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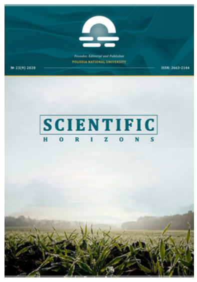


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# Assessment of fat-and-oil products quality conformity (safflower oil)

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**Abstract**. The study aims to analyse the qualitative characteristics of safflower oil, including its fatty acid profile, and determine the acid and peroxide numbers. The study also investigated the levels of heavy metals in the oil and assessed its potential as an inhibitor of α-amylase and α-glucosidase enzymatic activity. In this study, standardised methods were used to analyse the fatty acid composition of safflower oil using a standard mixture of 37 fatty acid methyl esters (Supelco™ 37 Component FAME Mix), which ensured high accuracy in determining the fatty acid composition. The physical properties of safflower oil, such as density (0.94) and specific gravity (0.917), depend on the fatty acid composition and temperature. The refractive index, determined at 1.469, was used to estimate changes in the oil's unsaturation and viscosity (45.6 cP). Colour parameters (lightness 45.24, red-green scale -2.87, yellow-blue scale 21.04) confirm the authenticity of the oil. The results of gas chromatographic

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analysis confirmed that the composition of the samples did not meet the requirements of the standard. The study also included the evaluation of the inhibitory activity of safflower oil against the enzymes α-amylase and α-glucosidase, where one of the samples showed significant inhibition of α-amylase activity and the other α-glucosidase activity, indicating their potential use as natural inhibitors. The safety control of heavy metal content showed that the levels of lead, cadmium and other toxic elements in the oil are well below the permissible limits, confirming its safety for consumption. These data indicate that, although some safflower oil samples do not meet the standards for fatty acid composition, its potential as a natural enzyme inhibitor and safety in terms of heavy metal content opens up prospects for further research and possible optimisation of production processes

**Keywords:** acid number; fatty acids; heavy metal content; inhibition; state standard; heavy metal content

## INTRODUCTION

In today's world, the issue of providing the population with safe and high-quality food enriched with vitamins, microelements and biologically active substances is of particular relevance. An unbalanced and irrational diet is one of the leading risk factors for the development of nutritionally dependent diseases, such as obesity, type 2 diabetes, cardiovascular diseases, certain types of cancer and others. In this regard, the search for new sources of biologically valuable substances and the development of functional foods that can compensate for nutritional deficiencies and improve public health is one of the most important tasks of modern nutrition science. In this context, safflower (*Carthamus tinctorius* L.), an oilseed crop with a unique complex of biologically active substances, is particularly promising. Following G.S. Aidarkhanova *et al.* (2021), safflower oil and extracted meal can be used as functional ingredients to enrich various foods, such as bakery products, dairy products, confectionery, meat and fish products. This, in turn, can significantly contribute to optimising food consumption patterns and improving public health.

Safflower, as a source of oil and fat products, has several outstanding advantages that determine its importance in human nutrition. Of particular note is the high content of linoleic acid in safflower oil, which reaches up to 80%. Linoleic acid is an essential fatty acid necessary for maintaining the health of the human body (Mukhametov *et al.*, 2023). This statement is supported by B.M. Iskakov *et al.* (2022) and M.T. Mursalykova *et al.* (2022), who also note the richness of safflower in B vitamins (B1, B2, B6), E, and K, as well as macro- and microelements such as potassium, magnesium, calcium, phosphorus, iron, copper and zinc. Moreover, safflower contains several biologically active substances, such as flavonoids, phytosterols and lignans, which have pronounced antioxidant, anti-inflammatory, antibacterial and other beneficial properties. Furthermore, safflower oil and safflower extract not only contribute to the improvement of internal health but also have a high value in the context of improving the appearance of the skin and hair. K.D. Rakhimov *et al.* (2020) identified the potential of safflower in nutraceuticals, where safflower oil and safflower extracts were used as the basis for the creation of biologically active food supplements (BAFS) aimed at preventing and correcting various diseases. Sh. Zhailaubayeva *et al.* (2023) showed that safflower has potential in the field of cosmetology. Given its rich composition, safflower oil can be successfully used as a component of cosmetic products for skin and hair care, making it a valuable ingredient not only for internal but also for external health and beauty improvement.

Many countries around the world have laws and standards governing the quality of fat and oil products. Quality conformity assessment is substantial for manufacturers to ensure that their products meet all the requirements and can be legally marketed (Musayeva *et al.*, 2024). S.T. Abildaev *et al.* (2023) employed statistical and heuristic (organoleptic) methods to assess the quality of fat and oil products. The authors addressed the analysis of the labelling of fat and oil products and concluded that it is necessary to strengthen control over the quality of labelling and packaging of products following the requirements, as well as the need for stricter control over the indication of trans fat content on the packaging of fat and oil products. These findings underline the importance of systematic monitoring and quality control of fat and oil products to ensure the safety and reliability of products on the market. One of the most important aspects of ensuring the quality of fat and oil products is to protect the health of consumers. Safflower oil, similar to other types of vegetable oils, can contain harmful impurities such as pesticides, heavy metals and carcinogens. Eating low-quality butter can lead to poisoning, allergic reactions and the development of various diseases (Bandura & Fialkovska, 2023). Quality conformity assessment was used to identify and withdraw substandard products from the market, thereby protecting the health and well-being of consumers. G. Dambaulova *et al.* (2023) note that butter adulteration by adding vegetable fats is a common type of fraud in the butter and fat industry.

