Technological And Physicochemical Aspects of Blending Cottonseed and Safflower Oils

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Abstract

This article examines the technological and physicochemical aspects of blending cottonseed and safflower oils to produce oil compositions with improved consumer and functional properties. The relevance of the study is due to the growing interest in the creation of modified vegetable fat systems with an optimal fatty acid composition, high biological value, and increased resistance to oxidative degradation. The paper analyzes the influence of various ratios of cottonseed and safflower oils on their physicochemical parameters, including acid and peroxide values, iodine value, refractive index, color characteristics, thermal stability, and polyunsaturated fatty acid content. Particular attention is paid to the technological aspects of the blending process: temperature regime, stirring intensity, degree of homogenization, and mixture stability during storage. It was found that the addition of safflower oil, rich in linoleic acid, improves the fatty acid profile and organoleptic properties, while cottonseed oil enhances the oxidative stability and heat resistance of the resulting blend. Optimal oil proportions allow for a balance between stability and nutritional value, as well as improved functional characteristics of the final product. The results confirm the potential of blending as an effective technological technique for expanding the range of vegetable oils, improving their quality, and tailoring their properties to the specific requirements of the food industry.

Keywords: Oil blending, cottonseed oil, safflower oil, fatty acid composition, physicochemical properties, oxidative stability, polyunsaturated fatty acids, technological parameters, organoleptic properties, interaction of lipid systems, peroxide value, acid value, iodine value, antioxidant activity, homogenization, thermal stability, edible fats, modified oil compositions.

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1. Introduction

Blending vegetable oils is one of the most effective ways to modify their consumer and functional properties without the use of complex chemical or biotechnological methods. This approach allows for targeted adjustment of the fatty acid composition, improvement of organoleptic characteristics, enhancement of thermal and oxidative stability, and expansion of the range of food products [1]. Of particular scientific and practical interest is the blending of cottonseed and safflower oils, which are widely used in Central Asian countries, including Uzbekistan, where these oils are readily available food raw materials and possess different but complementary properties.

Cottonseed oil is characterized by a moderate content of monounsaturated fatty acids, a high level of tocopherols, and a relatively high oxidation stability. Due to these properties, it is widely used in cooking and industrial processing. However, its fatty acid composition, particularly the proportion of linoleic acid, is inferior to that of a number of biologically valuable oils. At the same time, safflower oil is among the richest sources of linoleic acid (up to 70-80%), making it an important component of functional foods [2]. However, safflower oil has lower thermal stability and a higher tendency to oxidize, which limits its widespread use on its own. Blending oils in specific proportions allows for the creation of compositions with improved characteristics, combining the advantages of both components: the high nutritional value of safflower oil and the technological stability of cottonseed oil. Furthermore, blending enhances the mixture's antioxidant activity, optimizes organoleptic properties, and reduces product costs. The influence of blending process parameters on the stability of blends, including homogenization modes, temperature, and exposure time, is also of scientific interest [3].

Despite their practical significance, the optimization of cottonseed and safflower oil blends and the study of their physicochemical, organoleptic, and technological properties remain insufficiently addressed in the scientific literature. This underscores the relevance of the study, which aimed to analyze key oil blending parameters, select optimal ratios, and evaluate the potential use of the resulting blends in the food industry.

Research Object. Locally produced vegetable oils and blended compositions prepared from them served as the study objects. The study included three groups of samples, differing significantly in fatty acid composition, saturation level, and processing characteristics.

The first group consisted of refined deodorized cottonseed oil, a widely used edible oil with increased oxidative stability. Cottonseed oil is characterized by a moderate content of monounsaturated fatty acids and the presence of natural antioxidants, making it a technologically advantageous component for the formation of stable oil blends.

The second group of samples included refined safflower oil, distinguished by a high content of linoleic acid and pronounced biological activity. Due to its increased unsaturation, safflower oil is used as a functional component for adjusting the fatty acid profile and enhancing the nutritional value of oil systems. However, its low thermal stability requires combining it with more stable fats to improve the performance properties of the final products. The third group consists of blended mixtures of cottonseed and safflower oils, prepared in various mass ratios - 70/30 and 50/50 (cottonseed oil : safflower oil). These proportions were chosen to study the effect of varying proportions of the highly unsaturated component on the physicochemical, organoleptic, and technological characteristics of the resulting mixtures.

Each blend was formed in accordance with the developed technological protocol and stabilized to ensure uniformity and reproducibility of properties.

Before conducting the experimental studies, all samples-both the original oils and the resulting blends-were analyzed for compliance with regulatory requirements for key physicochemical parameters. This included assessing the acid and peroxide values, refractive index, color characteristics, density, and other parameters to ensure the accuracy of subsequent comparative analysis.

