TSUE
TASHKENT STATE UNIVERSITY OF ECONOMICS

International journal of topics

INNOVATION SCIENCE AND TECHNOLOGY

Scopus || Electronic journal specializing in Scopus

ISSUE 2

Acceptance of papers **February, 2026**

Acceptance of papers

Published monthly

Topics

economics, technology, social sciences

ISSN 3060-5229

THE SCIENTIFIC-POPULAR ELECTRONIC JOURNAL **"INNOVATION SCIENCE AND TECHNOLOGY"** HAS BEEN REGISTERED UNDER THE NUMBER **C-5669633** BY THE AGENCY FOR INFORMATION AND MASS COMMUNICATIONS (AOKA) OF THE REPUBLIC OF UZBEKISTAN, EFFECTIVE FROM OCTOBER 9, 2024.

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The scientific electronic journal “Innovation Science and Technology” has been included in the list of scientific publications recommended for the publication of main scientific results of dissertations for the award of PhD and DSc degrees in economics and technical sciences, in accordance with the Resolution No. 370 of the Presidium of the Higher Attestation Commission of the Republic of Uzbekistan, dated May 8, 2025.

Electronic publication, Issue 2. 52 pages.
Approved for publication on February, 2026.

Editorial board:

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ENVIRONMENTALLY EFFICIENT FATLIQUORING AGENTS IN KARAKUL FATLIQUORING TECHNOLOGY

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Abstract: The article compares the fatty acids present in waste oils generated during fish frying with the fatty acids found in fish oil and sunflower oil. The results show that the proportion of unsaturated fatty acids in the waste oil increased by 8.7% compared to the unsaturated fatty acids in fish oil. It is emphasized that the use of waste oils makes it possible to develop an economically efficient and resource-saving technology for the fatliquoring of karakul pelts.

Key words: karakul, fish oil, sunflower oil, waste oil, collagen fibers, fatty acids, resource saving, fatliquoring systems, secondary fats, collagen, fatliquoring composition.

Annotatsiya: Maqolada baliq qovurish jarayonida hosil bo'ladigan ishlatilgan yog'larda mavjud yog' kislotalari baliq yog'i va kungaboqar yog'idagi yog' kislotalari bilan taqqoslangan. Tadqiqot natijalariga ko'ra, ishlatilgan yog' tarkibidagi to'yinmagan yog' kislotalari ulushi baliq yog'idagi to'yinmagan yog' kislotalariga nisbatan 8,7 % ga yuqori ekanligi aniqlangan. Shuningdek, ishlatilgan yog'lardan foydalanish qorako'l terilarini yog'lashda iqtisodiy jihatdan samarali va resurs tejovchi texnologiyani yaratish imkonini berishi ta'kidlangan.

Kalit so'zlar: qorako'l, baliq yog'i, kungaboqar yog'i, ishlatilgan yog', kollagen tolalari, yog' kislotalari, resurslarni tejash, yog'lash tizimlari, ikkilamchi yog'lar, kollagen, yog'lovchi kompozitsiya.

Аннотация: В статье сравниваются жирные кислоты в отработанных маслах, образующихся при жарке рыбы, с жирными кислотами в рыбьем жире и подсолнечного масла. Было замечено, что доля ненасыщенных жирных кислот в отработанном масле увеличилась на 8,7% по сравнению с ненасыщенными жирными кислотами в рыбьем жире. Подчеркнуто, что использование отработанных масел позволяет создать экономически эффективную и ресурсосберегающую технологию жирования каракуля.

Ключевые слова: каракуль, рыбий жир, подсолнечное масло, отработанное масло, коллагеновые волокна, жирные кислоты, ресурсосбережение, жировальные системы, вторичные жиры, коллаген, жирующая композиция.

INTRODUCTION

Karakul is a national treasure and a source of pride for Uzbekistan. The distinctive shape and originality of its curls, the decorative elegance of the patterns, and the silky texture and noble luster of the hair have brought karakul pelts worldwide recognition, placing karakul in a special position among furs and peltries. Karakul pelts are high-quality natural materials obtained from lambs of the Karakul sheep breed. This breed has long been known for its valuable fur, distinguished by softness, sheen, and the unique pattern of its curls. Karakul products are in demand in the fashion industry and are regarded as symbols of elegance and luxury.