Based on the above, there is an urgent need for a comprehensive analysis of the chemical composition, physicochemical properties and microbiological parameters of safflower oil to verify its compliance with established quality and safety standards. The study aims to identify the key factors affecting the quality of this product and to provide specific recommendations for improving production processes and ensuring a high level of consumer safety.

## MATERIALS AND METHODS

In 2024, eleven different brands of safflower oil were purchased as part of a research project. The locations of purchase included pharmacies, markets, online retailers and cosmetic stores in Almaty, Kazakhstan. All samples were stored at a low temperature of about 4°C until they were used in the study. The samples were numbered with consecutive numbers for ease of organisation and analysis of the data. Each sample was assigned a unique number from 1 to 11, regardless of where it was purchased, which was used for record-keeping, storage, testing and references in the research report.

To accurately determine the composition of fatty acids in the samples, a standard mixture of 37 fatty acid methyl esters (Supelco™ 37 Component FAME (fatty methyl esters) Mix, FAME37, C4-24) was used in gas chromatographic analysis. This standard containing 100 mg of FAME37 was stored at -20°C to maintain its stability. In preparation for analysis, working solutions were prepared from this standard in an ice bath to prevent decomposition. To prepare a standard solution with a concentration of 400 mg/ml, 250 µl of dichloromethane was used, which was added to 100 mg of FAME37 standard. The resulting solution was mixed thoroughly with a shaking device. Then, for further dilution and preparation for injection into the gas chromatograph, 75 µl of this solution was mixed with 925 µl of $CH_2Cl_2$ and stirred on a vortexer.

For analysis by gas chromatography-mass spectrometer (GC-MS), 100 µl of FAME37 standard solution with a concentration of 30 mg/ml was placed in a special glass tube and hermetically sealed. Such precision in sample preparation ensured high accuracy and reproducibility of the analysis results. This method was used to study in detail the fatty acid profile of various samples, including food and biological materials. To study the effect of safflower oil on the activity of the α-amylase enzyme, the method described by H. Mechchate *et al*. (2021) was employed. The α-amylase enzyme was dissolved in water to obtain a final concentration of 4 U/ml. The substrate used was a 0.5% solution of potato starch in 20 mM phosphate buffer. The quality control of fatty acid composition, acid and peroxide numbers was determined according to GOST 5480-59 (Standard of the…, 2005).

Safflower oil was prepared in a solution of 100% MeOH at concentrations of 1 mg/ml, 0.5 mg/ml and 0.25 mg/ml. These samples were mixed with the α-amylase enzyme and incubated at 37°C. After the addition of the starch substrate, 50 ml of DNS (3,5-dinitrosalicylic acid) staining solution containing 96 mM 3,5-dinitrosalicylic acid, 5.31 M sodium potassium tartrate in 2 M NaOH was added to the mixture. The mixture was kept at 85°C for 15 minutes, after which it was diluted with water and left to cool to complete the reaction. The absorbance of the resulting solution was measured at 540 nm using an enzyme-linked immunosorbent assay (ELISA) plate reader. Acarbose was used for comparison.

To evaluate the inhibitory effect of safflower oil on the α-glucosidase enzyme, a method was also developed by H. Mechchate *et al*. (2021). The enzyme α-glucosidase type IV, isolated from *Bacillus stearothermophilus*, was dissolved in 0.5 M phosphate buffer with pH 6.5. The safflower oil was dissolved in 100% methanol to obtain concentrations of 1 mg/ml, 0.5 mg/ml and 0.25 mg/ml. These solutions were incubated with α-glucosidase in a 96-well microplate at 37°C. After the addition of the substrate consisting of 10 µl of 20 mM p-nitrophenyl-α-D-glucopyranoside, the reaction was left to proceed at the same temperature. The final assessment of the colour intensity was carried out using an ELISA plate reader at a wavelength of 405 nm. Control samples were used as a reference.

The concentrations of cadmium (Cd) and lead (Pb) in the products were determined by the atomic absorption method, which deals with the analysis of raw materials and food products for the content of toxic elements (Standard of the Republic…, 2005). The process involved the mineralisation of the sample by dry or wet ashing, after which the concentration of elements was measured in the mineralisation solution (in a 0.1 normal nitric acid solution) using flame atomic absorption spectrometry. The concentration of arsenic (As) was determined by atomic absorption at the resonant wavelength of 193.7 nm using the atomic absorption method, which provides an accurate assessment of the levels of these elements in products. These methods are key to ensuring food safety by identifying and quantifying potentially harmful toxic metals.

