Comparative characteristics of quality indicators of non-traditional vegetable oil types

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Abstract. The popularity of vegetable fats among consumers around the world is growing rapidly. That’s why it is necessary to expand the range of using various agricultural crops’ oils in accordance with the content of useful components in them. Since vegetable oils have different storage stability, it is very relevant to establish optimal storage modes and terms. This research was conducted in laboratories using standard methods. Fatty acid composition of unrefined rapeseed, colza, camelina and sunflower oils were identified and compared. Two temperature conditions were considered (22°C, 4°C) in with and without exposure to light; in glass containers; with and without air access. From the results of research it was found that the optimal ratio of Omega-3 and Omega-6 is observed in Camelina oil. The obtained data indicate a direct influence of temperature and exposure to light on the dynamics of changes in peroxide and acid numbers of vegetable oils during the storage period. The most unfavorable storage mode for non-traditional vegetable oils was the mode with access of light at 22°C.

1. Introduction

Vegetable oils in their composition contain 95% triglycerides and phosphatides (waxes), which give them their smell and color. Antioxidants, micronutrients and vitamins are also included in vegetable oils [1]. But not all their types are the same in the composition of the substances presented.

In Europe and North America people are paying great attention to rapeseed, colza, flax and camelina oil. For example, every American consumes an average 26-28 kg of vegetable oil per year, while a European slightly less. Particular attention people in Europe and North America pay to the consumption of flax oil [2–4].

The Russian Federation is one of the few countries where the consumption of vegetable oil is very low, given that the medical norm is 15 kg per person. Nevertheless, the consumption of vegetable oil in Russia is growing and in 2019 it averaged at about 14 kg per person.

Currently sunflower oil is the most widely used in the world. In Russia more than 80% of the oilseeds’ production is accounted for by sunflower. Given that the majority of the country’s population lives in conditions of short summer, prolonged cold and snow, which causes increased protein consumption rates for the functioning of the human body, a very important characteristic of the diet is the use of products balanced in fatty acids [5].
Recent studies of science and practice confirm the effectiveness of using unsaturated fatty acids for the prevention and treatment of various diseases, such as atherosclerosis, diabetes, stroke, coronary heart disease, etc. [6, 7].

Note that many oilseeds are well suited for production in the non-Chernozem zone of Russia. At the experimental agrotechnology station of Ryazan State Agrotechnological University high yields were obtained for such non-traditional oilseeds as safflower, Abyssinian krambe, as well as essential oil crops such as coriander, cumin, anise, and fennel. Foreign research confirms good biological adaptability for the production of oilseeds of these crops in many world regions [8–10].

The popularity of vegetable fats among consumers around the world is growing [11, 12]. In this regard it is necessary to expand the range of use of various oils of various agricultural crops in accordance with the content of useful components in them.

2. Problem statement
Domestic and foreign scientific research shows that the fatty acid composition of vegetable oils is one of the main characteristics of this product. Polyunsaturated fatty acids play a significant role in the life of a human body. They take an active part in metabolic processes as active physiological substances [13]. The leading role in this process is taken by fat glycerides, which contain the following essential or fatty acids – arachidonic, linoleic and linolenic. Insufficient content of polyunsaturated fatty acids in the human body contributes to the formation of esters by combining cholesterol with saturated fatty acids, which are difficult to break down during the process of metabolism [14].

In the process of accumulation in blood, esters deposit on the walls of the arteries. But if there is a sufficient amount of fatty acids, previously formed ethers can be oxidized to low-molecular-weight-acids with their further excretion from the body.

Polyunsaturated essential fatty acids are divided into two families depending on the position of the double bonds – Omega-3 and Omega-6. Alpha-linoleic acid represents the Omega-3 family, which is of plant origin. Gamma-linoleic and arachidonic acids belong to the Omega-6 family. The Omega-9 family includes monounsaturated fatty acids: oleic, elaidic, gondoic, erucic, nervonic, and midic. In contrast to Omega-3 and Omega-6, monounsaturated fatty acids are not essential, since the human body can produce them independently if all the necessary components (Omega-3, Omega-6) have been obtained from food [15]. Thus, the fatty oils of plants are energy and building material that is concentrated in the seeds and other plant organs. Fat is contained in various parts of plants in different amounts, which depends primarily on the type of plant, variety, soil and climatic conditions of the growing area.

