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DETERMINATION OF HIGH OLEIC SUNFLOWER OILCAKE QUALITY DURING STORAGE

Abstract

The article highlights problematic issues in the use of food and feed fats, in particular, low resistance to oxidation as a result of: toxic and anti-nutritional effects of hydroperoxides, secondary oxidation products and hydrocarbons, trans-isomers and diene conjugates that are resorbed in the digestive tract. Further transformation of secondary oxidation products of fat leads to anti-nutritional and toxic effects caused by complex compounds of oxidized fats with proteins, vitamins, and trace elements. A significant decrease in the nutritional and biological value of the finished product leads to the loss of the ability to assimilate it, to the transition to the category of unsuitable for feeding. Excluding the possibility of processes occurring in fats that are accompanied by changes in their organoleptic characteristics and chemical composition is an important scientific and practical problem. The rate of oxidation reaction significantly depends on the fatty acid composition of fat, therefore, the choice of components of compound feed products requires detailed justification, taking into account the features of the recipe, technological stages of production, direction of its use, to ensure the stability of the composition and properties of the finished product, and the predicted zootechnical efficiency. It is an established fact that the quantity and quality (content of saturated fatty acids, trans fats, ratio of ω6/ω3 polyunsaturated fatty acids (PUFA), etc.) of fat in the food and feed ration have a significant impact on the healthy functioning of the body. The demand for sources of fat with a more physiological lipid profile and functional components, in particular high-oleic type, has increased. The use of high-oleic varieties of oilseeds as a food ingredient is the most effective and most acceptable way to reduce the content of PUFA, increase nutritional and biological value, ensure resistance to free radical and peroxidative oxidation, deterioration of taste, etc. High-oleic sunflower oil differs from other crops (soybean, rapeseed high-oleic hybrids) in a higher level of oleic acid (up to 82%), a lower content of linoleic acid (up to 4%), a very low content of linolenic acid (up to 0.3%), but in other species it is absent altogether. High-oleic sunflower hybrids do not show a significant difference in grain yield, oil content and seed productivity compared to conventional sunflower hybrids, are the optimal alternative to meet global demand and are stable and useful vegetable oils. A by-product of obtaining vegetable oils is cake, which contains up to 7-9% oil. The purpose of the research is to check the possibility of using high-oleic sunflower cake after long-term storage in different conditions. During 8 months of storage, the quality indicators of high-oleic sunflower cake samples placed in different conditions were checked. For which, controlled conditions were created: one sample (I) (air temperature + 20 ± 3 ˚C, relative air humidity (φ) 80 ± 2%); II – temperature +10 ± 3˚C, relative air humidity (φ) 80 ± 2%; III – temperature + 20 ± 3 ˚C, relative air humidity 60 ± 2%; IV – temperature +10 ± 3˚C, relative air humidity (φ) 60 ± 2%. Changes in fat quality indicators during storage of the studied samples of high-oleic sunflower oil cake were determined. After 4 months of storage, the increase in total acidity fluctuates within 1.3-1.6 times depending on the storage conditions, while at the beginning of the experiment this change at the 4th month of storage was 1.6-4.7 times, which may also be associated with the intensification of the formation of secondary oxidation products. Reducing the ambient temperature to +10 ±3 ˚C reduces the rate of oxidative processes, the studied quality indicators differ by 1.2-1.7 times. Humidity has a significant impact on the course of oxidative and hydrolytic processes in the studied samples, its decrease slows down the accumulation of primary and secondary oxidation products by 1.5-2 times. For all studied samples, the main constants of fat for the 8th month of storage fluctuate within acceptable limits: acid number 5.9-12.1 mg KOH, peroxide number 3.1-7.7 ½ O mmol/kg, total acidity 3.6-8.7 ˚H. Based on the conducted research, a conclusion was made about the feasibility of using high-oleic sunflower oilcake in feed production, since even after long-term storage in various favorable and unfavorable conditions, it is able to maintain the constancy of quality indicators at a safe level and ensures the stability of the composition and properties of compound feed, safety, zootechnical efficiency of its use in livestock and poultry farming.

