation products dangerous to human health in vegetable oils offered for consumption by applying natural antioxidants in the production process.*

Keywords: *vegetable oils, oxidation of vegetable oils, prooxidants, antioxidants, peroxide value, primary-secondary-tertiary oxidation products.*

Fats and oils are necessary for human consumption . All over the world, more than 90% of these products are either directly used as food or as ingredients in food products [1]. Fats and oils in the diet are important not only as sources of fat-soluble

vitamins but also for providing other beneficial substances essential for human health. They play a crucial role in maintaining a balanced diet [2]. Furthermore, fats and oils significantly impact global trade and the economic situation[3]. Vegetable oils are one of the essential components of the human diet and are considered vital for daily consumption [4]. Based on their sources, vegetable oils are classified as either plant-based or animal-based.In the 2020/2021 period, the total global production of vegetable oils reached 207 million metric tons [5]. The four main kinds of vegetable oils include palm oil, soybean oil, rapeseed oil, and sunflower oil [6]. Vegetable oils are extracted either from oil-bearing plant seeds (such as sunflower, soybean, rapeseed, etc.) or from oil-rich fruits (e.g., olive and palm) using mechanical pressing or solvent extraction methods [4].

Vegetable oils quality is determined by their organoleptic (sensory) and compositional characteristics. These characteristics influence how well the oils meet agricultural-industrial standards and consumer acceptance levels [7]. Although vegetable oils have a lot of useful sides for health and are widely used in food, pharmaceuticals, and cosmetics, they are highly sensitive to various chemical reactions. These reactions can alter the fundamental properties of the oils, leading to the degradation of nutritional components, loss of taste and smell, and economic losses.

The main reason for this change is lipid oxidation, which significantly alters the biological and physical properties of oils [8,9]. Lipid oxidation is considered one of the most important and widespread spoilage processes in food products. This process causes unpleasant odors and flavors, making products unsuitable for consumption. Apart from this, these changes affect the nutritional value because fat-soluble vitamins and essential fatty acids are destroyed, and sensory characteristics (taste, smell, texture) deteriorate. Oxidation can also lead to the formation of toxic compounds, which may pose health risks to consumers and are considered harmful [10,11]. Additionally, during oxidation, Maillard reaction products may form due to interactions with proteins and sugars, further contributing to undesirable compounds. These reactions may also reduce the bioavailability of essential nutrients (e.g., amino acids), which can affect their absorption in the body [12].

Unpleasant odors and undesirable tastes in oils and fats are usually related with oxidation or hydrolytic breakdown, which occurs as a result of the decomposition of triglycerides. A lot of studies have demonstrated that oxidative stability is the main criterion for determining the quality of vegetable oils. In fact due to the complex chain of oxidative reactions, unpleasant odors may arise in vegetable oils, leading to spoilage and undesirable taste [13]. This process may occur during storage or production and is considered one of the main factors affecting the quality of vegetable oils. Furthermore, one of the most significant and harmful degradation processes in oils is oxidation, which directly affects the final nutritional and sensory quality of the product [14].

Therefore, the oxidative stability of vegetable oils during storage is of great importance [15, 16].Moreover, during the oxidation process, some toxic compounds can form, including reactive carbonyl compounds, which can lead to the formation of lipid peroxidation products. These substances may cause health risks to humans [17].

Several factors contribute to the oxidation of oils and fats: high temperature, storage conditions (presence of oxygen, light and humidity levels), the fatty acid composition of the oils and fats and their degree of unsaturation, the presence of chlorophyll, heavy metals and metal ions (such as Fe^{3+} and Cu^{2+}), which are known pro-oxidants [18, 19]. The oxidation reactions of vegetable oils may be explained by the free radical chain mechanism. Oxidation starts with the radical reactions of unsaturated fatty acids [20]. The mechanism of lipid oxidation depends on the environment and initiator factors, and it is classified into the following types:

1. Enzymatic oxidation (fermentative oxidation),
2. Photo-oxidation,
3. Auto-oxidation.

Considering all mentioned scientific conclusions and information, the goal is to assess the quality of vegetable oils currently offered for consumption in today's market.

Table 1

Acid value and the presence of primary oxidation products in samples of vegetable oils offered for consumption

№	Sample	Manufacturing company	Date of manufacture	Validity period	Acid value,*mg/KOH*	Peroxide value, *mmol/kg ½ O*
1	Oleina (Олейна)	Masleyntsa (Russia)	17.05.2024	17.05.2025	0,25	16,38
2	Golden seed (Золотая семечка)	MEZYug Rusi (Russia)	25.05.2024	25.05.2025	0,11	14,61
3	Golden branch (Золотая ветвь)	BALTON TRADING ASIA (Uzbekistan)	20.11.2024	20.01.2025	0,22	11,31
4	Ideal (Ideal)	Shrovetide (Kazakhstan)	18.12.2023	18.10.2025	0,29	13,36
5	Urgench oil company	Urgench oil company	15.10.2023	15.10.2024	0,22	17,22

	(Urganch yog'-moy AJ)	(Uzbekistan)				
6	Oasis (Voha)	Samega (Uzbekistan)	03.12.2024	03.12.2024	0,26	11,64
7	No words (Gap yo'q)	Gurlan Global Teks (Uzbekistan)	10.01.2025	09.01.2026	0,28	11,58
8	Darital (Darital)	Gurlan Global Teks (Uzbekistan)	08.05.2024	08.05.2025	0,35	10,71
9	Zlotozhar (Злотожар)	ECOBORN INC (Uzbekistan)	22.06.2025	22.06.2026	0,34	12,38
10	Amber (Янтаръ)	ECOBORN INC (Uzbekistan)	01.02.2025	01.02.2026	0,17	11,95

Analysis of the vegetable oils offered for consumption showed that the peroxide value of all ten tested samples ranged from 10.71 to 17.22 mmol O_2/kg. This means that—even though their shelf life had not expired—all samples contained primary oxidation products at levels 2–3 times higher than those required by the national standard. As a result, the analysis of the vegetable oil samples offered for consumption showed that oxidation processes had already begun in these samples. Since lipid oxidation proceeds via a chain-reaction mechanism, we can conclude that even while the oils remain within their labeled shelf life, both primary and secondary oxidation products hazardous to human health are already present in the tested samples. Pro-oxidant triggers may have acted at any stage of the oil's lifecycle during production, storage, transportation, or at retail facilities leading to the initiation of oxidation. To preserve the quality and nutritional value of vegetable oils, it is essential to introduce antioxidants during processing. Doing so can prevent the formation of harmful primary, secondary, and tertiary oxidation products in consumer-ready oils a pressing current issue. Our future research will continue to focus on this direction.

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