No other sheep breed produces such curled raw material at the birth of lambs as the Karakul sheep. As far back as antiquity, the originality of Karakul lamb pelts delighted the Arab geographer Ibn Hawqal and the Venetian traveler Marco Polo, who visited Turkestan and Khorezm—the territory of present-day Uzbekistan. In his book "Routes and Realms", Ibn Hawqal wrote of the high prices and lively trade in pelts taken from slaughtered lambs at that time [1].

Karakul sheep breeding is one of the important branches of animal husbandry, mainly developed in desert regions [2]. Karakul pelts are produced in more than 40 countries worldwide, including Namibia, South Africa, Angola, Argentina, Iran, Afghanistan, Austria, Germany, Romania, Russia (the Republic of Kalmykia), Ukraine, Moldova, Uzbekistan, Kazakhstan, Turkmenistan, and Tajikistan.

Nomadic Turkmen pastoralists living along the Bukhara–Afghanistan border raised Karakul sheep, and a large share of the production was exported to the global market [3]. European countries, particularly Germany and France, showed strong interest in karakul and were the principal buyers. For example, the "German Karakul Company" traded these pelts and operated dozens of karakul stores in European cities.

REVIEW OF LITERATURE ON THE SUBJECT

The development of environmentally efficient fatliquoring agents for karakul processing must be considered within both historical and technological contexts of karakul production. Ahmedov's comprehensive doctoral research provides a long-term analytical overview of the state of karakul breeding and processing in Uzbekistan from 1917 to 2017, highlighting structural transformations in raw material supply, processing practices, and technological modernization. This work underlines the increasing need for resource-efficient and environmentally responsible processing technologies in response to both economic pressures and ecological constraints.

Historical-industrial cooperation has also influenced the technological evolution of karakul processing. The documented collaboration between the Bukhara People's Republic and Germany during the early twentieth century demonstrates early efforts to integrate European industrial practices into local production systems. Although this cooperation was not explicitly focused on environmental aspects, it laid foundational principles for technological transfer and process optimization that remain relevant for contemporary sustainable leather and fur technologies.

Modern research increasingly emphasizes the improvement of fatliquoring materials and processes from both performance and environmental perspectives. Shamsieva et al. provided a detailed review of effective fatliquoring agents and technologies used in leather and fur production, emphasizing emulsion stability, penetration depth, and the impact of fat composition on mechanical and hygienic properties. Their findings underscore that the selection of fatliquoring agents significantly affects not only product quality but also wastewater load and biodegradability.

International studies reinforce this direction by focusing on functional and eco-oriented fatliquors. Yorgancioglu investigated thymol-loaded antibacterial fatliquors, demonstrating that bioactive components can be successfully emulsified and applied without compromising leather softness while simultaneously enhancing antimicrobial properties. This approach aligns with sustainable production goals by reducing reliance on synthetic preservatives and harmful chemical additives.

Research by Suseno et al. explored the production of fatliquors based on blends of palm and soybean oils, confirming that vegetable oil-based systems can meet technological requirements for leather processing. Their work is particularly relevant for environmentally efficient technologies, as plant-based oils offer renewable sourcing, improved biodegradability, and lower toxicity compared to petroleum-derived fatliquors.

Local research efforts further expand the ecological dimension of fatliquoring technology. Shamsieva, Rustamov, and Kurbanov examined the use of locally available waste fats in karakul processing, demonstrating that secondary raw materials can be effectively utilized without significant deterioration of fur quality. This approach directly contributes to circular economy principles by reducing industrial waste and dependency on imported chemical agents.

Stepwise fatliquoring methods have also been proposed as a means of optimizing fat distribution and minimizing chemical consumption. Shamsieva and Abduqahhorova showed that multi-stage fatliquoring improves softness, elasticity, and thermal properties of natural leather while allowing better control over fat uptake. Such technological strategies are particularly important for karakul fur, where uneven fat distribution can negatively affect hair structure and appearance.

Further technological advancements include the application of used oils as alternative fatliquoring agents. Rustamov and Shamsieva demonstrated the feasibility of fatliquoring karakul using recycled oils, while subsequent IR-spectroscopic studies by Shamsieva, Rustamov, and Makhammadieva confirmed the chemical stability and functional suitability of these materials in emulsion systems. These findings provide strong analytical evidence supporting the reuse of secondary fat resources in environmentally efficient fatliquoring technologies.