Keywords: feed, fat, quality, oxidation, oleic acid, high-oleic sunflower oilcake.

Introduction

Fats, due to the peculiarities of their chemical composition, are easily susceptible to changes during storage and industrial processing, which reduces their quality and biological value. The characteristic consequences of oxidation of food and feed fats are: toxic and anti-nutritional effects of hydroperoxides, secondary oxidation products and hydrocarbons, trans-isomers and diene conjugates, which are absorbed in the digestive tract. Further transformation of secondary oxidation products of fat leads to anti-nutritional and toxic effects caused by complex compounds of oxidized fats with proteins, vitamins, and trace elements. A significant decrease in the nutritional and biological value of the finished product leads to the loss of the ability to assimilate, to the transition to the category of unfit for feeding [1, 2].

Therefore, reducing the intensity of processes in fats, accompanied by changes in their organoleptic characteristics and chemical composition, is an important scientific and practical problem. The rate of oxidation reaction significantly depends on the fatty acid composition of fat, therefore, the choice of components of compound feed products requires detailed justification, taking into account the features of the recipe, technological stages of production, the direction of its use, to ensure the stability of the composition and properties of the finished product, and the predicted zootechnical efficiency.

Literature review

Today, scientists have established a significant impact on the quantity and quality (content of saturated fatty acids, trans fats, ω6/ω3 PUFA ratio, etc.) of fat in the food and feed ration on the healthy functioning of the body (inflammatory processes, lipotoxicity, cholesterol levels, low-density lipoproteins, cardiovascular diseases, complications of a number of chronic diseases, cancer, diabetes, neurodegenerative diseases, etc.) [3, 4, 5].

The demand for fat sources with a more physiological lipid profile and functional components has increased worldwide [6]. It has been experimentally confirmed that oils with a high content of oleic acid produce lower levels of aldehydes than PUFAs [7, 8]. Cellular oxidation of PUFAs leads to the formation of excessive amounts of aldehyde products (4-hydroxyhexenal, 4-hydroxynonenal), which cause apoptosis and necrotic cell death [9-11]. Oxidized metabolites of linoleic acid cause oxidative stress, chronic inflammation [12, 13].

High-oleic oil has been used in the food industry worldwide for more than 10 years, which is due to its significant advantages in nutritional and biological value, resistance to free radical and peroxidative oxidation, and resistance to taste deterioration [14, 15, 16, 17]. It has been established that the use of high-oleic varieties of oilseeds as a food ingredient is the most effective and acceptable way to reduce the content of PUFA in the human diet [18-21].

More than 90% of high-oleic sunflower oil produced in Ukraine is exported, since the demand for it is mainly formed by the countries of the European Union [14]. Sunflower oil is among the five most common edible oils in the world, as well as sunflower seeds in the overall structure of oilseeds in the world [22-24].

High-oleic sunflower oil differs from the oil of other crops (soybean, rapeseed of high-oleic hybrids) in a higher level of oleic acid (up to 82%), a lower content of linoleic acid (up to 4%), a very low content of linolenic acid (up to 0.3%), which is completely absent in other types. The lower linoleic acid content makes high-oleic sunflower oil a more effective alternative for the formation of oxidative stability. The reduction in linoleic acid content not only has a positive effect on the stability of oil quality and safety indicators, but also ensures compliance with consumer requirements for physiological value. Even at the highest oleic acid content, high-oleic sunflower hybrids do not show a significant difference in grain yield, fat content compared to conventional sunflower hybrids. Therefore, due to the more favorable fatty acid profile and the availability of commercial hybrids with good agronomic indicators, high-oleic sunflower oil is positioned as an optimal alternative to meet the global demand for stable and useful vegetable oils [25-29].

A by-product of obtaining vegetable oils, in particular from high-oleic sunflower, is cake, which contains up to 7-9% oil, depending on the processing characteristics, and can be an effective source of protein and fat in compound feed products.

The purpose of the research is to check the possibility of using high-oleic sunflower cake in feed production after long-term storage in different conditions.