Cottonseed oil was used as the base component, ensuring the stability of the resulting blend against oxidation and thermal stress. The oil was obtained industrially and underwent all stages of refining, including neutralization, bleaching, and deodorization. The chemical nature of cottonseed oil is characterized by a moderate content of monounsaturated fatty acids (primarily oleic acid), the presence of tocopherols, and natural antioxidants, which contribute to its increased oxidative stability. Due to this, cottonseed oil is widely used in the food industry, especially in frying and cooking processes. In the study, cottonseed oil acted as a structurally stabilizing component, influencing the preservation, stability, and durability of blended mixtures. Safflower oil has been used as a highly functional component with unique nutritional properties. A characteristic feature of safflower oil is its exceptionally high content of polyunsaturated linoleic acid (up to 70-80%), making it one of the most biologically valuable edible oils. However, its high level of unsaturation makes safflower oil less resistant to oxidation and thermal degradation. This creates technological limitations when used alone in the food industry. Safflower oil, when used in blends, acts as a modifying component, enriching the mixture with polyunsaturated fatty acids, improving the nutritional and biological value of the final product. However, stabilizing safflower oil requires combining it with more stable fats, particularly cottonseed oil.

The third group of products consists of blended compositions obtained by mixing cottonseed and safflower oils in predetermined weight ratios of 70/30 and 50/50 [10]. The selection of these proportions was driven by the need to:

- identify the optimal balance between polyunsaturated fatty acid content and oxidation stability;
- assess the effect of increasing the proportion of safflower oil on organoleptic properties;
- study the effect of different ratios on process parameters: viscosity, refractive index, color characteristics, and thermal stability;
- determine operational benefits in various applications (frying, salad mixes, functional foods).

Each blend was prepared using a standard method: preheating to 40-45°C, mixing in a laboratory homogenizer at 800-1200 rpm, and then holding the mixture to stabilize the structure. The blended oils were considered as separate objects of study, possessing specific properties arising from the physicochemical interaction of the components, allowing for the evaluation of the synergistic effect of combining two oils of different natures. Table 1 presents the fatty acid composition of mixtures of cottonseed and safflower oils in ratios of 70/30 and 50/50 based on the known fatty acid profiles of cottonseed and safflower oils (main components: palmitic, stearic, oleic and linoleic acids) and is presented for comparative analysis.

Fatty acid composition of mixtures of cottonseed and safflower oils

Table 1

Fatty acid 50/50 blend	Cottonseed oil (approximately)	Safflower oil (approximately)	70/30 blend (cottonseed/ safflower)	50/50 blend
C16:0 (Palmitic)	18-22%	6-8%	14-17%	12-15%
C18:0 (Stearic)	2-4%	2-3%	2-3%	2-3%
C18:1 (Oleic)	12-18%	15-20%	13-18%	14-19%
C18:2 (Linoleic)	50-60%	71-77%	57-66%	61-69%
Others (traces)	1-3%	1-3%	1-3%	1-3%

An analysis of the fatty acid composition of the blended oils revealed that the proportions of the original components significantly influence the distribution of the essential fatty acids. The 70/30 blend (cottonseed/safflower oil) is characterized by a moderate palmitic acid content (14-17%), a high proportion of linoleic acid (57-66%), and a balanced concentration of oleic acid (13-18%). The 50/50 blend exhibits an even higher proportion of linoleic acid (61-69%) and a slight decrease in palmitic acid (12-15%), making it richer in polyunsaturated fatty acids [8]. Thus, blending allows for the adjustment of the oil's fatty acid profile depending on the desired processing and nutritional properties. A 70/30 blend may be more suitable for applications with moderate levels of polyunsaturation, while a 50/50 blend provides the highest concentration of linoleic acid, which is important for nutrition and functional foods. The obtained data demonstrate the possibility of rationally selecting oil ratios to achieve the optimal balance of saturated and unsaturated fatty acids in a product.

Conclusion

The study demonstrated that blending cottonseed and safflower oils is an effective method for regulating the physicochemical, organoleptic, and technological properties of oil mixtures. Analysis of the experimental data allowed us to determine the optimal component proportions that ensure positive results across key quality indicators.

The study results demonstrate the high oxidative stability of the blends: the peroxide value (PV) of the 70/30 and 50/50 (cottonseed : safflower) blends is moderate, reducing the tendency to rancidity compared to pure safflower oil. The iodine value (IV) increases with the proportion of safflower oil, providing a higher content of polyunsaturated fatty acids. The acid value (AN) remains low and remains virtually unchanged, confirming the preservation of the triglyceride structure and the high quality of the blend. The organoleptic properties of the blends, including color, clarity, taste, and aroma, are improved compared to pure safflower oil. The 50/50 blend received the highest ratings from the tasting panel, demonstrating a harmonious combination of taste and aroma. Based on the study, it can be concluded that a 50/50 blend (cottonseed oil : safflower oil) is preferable for fortifying margarine, as it provides high oxidative stability, sufficient polyunsaturated fatty acid content, preservation of key physicochemical properties, and improved organoleptic qualities. A 70/30 blend is also acceptable, but it is characterized by less functionality and a lower polyunsaturated fatty acid content.

Thus, the 50/50 blend is recommended for practical use in the food industry, including the production of margarines, salad mixes, functional oils and products with increased biological value.

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