## RESULTS

The physical properties of safflower oil, such as density and specific gravity, depend on its fatty acid composition and temperature. The density, defined as mass per unit volume, for safflower oil, was 0.940. Moreover, the specific gravity, which usually increases with the degree of unsaturation of the oil, was measured at 0.917. This value tends to decrease with increasing temperature, which reflects the temperature sensitivity of this parameter. The specific gravity and refractive index are crucial, but not conclusive, for the identification of pure substances. However, they are valuable for detecting any contamination or adulteration in oils. The refractive index of safflower oil was determined to be 1.469, which indicates a change in unsaturation due to processes such as hydrogenation and gives an indication of the viscosity of the oils, which was 45.6 cP. Colour parameters, including lightness, red-green scale and yellow-blue scale, are often associated with the quality of oils, especially those used in salads and shortening. For all samples of safflower oil, the lightness value was 45.24, the red-green scale was -2.87, and the yellow-blue scale was 21.04. These colour indicators are used to assess the quality of the oil and possible adulteration and show that the oil is genuine.

The results showed that out of 11 samples, only two, n1 and n5, met the standard for acid number, which indicates their good condition and proper storage (Table 1). The remaining 9 samples show acid values above 0.5, which may indicate oxidation due to improper storage or processing, which in turn reduces their shelf life and nutritional value. The acid number should not exceed 0.5, and the peroxide number should not exceed 10. As for the peroxide number, only samples n1 and n4 are within the normal range, which indicates a low level of oxidation of these oils and preservation of their taste. This makes them preferred for consumption, as the lower level of oxidised fatty acids provides better flavour and aroma. At the same time, the high peroxide number of the remaining samples can lead to rancidity, making the oil less suitable for use, especially in food products.

***Table 1.*** *Indicators of acid and peroxide number of safflower oil samples of the Republic of Kazakhstan*

| Sample | Acid number ± SD | Peroxide number ± SD |
|---|---|---|
| n1 | 0.2 ± 0.1 | 7.5 ± 1.6 |
| n2 | 1.4 ± 0.1 | 28.6 ± 0.2 |
| n3 | 1.3 ± 0.2 | 14.6 ± 0.3 |
| n4 | 1.2 ± 0 | 8.2 ± 0.4 |
| n5 | 0.4 ± 0 | 12.8 ± 2.1 |
| n6 | 0.7 ± 0.1 | 14.8 ± 1.5 |
| n7 | 0.8 ± 0.2 | 157.7 ± 6.1 |
| n8 | 1.3 ± 0.1 | 25.4 ± 3.4 |
| n9 | 1.9 ± 0.1 | 18.4 ± 1.9 |
| n10 | 0.8 ± 0.1 | 87.8 ± 0 |
| n11 | 1.1 ± 0.1 | 30.4 ± 1.5 |

***Note:*** *SD – standard deviation*
***Source:*** *compiled by the authors*

Firstly, there is a significant variation in the peroxide values among the samples, which may indicate differences in storage conditions or the age of the oils. The sample n7 stands out as having an extremely high peroxide number, which may indicate a critical deterioration in its quality. Such high values can be the result of prolonged exposure to light, temperature and oxygen, which leads to accelerated oxidative degradation. At the same time, the low acid number in samples n1 and n5 indicates that these oils were better protected from external factors or processed in a gentler way, which preserves their original qualities. This makes them potentially more valuable for use in food and other applications where oil quality is of paramount importance. The GOST 5480-59 standard distinguishes between two types of safflower oil, which are obtained from the seeds of the *Carthamus tinctorius* plant (Standard of the Republic of Kazakhstan No. 1428-2005, 2005). Type I oil is produced directly from the seeds of a given plant through expression or extraction processes. Type II oil, in turn, is made from the seeds of hybrid forms of the same plant. These two types of oil can differ in their chemical composition and properties. A problem arises when analysing purchased oil samples: the packaging usually does not indicate whether the oil is derived from hybrid or non-hybrid seeds. This makes it difficult to accurately assess their quality and compliance with standards. In this regard, to analyse the fatty acid composition of the samples under study, they were evaluated based on the criteria for type I oil, as indicated in Table 2.