Materials and methods

The work used high-oleic sunflower cake, obtained as a by-product in the production of olive oil by Biohimtech LLC (Odessa) at the Plant of Stone and Vegetable Oils LLC (Odessa). The determination of fat quality indicators was carried out according to generally accepted standardized methods.

During 8 months of storage, the quality indicators of high-oleic sunflower cake samples placed in different conditions were checked. For this, all samples were placed in controlled conditions: one sample (I) (air temperature + 20 ± 3 ˚C, relative air humidity (φ) 80 ± 2 %); II - temperature +10 ± 3˚C, relative air moisture mass fraction (φ) 80 ± 2 %; III - temperature + 20 ± 3 ˚C, relative air humidity 60 ± 2 %; IV - temperature +10 ± 3˚C, relative air humidity 60 ± 2 %.

Results and discussion

All studied samples had the same quality indicators when stored (Fig. 1-3). Usually, fats contained in immature plant seeds are characterized by the presence of a larger amount of free fatty acids. As the seeds ripen, the acidity of the fat in it decreases. Free fatty acids are absent in the oil of fully ripe seeds, but in the process of releasing fat from the raw material and storing them, they are formed as a result of hydrolysis. In the technological process of obtaining vegetable oils, the by-product of which is oil cake, metal ions from the equipment can enter the fat, which also activate the oxidation process [2, 3]. Factors of influence in the production process are also: oxygen, enzymes (lipoxygenase), microorganisms (biochemical changes under the action of lipase), light, temperature, mechanical action. As a result, the processes of hydrolysis, oxidation, interaction with proteins and carbohydrates occur with the formation of glycerol, fatty acids, primary and secondary oxidation products, protein-

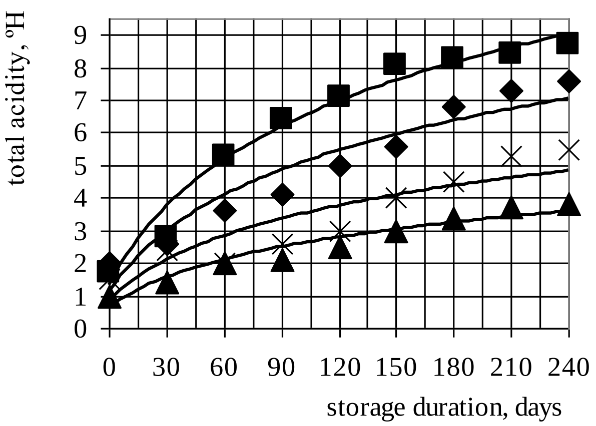

Fig. 1 - Change in total fat acidity during storage of high-oleic sunflower oilcake

■ I (t+20±3˚C, φ 80±2%) ◆ II (t+10±3˚C, φ 80±2%)
× III (t+20±3˚C, φ 60±2%) ▲ IV (t+10±3˚C, φ 60 ± 2 %)

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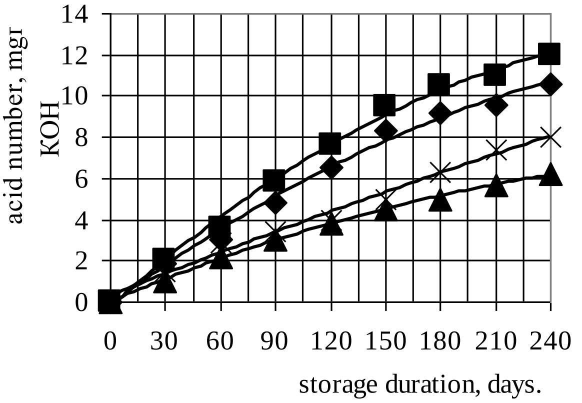

Fig. 2 - Change in the acid value of fat during storage of high-oleic sunflower oil cake

■ I (t+20±3˚C, φ 80±2%) ◆ II (t+10±3˚C, φ 80±2%)
× III (t+20±3˚C, φ 60±2%) ▲ IV (t+10±3˚C, φ 60 ± 2 %)