Fatty acid composition is the main criterion for evaluating the biological value and consumer properties of vegetable oils. In this regard it is necessary to know about the fatty acid composition of various types of vegetable oils. At present it is possible to obtain high-quality vegetable oils from many types of oilseeds, which have different fatty acid composition, consumer can choose depending on the need for vegetable oil. The consumer needs to know not only what oil has the most favorable fatty acid composition for the body and is more useful for eating. It is also important to know under what conditions and how long it can be stored, because oils of non-traditional crops are unstable in storage.

3. Materials and methods
Oil quality determination research was conducted in 2018-2020 in laboratories of Ryazan State Agrotechnological University, Efremovsky Creamery – Kuban oil in Tula region, and in Ryazan Center of Standardization and Metrology.

The objects of research were the types of unrefined vegetable oils non-traditional for the Ryazan region – rapeseed, colza, camelina – in comparison with sunflower oil (control).

Acid and peroxide numbers are not only the main indicators of quality of vegetable oils, but also indicators of their freshness and storability. Acid number characterizes the degree of hydrolysis of lipids because the amount of free acids in natural oils and fats is negligible. During storage, provided oxygen is available, occurs the process of hydrolysis, which is accompanied by the oxidation of fatty acids. The
probability of formation of carcinogens in oil under incorrect storage conditions is less when the acid number of oil is lower.

Acid number of all types of vegetable oils should not exceed 4.0 mg KOH/g in accordance with the requirements of Sanitary Norms and Rules No. 2.3.2.1078-01 Hygienic requirements for food safety and nutritional value. Acid number depends on many factors, such as quality of the raw material, oil obtaining method, storage conditions, etc.

The degree of oxidation of oil (fat), which is caused by accumulation of peroxide compounds in the process of fat oxidation during storage, is a Peroxide number. This process is especially active in the presence of light. The products formed during this process cause negative organoleptic indicators of oil quality. Studying and forecasting of Peroxide and Acid numbers of vegetable oils significantly reduces the risks of oil storage. Peroxide number of all types of vegetable oils according to regulatory documents should be no more than 10.0 mmol of active oxygen/kg.

In this regard, research was conducted to identify the most favorable storage conditions for unrefined vegetable oils of cruciferous crops, which are more optimal in terms of fatty acid composition for the human body. Were considered two temperature conditions (22°C, 4°C) in light and without exposure to light; in glass containers; with and without air access.

Acid number was determined according to the method described in ГОСТ 31933-2012 Vegetable Oils. Methods for determining the acid number, by a titrimetric method with potentiometric indication. Peroxide number was determined according to ГОСТ ISO 3960-2013 Animal and Vegetable Fats and Oils. Determination of the peroxide number. Iodometric (visual) determination by endpoint.

4. Results and discussion

Oilseeds of the cruciferous family contain a large amount of polyunsaturated fatty acids (Figure 1), which is an important factor in selecting a vegetable oil.

![Figure 1. Fatty acid composition of certain types of vegetable oils](image)

Having conducted a comparative analysis of cruciferous crop oil with sunflower oil (traditionally used), it can be concluded that they are in many ways "richer" in polyunsaturated and monounsaturated fatty acids. For example, there is almost no Omega-3 in sunflower oil, despite the fact that in camelina oil it is contained in sufficient quantities. This fact can raise rapeseed, camelina and colza oil to a new level from edible vegetable oils.
However, not only the amount, but also the ratio of polyunsaturated fatty acids in vegetable oils determines the nutritional value of the product. In particular, an important factor is the ratio of linoleic acid of the Omega-6 family and linolenic acid of the Omega-3 family. According to theoretical calculations, the ratio of Omega-3 and Omega-6 in the diet of a healthy person should be 1 to 1. This balance must be observed. The fact is that Omega-3 is anti-inflammatory agent in human body, while Omega-6 contributes to the occurrence of inflammatory processes. In this case, inflammation is important for survival, because it protects against infections and damage, but it can also cause significant harm and lead to the progressing of various diseases. Thus, a lack of Omega-3 and an excess of Omega-6 in human body can trigger chronic inflammation and dangerous diseases. Unfortunately, currently most people around the world have a ratio of these acids is 1 to 16, and in some cases 1 to 20 and 1 to 50. Researchers around the world attribute this disparate ratio to two factors. The first is insufficient intake of Omega-3. The second is excessive consumption of Omega-6. The second reason is the most common at present.

As follows from fig. 1, the ratio of Omega-3 and Omega-6 in sunflower oil is 1 per 60, which is the most unfavorable for the human body. In turn, considered oils of cruciferous crops – colza oil, camelina oil and rapeseed oil – contains the most favorable ratio of polyunsaturated fatty acids of different families – respectively 1 to 15; 1 to 1; 1 to 2.