***Table 2.*** *Criteria for oil component content*

| FAMEs components | Content range (%) |
|---|---|
| C16:0 (palmitic acid) | 4-10 |
| C18:0 (stearic acid) | 1-5 |
| Σ saturated FAMEs (C16:0 and C18:0) | 5-15 |
| C18:1 (oleic acid) | 8-21 |
| C18:2 (linoleic acid) | 68-83 |
| Σ unsaturated FAMEs (C18:1 and C18:2) | 76-105 |

***Source:*** *Standard of the Republic of Kazakhstan No. 1428-2005 "Edible Safflower Oil" (2005)*

From the table with the percentage of fatty methyl esters in safflower oil, several important conclusions can be drawn about the characteristics of this product. Particularly noteworthy are the high values of linoleic acid in each sample, which is typical for safflower oil and makes it a valuable source of omega-6 polyunsaturated fatty acids. This is of significant nutritional and dietary importance, as omega-6 acids are substantial in maintaining cardiovascular health and regulating metabolism. In addition, the presence of up to 21% oleic acid highlights the potential benefits of safflower oil for improving blood cholesterol levels, as oleic acid is a monounsaturated fatty acid that can help reduce LDL cholesterol (bad cholesterol) without reducing HDL cholesterol (good cholesterol). The presence of saturated fatty acids in smaller amounts, such as palmitic and stearic acids, which make up a smaller proportion of the total fatty acid composition, underlines the benefits of safflower oil as a source of unsaturated fat. This makes it the preferred choice for use in healthy foods compared to oils rich in saturated fat. The combination of fatty acids present in safflower oil reflects its potential utility in the food, pharmaceutical and cosmetic industries, where such characteristics can be particularly valuable in creating products that promote health and well-being. The quantitative analysis of fatty acid content in safflower oil samples was carried out using the chromatography method. To determine the concentrations, an approach based on measuring the peak areas on the chromatogram was used, followed by comparing the retention times with those of standard fatty acids.

The results presented in Table 3 show the fatty acid composition analysis of safflower oil, demonstrating its rich profile of mono- and polyunsaturated fatty acids, which range from 67.10% to 99.53% of the total fatty acid content. Among the fatty acids present in the oil, linoleic acid (C18:2) occupies a dominant position with a share ranging from 49.69% to 92.59%, which underlines the outstanding potential of safflower oil as a source of polyunsaturated fatty acids. Oleic acid (C18:1) is also present in significant amounts, ranging from 4.09% to 40.34%, while saturated fatty acids such as palmitic acid (C16:0) and stearic acid (C18:0) make up only a small proportion, ranging from 0.54% to 12.01% and from 0.05% to 1.35%, respectively. The saturated fat content of safflower oil ranges from 0.58% to 12.18%, making it an unsaturated fat source and a preferred choice for diets aimed at improving cardiovascular health. These data emphasise not only the quality of safflower oil as a food product but also its usefulness in dietary nutrition, helping to maintain optimal blood lipid levels and improve overall health. However, despite the positive characteristics of the fatty acid composition, the research results showed that none of the samples met all the requirements for safflower oil according to GOST 5480-59. This discovery highlights the need for further study and adjustment of the butter production and storage processes to ensure its compliance with GOST 5480-59 (Standard of the Republic of Kazakhstan No. 1428-2005, 2005).

***Table 3.*** *Analysis of fatty acid composition of safflower oil samples from the Republic of Kazakhstan*

| Fatty acids (FAMEs) | n1 | n2 | n3 | n4 | n5 | n6 | n7 | n8 | n9 | n10 | n11 |
|---|---|---|---|---|---|---|---|---|---|---|---|
| Palmitic acid (C16:0) | 3.8 | 4.49 | 10.81 | 4.52 | 3.04 | 6.77 | 0.59 | 1.9 | 1.88 | 2.1 | 2.47 |
| Stearic acid (C18:0) | 0.05 | 0.47 | 0.15 | 1.44 | 1.37 | 0.56 | 0.04 | 0.2 | 0.08 | 0.39 | 0.52 |
| Σ saturated fatty acids (palmitic and stearic) | 3.85 | 4.96 | 10.96 | 5.96 | 4.41 | 7.31 | 0.63 | 2.1 | 1.96 | 2.49 | 2.79 |
| Oleic acid (C18:1) | 4.09% | 6.32% | 37.34% | 40.34% | 24.51% | 23.17% | 9.37% | 8.83% | 6.25% | 12.29% | 9.75% |
| Linoleic acid (C18:2) | 92.59% | 87.73% | 54.78% | 49.69% | 68.2% | 69.52% | 86.51% | 82.61% | 91.45% | 84.81% | 86.9% |
| Σ unsaturated LCs (Oleic and Linoleic) | 96.68% | 94.05% | 92.12% | 90.03% | 92.71% | 92.69% | 95.89% | 91.44% | 97.70% | 97.10% | 96.65% |

***Source:*** *compiled by the authors*

The study evaluated the efficiency of inhibition of α-glucosidase enzyme activity using different concentrations of safflower oil samples. The α-glucosidase enzyme catalyses the final step in the hydrolysis of di- and oligosaccharides to monosaccharides, which is key to carbohydrate metabolism. The activity of this enzyme directly affects the level of glucose in the blood after a meal, thereby playing an important role in the pathogenesis of type 2 diabetes mellitus. The experimental study tested the inhibitory effect of various concentrations of vegetable oil on the activity of the α-glucosidase enzyme, which plays a critical role in carbohydrate metabolism by catalysing their breakdown into glucose. Three different concentrations were used for this purpose: 0.25 mg/ml, 0.5 mg/ml and 1 mg/ml. The results showed that most of the oil samples had no significant effect on the enzyme activity. However, an important observation was made for sample No. 11, which at a concentration of 0.25 mg/ml showed an inhibition of 7.41 ± 2.75%, which is statistically significant, although the clinical significance of this effect remains low.