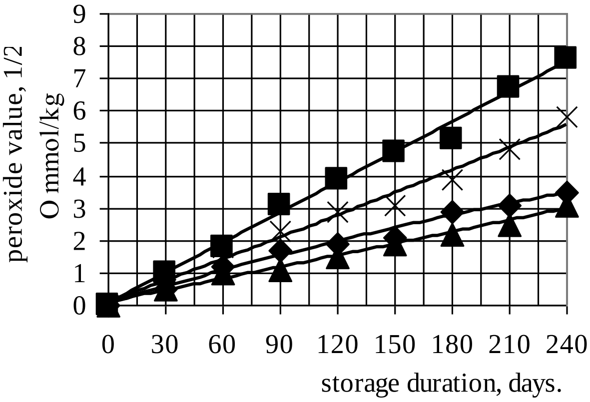

Fig. 3 - Change in the peroxide value of fat during storage of high-oleic sunflower oil cake

■ I (t+20±3˚C, φ 80±2%) ◆ II t(+10±3˚C, φ 80± 2%)
× III (t+20±3˚C, φ 60±2%) ▲ IV t(+10±3˚C, φ 60± 2%)

lipid complexes and lipid-carbohydrate complexes [2]. When storing oilseeds in conditions of high temperature and high mass fraction of moisture, the hydrolysis process is intensive and the products of processing such seeds (oil, cake) even immediately after production have a high acid number, however, such trends were not detected in the studied samples, as evidenced by certain initial quality indicators [2].

When storing seeds and products of processing oilseeds (cake) in conditions of high temperature and high mass fraction of moisture, the hydrolysis process in fat is particularly intensive. Usually, fats in which oxidative processes have begun, in particular, characteristic of oils and cakes from ordinary high-linoleic sunflower varieties, have reduced stability during further storage, and the studied samples turned out to be more resistant to the influence of regulated factors.

For example, after 4 months of storage of the studied samples, the rate of accumulation of primary oxidation products decreases somewhat, in particular: the increase in total acidity (Fig. 1) varies within 1.3-1.6 times depending on storage conditions, while at the beginning of the experiment this change for the 4th month of storage was 1.6-4.7 times. Similarly, the increase in acid number (Fig. 2) for the first 4 months for all samples varies within 4.1-7.5 times, for the next 4 months the change was 1.5-2.3 times, which may also be associated with the intensification of the formation of secondary oxidation products.

The peroxide value (Fig. 3) at the end of the experiment increases by 5.8…7.1 times for samples (I, II) and by 2.7..3.2 times for samples (III, IV).

It is known that peroxides are able to accelerate the oxidation reaction of fat, while they themselves decompose with the formation of oxides, aldehydes and other substances. The oxidation reaction is a free radical chain reaction, therefore it is accelerated under the action of free radicals. The high activity of the lipase enzyme accelerates the reaction, since free fatty acids are oxidized faster than those that are part of acylglycerols. However, despite the occurrence of oxidative and hydrolytic processes in all studied samples (Fig. 3), their speed is insignificant and allows to ensure compliance with the quality and safety of the product during the studied period.

For all studied samples, the main constants of fat for the 8th month of storage fluctuate within acceptable limits: acid number 5.9-12.1 mg KOH, peroxide number 3.1-7.7 ½ O mmol/kg, total acidity 3.6-8.7 ˚H.
It was established that a decrease in ambient temperature to +10 ˚C reduces the rate of oxidative processes, in particular, the studied quality indicators differ by 1.2-1.7 times.

The decisive influence of the moisture factor on the course of oxidative and hydrolytic processes in the studied samples has been established. Such conditions (III, IV) slow down the accumulation of primary and secondary oxidation products by 1.5 - 2 times (Fig. 1-3).