The obtained data indicate a direct influence of temperature and exposure to light on the dynamics of changes in Peroxide and Acid numbers over the storage period of vegetable oils (table 1, table 2).

| Oil       | Value in storing | Storage conditions and terms | Storage conditions and terms |
|-----------|------------------|------------------------------|------------------------------|
|           | without exposure to light at 22°C | with exposure to light at 22°C | without exposure to light at 4°C | with exposure to light at 4°C |
|           | 10 days | 20 days | 30 days | 40 days | 10 days | 20 days | 30 days | 40 days | 10 days | 20 days | 30 days | 40 days |
| Sunflower | 1.4     | 1.6     | 1.7     | 1.8     | 1.9     | 1.5     | 1.6     | 1.7     | 1.7     | 1.4     | 1.5     | 1.5     | 1.6     |
| Rapeseed | 0.8     | 1.0     | 1.1     | 1.4     | 1.6     | 1.5     | 1.9     | 2.9     | 3.4     | 0.8     | 0.9     | 1.2     | 1.2     |
| Colza     | 1.5     | 1.8     | 1.9     | 2.3     | 2.9     | 1.9     | 2.3     | 3.4     | 4.3     | 1.5     | 1.6     | 1.6     | 1.8     |
| Camelina | 1.3     | 1.7     | 2.3     | 2.6     | 3.2     | 1.6     | 2.1     | 3.5     | 4.5     | 1.3     | 1.5     | 1.6     | 1.5     |

Data shows that all types of oils are particularly active in accumulating peroxides at 22°C when exposed to light. In storing without exposure to light, this process slows down. The slowest formation of primary oxidation products among the analyzed types of vegetable oils occurs under cooled conditions (4°C) and the absence of contact with light is important factor.

After analysis of the obtained data, it may be concluded that the dynamics of accumulation of peroxides during the tests (40 days) was different under different conditions. In oil samples that were stored with exposure to light, the rate of change of Peroxide numbers was maximum. It should be noted that the value of this indicator at the beginning of the experiment directly determined the intensity of the subsequent increase over the course of the experiment. The most unfavorable for storing the oils was
the temperature regime of 22°C. Peroxide number in 22°C was higher than under the same storage conditions in 4°C.

Table 2. Changes in the peroxide number of vegetable oils under different conditions and storage periods, mmol of active oxygen/kg.

| Oil         | Value in storing | Storage conditions and terms |   |   |   |   |   |   |   |
|-------------|------------------|------------------------------|---|---|---|---|---|---|---|
|             | Value in storing | without exposure to light at 22°C | with exposure to light at 22°C | without exposure to light at 4°C | with exposure to light at 4°C |   |   |   |   |
|             | 10 days 20 days 30 days 40 days | 10 days 20 days 30 days 40 days | 10 days 20 days 30 days 40 days | 10 days 20 days 30 days 40 days | 10 days 20 days 30 days 40 days |   |   |   |   |
| Sunflower   | 3.5 3.6 4.5 5.2 | 6.1 4.1 5.1 7.5 8.3 | 3.5 4.0 5.0 | 5.5 | 3.6 5.0 | 6.2 7.2 |
| Rapeseed    | 4.5 4.6 5.2 6.1 | 7.1 5.1 7.1 8.7 10.5 | 4.5 5.0 | 5.7 | 6.1 4.9 | 5.2 | 7.0 8.1 |
| Colza       | 2.4 2.5 3.2 4.5 | 5.7 3.1 4.6 8.4 11.4 | 2.5 3.1 | 3.9 | 4.2 2.7 | 3.9 | 4.8 8.9 |
| Camelina    | 3.1 3.3 4.0 4.1 | 5.9 3.5 4.6 9.8 12.3 | 3.2 3.6 | 4.0 | 5.0 3.6 | 4.2 | 5.0 7.1 |

5. Conclusion

According to research results the optimal ratio of Omega-3 and Omega-6 is observed in camelina oil. In rapeseed and colza oils this ratio is slightly less balanced, and in sunflower oil this ratio is the most unfavorable for the human body. In this regard, it can be recommended to eat cruciferous oil crops.

Using the values of Peroxide and Acid numbers it was found that the most unfavorable storage mode for non-traditional types of vegetable oils was the mode with exposure to light at 22°C. By the end of 40 days Peroxide number of rapeseed, colza and camelina oils, and Acid number of colza and camelina oils was higher than the permissible limits, that means the oil has become unsuitable for human consumption. At the same time sunflower oil showed an increase in Peroxide and Acid numbers during storage, but it remained within the norm.

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