When the sample concentration was increased to 1 mg/ml, the inhibitory effect decreased to 4.61 ± 1.04%. This decrease in efficiency can be explained by the phenomenon of saturation of the enzyme's reaction centres. When a certain concentration is reached, the enzyme's active centres become fully occupied, and further increases in oil concentration do not lead to an increase in the inhibitory effect. It is also possible that conformational changes in the enzyme structure occur, which may alter its ability to bind to the inhibitor, which also affects the activity of α-glucosidase. This highlights the potential of vegetable oils as sources of natural inhibitors for enzymes involved in carbohydrate metabolism. These results may indicate the presence of certain bioactive components in safflower oil that can modulate the activity of enzymes involved in carbohydrate metabolism. This indicates the potential of safflower oil as a source of natural α-glucosidase inhibitors, as well as the efficacy and safety of this inhibitor in the context of the treatment and prevention of type 2 diabetes.

For comparison, acarbose, a well-known α-glucosidase inhibitor, was used as a control standard. The results for acarbose were significantly higher, reaching 99.09 ± 0.49% at a concentration of 0.25 mg/ml, 99.74 ± 0.03% at 0.5 mg/ml and 99.78 ± 0.03% at 1 mg/ml. These data highlight the high efficiency of acarbose compared to safflower oil, confirming its use in medicine as a standard treatment for blood glucose control in diabetic patients. Thus, the study confirmed that safflower oil, except in one sample, has limited activity in terms of α-glucosidase inhibition, and its use as a potential inhibitor requires further research and modification. The study evaluated the ability of safflower oil samples to inhibit the activity of the α-amylase enzyme, which is responsible for the breakdown of complex carbohydrates in the body. The study determined that most of the oil samples did not have a pronounced inhibitory effect on this enzyme at different concentrations. The exception was sample No. 1, which showed moderate inhibitory activity. At a concentration of 1 mg/ml, this sample showed an inhibition of enzymatic activity at the level of 49.82 ± 3.07% (Table 4).

***Table 4.*** *A-amylase activity inhibition values for each safflower oil sample and acarbose reference preparation*

| Sample | Inhibition at 0.25 mg/ml | Inhibition at 0.5 mg/ml | Inhibition at 1 mg/ml |
|---|---|---|---|
| n1 | - | 5.14 ± 2.98 | 49.82 ± 3.07 |
| n2 | 13.16 ± 3.69 | - | 7.93 ± 0.92 |
| n3 | - | 14.71 ± 3.47 | 5.93 ± 2.01 |
| n4 | 13.27 ± 3.74 | 3.22 ± 1.11 | 13.12 ± 1.13 |
| n5 | 8.15 ± 3.74 | 4.64 ± 1.89 | - |
| n6 | - | 10.93 ± 1.14 | - |
| n7 | 7.70 ± 3.05 | 5.10 ± 1.26 | 20.08 ± 8.20 |
| n8 | 15.28 ± 3.96 | 16.33 ± 1.12 | 23.27 ± 5.40 |
| n9 | 26.99 ± 5.23 | 19.88 ± 2.56 | 23.42 ± 2.99 |
| n10 | 38.36 ± 3.47 | 17.22 ±V4.42 | 16.11 ± 3.18 |
| n11 | - | 7.15 ± 1.95 | 3.81 ± 5.88 |
| Acarbohydrate | 88.17 ± 6.19 | 93.58 ± 7.11 | 95 ± 0.04 |

***Source:*** *compiled by the authors*

For comparison, acarbose, used as a reference in the experiment, showed 95% inhibition of α-amylase activity at the same concentration. This highlights the high efficiency of acarbose as a pharmaceutical α-amylase inhibitor, which is widely used to treat conditions associated with carbohydrate metabolism. Final testing of the quality of vegetable oils revealed various levels of heavy metal contamination, which, despite exceeding natural backgrounds, remain well below the established safe limits. These indicators can have a variety of health and environmental implications. For instance, sample No. 4 was found to contain the highest level of lead (Pb) at 0.065 mg/kg, which is 40% below the maximum permissible concentration. Despite compliance with the regulations, even low levels of lead can accumulate in the body over time, potentially leading to neurological and cognitive disorders, especially in children. The content of cadmium (Cd), which was found in the highest amount in sample No. 8 (0.009 mg/kg, 80% below the maximum permissible levels), is also a cause for concern. Cadmium is a carcinogen that can cause kidney failure and bone disease if exposed for a long time, even in low doses.