The obtained results of changes in quality indicators during storage of samples of high-oleic sunflower cake are explained by the fact that the content of saturated, monounsaturated and polyunsaturated fatty acids (PUFA) is considered the most important parameters affecting oxidative stability [30-32]. It has been established that the oxidation rate of a number of unsaturated fatty acids: oleic, linoleic, linolenic is in the ratio to stearic 1:100:1200:2500 [33]. The degree of resistance of different types of oils to oxidation at elevated temperatures (120 ºC) was determined by the oxidative stability index, induction period, in particular, in hours: palm 7-12, soybean 1-7, rapeseed 3-5, olive 6-11 [34].

Conclusions

Based on the conducted studies, it can be concluded that it is advisable to use high-oleic sunflower oilcake in feed production, since even after long-term storage in various favorable and unfavorable conditions, it is able to maintain the constancy of quality indicators at a safe level and ensures the stability of the composition and properties of compound feed, safety, zootechnical efficiency of its use in livestock and poultry farming.

A significantly lower intensity of oxidative and hydrolytic processes in fat helps minimize the use of antioxidants, most of which are of chemical origin and the use of which is associated with the entry of toxic and anti-nutrients into livestock and poultry products.

The use of high-oleic sunflower cake in feed production corresponds to modern trends in the formation of safe and high-quality food products.

Further research is needed to substantiate the methods of maximum effective use of seeds and products of high-oleic sunflower processing in the production of compound feed products, based on the study of the biological potential of raw materials and modern approaches to keeping and feeding farm poultry.

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ВИЗНАЧЕННЯ ЯКОСТІ МАКУХИ ВИСОКООЛЕЇНОВОГО СОНЯШНИКА В ПРОЦЕСІ ЗБЕРІГАННЯ

Анотація

В статті висвітлено проблемні питання при використанні харчових і кормових жирів, зокрема низька стійкість до окиснення як наслідок: токсична та антиаліментарна дія гідропероксидів, вторинних продуктів окиснення та вуглеводнів, транс-ізомерів та дієнових кон'югантів, що резорбуються в травному тракті. Подальше перетворення вторинних продуктів окиснення жиру призводить до антиаліментарних та токсичних ефектів, викликаних комплексними сполуками окиснених жирів з білками, вітамінами, мікроелементами. Значне зниження поживної та біологічної цінності готової продукції призводить аж до втрати можливості її засвоєння, переходу до категорії непридатної для згодовування. Виключення можливості протікання в жирах процесів, що супроводжуються зміною їхніх органолептичних показників і хімічного складу, є важливою науково – практичною проблемою. Швидкість реакції окиснення значно залежить від жирнокислотного складу жиру, тому вибір компонентів комбікормової продукції потребує детального обґрунтування, враховуючи особливості рецептури, технологічних етапів виробництва, напрямку її використання, для забезпечення стабільності складу та властивостей готової продукції, прогнозованої зоотехнічної ефективності. Встановленим фактом є значний вплив кількості та якості (вміст насичених жирних кислот, транс жирів, співвідношення ω6/ω3 поліненасичених жирних кислот (ПНЖК) та ін.) жиру в харчовому і кормовому раціоні на здорову життєдіяльність организму. Зріс попит на джерела жиру із більш фізіологічним ліпідним профілем і функціональними складовими, зокрема високоолеїнового типу. Використання високоолеїнових сортів олійних культур як харчового інгредієнту є найефективнішим та найприйнятнішим способом зменшення вмісту ПНЖК, підвищення поживної, біологічної цінності, забезпечення стійкості до вільнорадикального та перекисного окиснення, погіршення смаку та ін. Високоолеїнова соняшникова олія відрізняється від решти інших культур (соя, ріпак високолеїнових гібридів) вищим рівнем олеїнової кислоти (до 82 %), нижчим вмістом лінолевої кислоти (до 4 %), дуже низьким вмістом ліноленової кислоти (до 0,3 %), проте в інших видах вона взагалі відсутня. Гібриди високоолеїнового соняшнику не демонструють суттєвої різниці у врожайності зерна, вмісті олії та продуктивності насіння порівняно із звичайними гібридами соняшнику, є оптимальною альтернативою для задоволення світового попиту та стабільні та корисні рослинні олії. Побічним продуктом при отриманні рослинних олій, є макуха, яка містить до 7- 9 % олії. Метою досліджень є перевірка можливості використання макухи високоолеїнового соняшника після тривалого зберігання в різних умовах. Протягом 8-ми місяців зберігання перевірено *показники якості зразків макухи високоолеїнового соняшника, поміщених в різні умови. Для чого створено регульовані умови: один зразок (I) (температура повітря + 20 ± 3 ˚С, відносна вологість повітря (φ) 80 ± 2 %); II – температура +10 ± 3˚С, відносна вологість повітря (φ) 80 ± 2 %; III – температура + 20 ± 3 ˚С, відносна вологість повітря 60 ± 2 %; IV – температура +10 ± 3˚С , відносна вологість повітря(φ) 60 ± 2 %. Визначено зміни показників якості жиру в процесі зберігання досліджуваних зразків макухи високоолеїнового соняшника. Після 4-х місяців зберігання збільшення загальної кислотності коливається в межах 1,3-1,6 разів у залежності від умов зберігання, в той час як на початку експерименту ця зміна на 4-й місяць зберігання становила 1,6-4,7 разів, що може також бути пов'язано із інтенсифікацією утворення вторинних продуктів окиснення. Зниження температури навколишнього середовища до +10 ˚С знижує швидкість протікання окисних процесів, досліджувані показники якості відрізняються від в 1,2-1,7 разів. Значний вплив має вологість на протікання окисних і гідролітичних процесів в досліджуваних зразках, її зменшення уповільнює в 1,5 - 2 рази накопичення первинних і вторинних продуктів окиснення. Для усіх досліджуваних зразків основні константи жиру на 8 – й місяць зберігання коливаються в допустимих межах: кислотне число 5,9-12,1 мг КОН, пероксидне число 3,1-7,7 ½ О ммоль/кг, загальна кислотність 3,6-8,7 ˚Н. На основі проведених досліджень зроблено висновок про доцільність використання макухи високоолеїнового соняшника у кормовиробництві, оскільки навіть після тривалого зберігання в різних сприятливих і несприятливих умовах вона здатна зберігати сталість показників якості на безпечному рівні та забезпечує стабільність складу та властивостей комбікорму, безпечність, зоотехнічну ефективність його використання у тваринництві та птахівництві.*