The most recent research consolidates economic and ecological considerations into integrated technological solutions. Shamsieva and Rustamov proposed an economically and environmentally efficient fatliquoring technology for semi-finished karakul fur, demonstrating reduced chemical consumption, lower environmental impact, and improved production efficiency. Their work represents a synthesis of earlier research trends and establishes a practical framework for sustainable karakul fatliquoring.

Overall, the reviewed literature demonstrates a clear shift from conventional fatliquoring practices toward environmentally efficient, resource-saving, and scientifically optimized technologies. The integration of biodegradable materials, recycled fats, antibacterial components, and stepwise processing methods forms the scientific basis for developing sustainable fatliquoring agents tailored specifically to karakul fur processing.

RESEARCH METHODOLOGY

The research methodology is based on experimental and analytical approaches. Fatliquoring agents were obtained from locally available waste oils using emulsification techniques. Data were collected through physicochemical testing of fatliquoring compositions and treated Karakul pelts. The obtained results were analyzed using comparative and spectral analysis methods to assess efficiency and suitability.

ANALYSIS AND RESULTS

The introduction of modified fatliquoring agents into the fatliquoring process helps reduce inter-fiber friction and prevents excessive adhesion of collagen bundles. This, in turn, has a positive effect on the softness and plasticity of Karakul pelts. Experimental observations show that the use of resource-saving fatliquoring systems ensures a more uniform distribution of fats throughout the dermal layer, which improves the physico-mechanical properties of the finished product.

A comparative analysis of the fatty acid composition of waste oil was carried out against that of sunflower oil and fish oil. The results are presented in the table below (Table 1).

Table 1. Fatty Acid Composition of Comparative Samples[1]

No.	Name of fatty acids	Content, %		
		Fish oil	Sunflower oil	Waste refined fat
1	C14:0 Tetradecanoic (myristic)	4.7	0.2	0.25
2	C15:0 Pentadecanoic	1.0		
3	C16:0 Hexadecanoic (palmitic)	12.3	5.0	8.72
4	C16:1 Hexadecenoic (palmitoleic)	5.8	–	–
5	C16:1 Hexadecenoic (palmitoleic)		0.3	1.24
6	C17:0 Heptadecanoic (margaric)	1.0	–	0.10
7	C18:0 Octadecanoic (stearic)	3.7	2.7	4.43
8	C18:1 Octadecenoic (oleic)	14.1	14.0	17.65
9	C18:2 Octadecadienoic (linoleic)	2.5	45.3	52.67
10	C18:3 (n-3) Octadecatrienoic (linolenic)	2.0	0.3	
11	C18:3 Octadecatrienoic (linolenic)	2.0	–	11.78
12	C18:4 Stearidonic, Omega-3	3.6	–	–
13	C20:0 Eicosanoic (arachidic)	0.5	0.5	0.06
14	C20:1 Eicosenoic (gondoic)	9.7	0.3	0.85
15	C20:4 Arachidonic	2.3	–	–
16	C20:4 Eicosapentaenoic, Omega-3	3.0	–	–
17	C20:5 Eicosapentaenoic (EPA), Omega-3	11.0	31.2	

1 Source: authors' own development

18	C21:5 Heneicosapentaenoic, Omega-3	4.0		
19	C22:0 Docosanoic (behenic)	–	0.3	0.66
20	C22:1 Docosenoic (erucic)	1.5	0.2	–
21	C22:1 (n-11) Cetoleic	1.3		
22	C22:5 (n-3) Docosahexaenoic	2.8		
23	C22:6 Docosahexaenoic (DHA), Omega-3	11.2	–	–
24	C24:0 Tetracosanoic (lignoceric)	–	0.5	0.21
25	C22:5 Docosapentaenoic (DPA), Omega-3	–	–	–
26	Trans acids	–	–	1.38
27	Σ Saturated fatty acids	23.2	8.4	14.43
28	Σ Unsaturated fatty acids	76.8	91.6	85.57

The data presented in the table indicate that waste oil obtained from repeated frying of fish contains most of the fatty acids found in fish oil and sunflower oil [8]. It can be observed that the proportion of unsaturated fatty acids in the waste oil increased by 8.77% compared with fish oil and is 6.03% lower than that of sunflower oil. In addition, trans fatty acids—absent in both fish oil and sunflower oil—account for 1.38% of the waste oil. Trans acids are a type of unsaturated fats in the trans configuration, typically formed during heating of fats [9].