Arsenic (As), detected in samples No. 5 and No. 8 at 0.003 mg/kg (96% below the limit), is a toxic element that can cause skin, lung and other organ cancer with prolonged exposure. Nickel (Ni), present in sample No. 4 at 0.433 mg/kg, although within safe limits, can cause allergic reactions and aggravate respiratory diseases at high concentrations. However, when the information received was clarified, it was found that in Kazakhstan the average consumption of edible oil per person is about 36 grams per day, which exceeds the recommended norm of 29 grams by the World Health Organisation (WHO) (2024). This level of consumption of sunflower oil, which is one of the most popular in the region, amounts to approximately 1,116 grams per person per month. The predicted impact of this level of consumption on human health was estimated based on the average weight of an adult resident of Kazakhstan, which is 60 kg. The health risk assessment was based on specialised formulas proposed by the WHO, which consider both the quantitative and qualitative characteristics of the oil consumed.

Based on these analyses of the heavy metal content of vegetable oils in Kazakhstan, these products fully comply with the established safety standards. Studies have shown that the concentrations of metals such as lead, cadmium, arsenic and nickel in the human body during consumption are well below the permissible limits. This indicates that there is no direct risk to human health when eating these oils.

## DISCUSSION

Despite the positive characteristics of the fatty acid composition of the safflower oil samples under study, none of them meet the requirements for this type of product following GOST 5480-59. This points to the need for further analysis and improvement of production and storage processes to ensure compliance with quality standards. However, to ensure a more objective and relevant interpretation of the data obtained, it is important to carry out a comparative analysis with the results of similar studies conducted by other authors.

The study of the importance of safflower oil quality is a significant topic in modern science. One of the key aspects in this area is to identify the positive characteristics of this product, such as the high level of polyunsaturated fatty acids, in particular linoleic acid. The study determined that quality problems with safflower oil samples may be related to improper storage or processing, which leads to a loss of nutritional value. M. Nazir *et al*. (2021), Z. Samai *et al*. (2022) and G. Lei *et al*. (2023), also addressed this aspect in their research, emphasising the need to improve the quality of safflower oil. This research has examined the effectiveness of filtration in improving oil quality, as well as the potential use of recycled products such as flax fibre in this process. The authors believe that filtration methods have a direct impact on the quality characteristics and shelf life of the oil and optimise subsequent refining processes. The introduction of efficient filtration methods can reduce production costs and improve the overall quality of the final product (Yaheliuk *et al.*, 2024). The use of recycled products as filter media is an innovative approach that could be promising in the context of improving safflower oil production processes. Thus, this study not only confirms the importance of safflower oil quality and the need to improve it but also opens new research methods based on innovative materials.

D. Alimi *et al.* (2022) and A. Khan *et al.* (2024), also highlight the positive characteristics of safflower oil, emphasising the importance of the fatty acid content of vegetable oils and their suitability for certain applications, whether food, industrial or medical. The authors note that the fatty acids present in vegetable oils (such as oleic, linoleic, lignoceric, elaidic, palmitic, palmitoyl and stearic) have significant pharmacological utility in both human and animal medicine, which is indicative of their high biological activity. Safflower oil has a fatty acid composition that is similar to olive oil, especially due to its high content of oleic and linoleic acids, as indicated by L. Ugolini *et al.* (2023) and Z. Najafi *et al.* (2022). This makes it an affordable alternative to olive oil, given its lower price for consumers. Safflower oil is also valued for its ability to reduce low-density lipoprotein (LDL), known as "bad cholesterol", making it a popular choice in countries such as North America, Germany and Japan.

In addition, safflower oil causes minimal allergic reactions compared to other oils, making it suitable for use in cosmetic products. Studies by L. Xin *et al.* (2022) and L. Chehade *et al.* (2022) on ovariectomised rats showed that fat-free safflower seed powder can increase good cholesterol levels. At the same time, aqueous and ethanolic extracts of safflower seeds affect the level of triglycerides and total cholesterol in the blood plasma. The flavonoids, lignans and serotonin derivatives contained in safflower seeds play an important role in modulating and lowering cholesterol levels, improving the overall lipid profile of the body. This is especially important in conditions of estrogen deficiency. Such polyphenolic substances also help prevent LDL oxidation and the development of atherosclerosis, as shown *in in vitro* and *ex vivo* studies. This indicates the wide variety of uses and benefits of safflower oil, which can be exploited in Kazakhstan when purchased samples meet all the standards.

A comparative analysis of the effectiveness of safflower oil and the control standard, acarbose, in inhibiting α-glucosidase revealed a high activity of acarbose compared to safflower oil, which confirms the advantage of acarbose in this context. These results are in line with the findings of Ž. Tarasevičienė *et al.* (2023), who evaluated the effect of safflower oil on α-amylase and α-glucosidase in the context of weight control, noted the absence of an inhibitory effect in oil samples. The author also noted that the possible impact of low-quality oil samples on enzyme activity highlights the need for stricter quality control of safflower oil in further research and clinical practice.