Ключові слова: комбікорм, жир, якість, окиснення, олеїнова кислота, макуха високоолеїнового соняшника.

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IMPACT OF NONPATHOGENIC MICROBIAL BURDEN OF FEED ON THE HEALTH OF LABORATORY RATS

Abstract

Compound feeds provide nutritious and favorable environment for microorganisms, which can affect animal health during feeding. Microorganisms can interact with the animal's normal gut microbiota and its own body, affecting the processes of feed digestion and assimilation, and consequently the animal's health and productivity. During these interactions, biochemical, physiological, and even behavioral changes occur in animals; however, undesirable expenditure of metabolic energy on the immune response may be observed. These factors are considered most significant for young animals, as they are the most vulnerable group with an underdeveloped microbiome and immune system. It is known that adding probiotic microorganisms to feed stimulates body weight gain, promotes protection against pathogenic species, and improves animal health; however, the role of the background non-pathogenic microbiota is unknown. In this study, two groups of laboratory rats, each consisting of 5 males aged 1.5 months, were fed feed samples with different levels of microbial contamination: the control sample contained no more than 20,000 CFU/g, and the experimental sample contained no more than 500,000 CFU/g. The samples were disinfected with dry heat, and suspensions of non-pathogenic microorganisms were added in the previously calculated required amounts: the bacteria Bacillus subtilis and Micrococcus luteus, and the fungi Aspergillus awamori, Penicillium decumbens, and Saccharomyces cerevisiae. The rats were fed for 9 days; during this period, their body weight and feed intake were measured, and absolute and relative body weight gain were calculated. Feed intake in the two groups was equal, and the absolute body weight gain on day 9 in the experimental group was 21.2% higher than in the control group (43.8 g in the control group