In conclusion, after purification, waste oil can be used as a technical product for the fatliquoring of Karakul pelts. The content of unsaturated fatty acids in the waste oil reaches 85.57%, which enhances the binding capacity of fatty substances with collagen fibers [10]. In waste oil, fish oil and vegetable oil form a fatliquoring composition. Moreover, this approach expands the possibilities for utilizing waste oils and enables the development of an economically efficient and resource-saving technology for Karakul fatliquoring (Figure 1) [11].

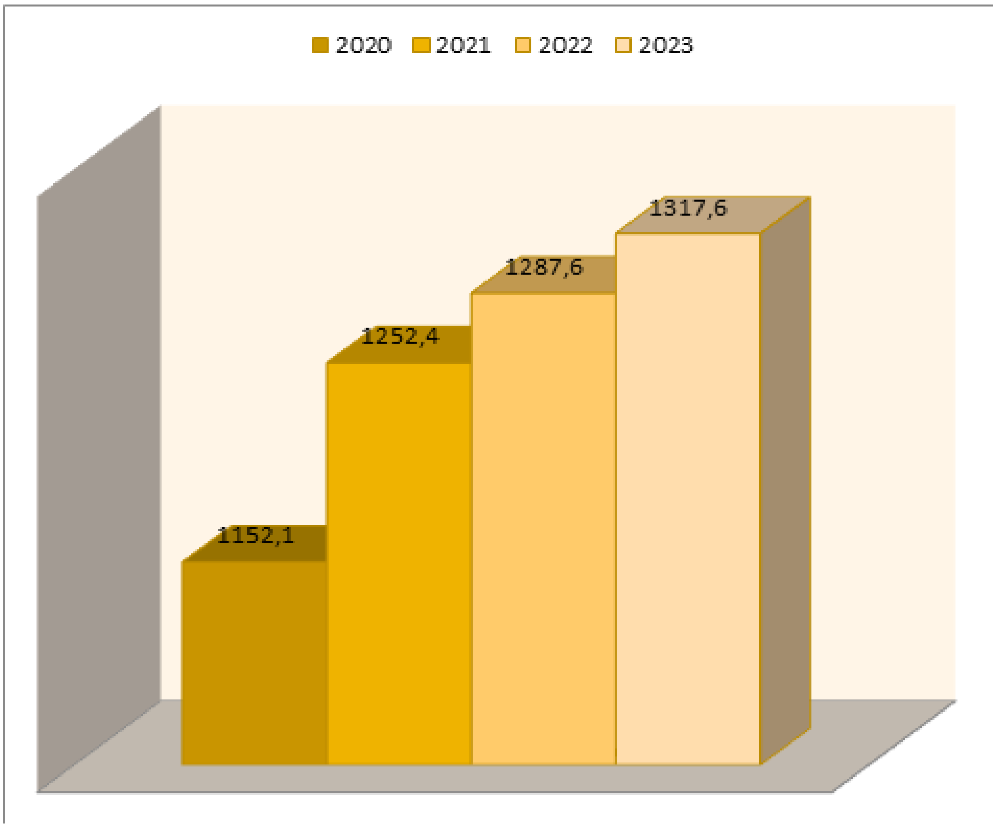

Figure 1. Dynamics of Karakul Pelt Production in the Republic (2020–2023)[2]

The figure illustrates the dynamics of Karakul pelt production in the Republic over the period 2020–2023, showing a steady and consistent upward trend. In 2020, production amounted to 1152.1 thousand units, which

2 Source: authors' own development

increased markedly to 1252.4 thousand units in 2021. This growth indicates a recovery and expansion of the sector, likely driven by improved breeding practices and market demand. In 2022, production continued to rise, reaching 1287.6 thousand units, reflecting further stabilization of the industry. The highest level was recorded in 2023 at 1317.6 thousand units, confirming sustained positive development. Overall, the data demonstrate a cumulative increase in production capacity and efficiency over the analyzed period. This trend suggests favorable conditions for the karakul industry, including better resource utilization, modernization of processing technologies, and growing interest in karakul pelts on domestic and international markets.

CONCLUSIONS AND SUGGESTIONS

A resource-saving approach to the fatliquoring of Karakul pelts represents an effective direction for the development of the leather industry. The use of secondary fatty resources in fatliquoring systems ensures improved quality of finished leathers, reduced production costs, and a lower negative impact on the environment. The findings obtained confirm the feasibility of further development and practical implementation of resource-saving fatliquoring technologies.

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Proofreader: Zokir ALIBEKOV

Layout and Designer: Oloviddin Sobir ugli

2026. № 2

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