A review of the studies by D. Deliorman Orhan *et al.* (2022), L. Song *et al.* (2023) and S. Liu *et al.* (2023) determined that these were the first to evaluate the quality of safflower oils on the Turkish market and their effectiveness in terms of two enzymes: α-amylase and α-glucosidase. As part of the work, 9 samples of safflower oil purchased on the local market were analysed and found not to meet the quality criteria set by the European Pharmacopoeia. The study found low oleic acid and high linoleic acid content, suggesting that oleic acid is oxidised to linoleic acid due to production and storage conditions. These results raise concerns about the methods of production and storage of butter, which may affect its quality. The analysis of the inhibitory effect of oils on the enzymes α-amylase and α-glucosidase showed that these oil samples do not have a significant effect on weight management by inhibiting the enzymes involved in carbohydrate digestion. This study highlights the need to improve the quality standards and storage conditions of safflower oil to meet pharmacopoeial requirements and achieve the desired health benefits. These results are directly confirmed by the study of safflower oil quality in the Republic of Kazakhstan, which makes these studies more objective and further points to the problems of state regulation of the standards of producers and the rules for preserving this product.

Before that, the American researcher M. Hugar *et al.* (2023) studied the effect of methanolic extracts of safflower seeds on the activity of the α-glucosidase enzyme and identified compounds such as N-p-coumaroylserotonin and N-feruloylserotonin, which showed a more pronounced inhibitory effect compared to acarbose. However, it is important to note that the chemical composition of secondary metabolites in seed oils may differ from that found in extracts. Another study by G. Sousa *et al.* (2022) showed that oleic and linoleic acids effectively inhibit glucosidase activity, which may be associated with the potential to combat diabetes. However, an important aspect is the degree of oxidation of oils and the compliance of their fatty acid content with the desired standards, which affects the assessment of their effectiveness and safety of use. It is this aspect, studied in the above research, that highlights the importance of these indicators. Having analysed the work of American scientists, it is possible to state that it was the discrepancy in acid content standards that in most samples did not give positive inhibition of amylase and glucosidase.

The study, which focused on the quality of edible oils, paid particular attention to the determination of acid and peroxide numbers, which are important for assessing the degree of freshness and oxidative stability of oils. S. Shinde *et al.* (2023) and P. Kadirvel *et al.* (2023) determined that the acid number measures the amount of free fatty acids and in this study, it did not exceed the maximum permissible level of 0.6 mg KOH per gram of oil, which is in line with WHO standards. This indicates good quality in terms of freshness. As for the peroxide number, which reflects the content of primary fat oxidation products, its values for the samples studied were also within the permissible limits and ranged from 1.09 to 2.43 mEq/kg. These indicators confirm that the oils have not undergone significant oxidation, which is an indicator of their quality and stability. The average peroxide values were compared with the WHO and Food and Agriculture Organisation international standards of 10 milli equivalents of active oxygen per kilogram of oil and found to be in line with these requirements. The lower peroxide values in some samples may be due to their high saturation with fatty acids, which contributes to oxidation resistance. In addition, the presence of antioxidants such as vitamin E in oils also contributes to improving their oxidative stability and extending their shelf life (Yaheliuk & Didukh, 2022). Thus, the data obtained indicate the high quality of the oils under study, confirming their safety and nutritional value for the consumer. This may explain the elevated acid value in the safflower oil samples from Kazakhstan, with normal peroxide values.

Following the analysis of the fatty acid composition of safflower oil by S. Pelaracci *et al.* (2022) and M. Tonguç *et al.* (2023), among saturated fatty acids, palmitic acid (C16:0) has the highest concentration of 6.02%, followed by stearic acid (C18:0) with 2.37%. Other saturated fatty acids, including lauric (C12:0), myristic (C14:0), heptadeconic (C17:0), arachidonic (C20:0), behenic (C22:0) and lignoceric (C24:0) are present in much smaller amounts, amounting to 0.07%, 0.11%, 0.04%, 0.37%, 0.23% and 0.12% respectively. In the total fatty acid balance of safflower oil, saturated fatty acids make up 9.61%, while unsaturated fatty acids make up 90.33%. Among the unsaturated fatty acids, monounsaturated fatty acids account for 14.07%, and polyunsaturated fatty acids (PUFAs) dominate 76.26%. This emphasises the high proportion of PUFAs in safflower oil, which makes it attractive for diets aimed at improving cardiovascular health and lowering cholesterol levels. In addition, the ratio of polyunsaturated to monounsaturated fatty acids in an oil expresses its nutritional value and stability. However, it is worth noting that an important aspect when choosing an oil is the ratio of omega-6 to omega-3 fatty acids, where in safflower oil omega-6 makes up a significant percentage (76.22%), which requires attention when included in the diet to prevent an imbalance of these acids (Kachanova *et al.*, 2023). These studies show both the indicators already tested in the above study and new ones. The ratio of omega-6 to omega-3 fatty acids has an important influence on the quality of safflower oil and should also be considered by producers.

Safflower oil has a variable composition and nutritional profile, which depends on the growing conditions, soil type and safflower varieties used. S. Adewinogo *et al.* (2021) and M. Ruyvaran *et al.* (2021) state that the future use of safflower oil in the food industry will depend on the successful selection of high-yielding plant varieties. Currently, safflower oil is actively used in the production of margarine and universal shortening for bakery products, as well as in emulsified shortening used for making cakes. Due to its high content of oleic and linoleic acids and antioxidants, safflower oil is an excellent choice for replacement in infant formula. Its natural flavour and mildness also make it a popular ingredient in seasonings, flavourings and dried fruits. These studies once again point to the great importance and breadth of application of safflower oil, if properly produced, which can significantly expand the production and export of this commodity in the Republic of Kazakhstan.

## CONCLUSIONS

In this study, the quality of safflower oil was analysed using several indicators, including acid and peroxide numbers, as well as the ability of oils to inhibit the activity of α-glucosidase and α-amylase enzymes. Of the eleven samples, only two (n1 and n5) met the acid number standard, falling below the threshold of 0.5. This indicates that the samples are in good condition and have been stored correctly. The average acid number of the other nine samples is 0.75, which is higher than normal and indicates oxidation due to improper storage or processing. The study also determined that only samples n1 and n4 met the peroxide standard, which indicates a low level of oxidation and preservation of the oil's taste. This makes these samples preferable for consumption. However, despite the positive aspects in terms of acid and peroxide numbers, none of the samples meets all the requirements for fatty acid composition set out in GOST 5480-59 for safflower oil. This highlights the need for further study and adjustment of the oil production and storage processes.

The ability of the oil samples to inhibit the activity of the α-amylase enzyme was evaluated, and only sample No. 1 showed moderate inhibitory activity. This indicates the potential for safflower oil to be used as an inhibitor, but further research is needed to improve its effectiveness. Studies on the content of heavy metals in vegetable oils have shown that the products fully comply with established safety standards, which significantly reduces the health risks associated with the use of these oils. The study's shortcomings include the lack of long-term monitoring of oil quality changes over time, which could provide a more complete picture of its stability and resistance to oxidation. It is also worth noting that there is no comparison with other types of oils, which could help determine the unique properties of safflower oil. Lastly, although the effect of oil on enzyme activity has been investigated, the data was limited to only two types of enzymes, leaving questions about its potential impact on other key aspects of metabolism. Prospects for further research are based on the need to improve the production and storage processes of safflower oil to achieve compliance with pharmacopoeial standards, as well as to further study its potential use as an amylase inhibitor.

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## CONFLICT OF INTEREST

None.

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# Оцінка відповідності якості олійно-жирової продукції (олія сафлорова)

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**Анотація**. Метою даного дослідження був аналіз якісних характеристик сафлорової олії, включно з її жирнокислотним профілем, а також визначенням кислотного і перекисного чисел. Дослідження також було спрямоване на вивчення рівнів важких металів в олії та оцінку її потенціалу як інгібітора ферментативної активності α-амілази та α-глюкозидази. У цьому дослідженні застосовували стандартизовані методи для аналізу жирнокислотного складу сафлорової олії, використовуючи стандартну суміш метилових ефірів 37 жирних кислот (Supelco™ 37 Component FAME Mix), що дало змогу досягти високої точності у визначенні складу жирних кислот. Фізичні властивості сафлорової олії, як-от густина (0.94) і питома вага (0.917), залежать від жирнокислотного складу і температури. Коефіцієнт заломлення, визначений на рівні 1.469, допоміг оцінити зміни в ненасиченості та в'язкості олії (45.6 сП). Параметри кольору (світлота 45.24, червоно-зелена шкала -2.87, жовто-блакитна шкала 21.04) підтверджують справжність олії. Результати газохроматографічного аналізу підтвердили невідповідність складу зразків вимогам стандарту. Дослідження також включало оцінку інгібуючої активності сафлорової олії проти ферментів α-амілази та α-глюкозидази, де один зі зразків продемонстрував значне пригнічення активності α-амілази, а інший – α-глюкозидази, вказуючи на їхнє потенційне застосування як натуральних інгібіторів. Контроль безпеки за вмістом важких металів засвідчив, що рівні свинцю, кадмію та інших токсичних елементів в олії значно нижчі за допустимі межі, підтверджуючи її безпеку для вживання. Ці дані вказують на те, що, незважаючи на невідповідність деяких зразків сафлорової олії стандартам за жирнокислотним складом, її потенціал як натурального інгібітора ферментів і безпека за вмістом важких металів відкривають перспективи для її подальшого дослідження та можливої оптимізації виробничих процесів

**Ключові слова:** кислотне число; жирні кислоти; вміст важких металів; інгібування; державний стандарт; вміст важких металів