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Taxonomy and Phytocenology of the Species Included in the *Dianthus* L. Genus in Shahbuz District and Study of Their Bioecological Characteristics to Learn Their Effective Use Methods

Abstract

In the research study, information was given about the taxonomic composition and phytocenological properties of species belonging to the genus *Dianthus* L. distributed in the Shahbuz region, and the methods of studying the effective use of the species were mentioned. The distribution and bioecological properties of 4 species belonging to the genus (*Dianthus Calocephalus* Boiss., *Dianthus aristatus* Boiss., *Dianthus cretaceus* Adams., *Dianthus orientalis* Adams.) in the Shahbuz region were shown. Plant groups formed by the species were examined. It was determined that the species included in the genus *Dianthus* L. were grouped with annual and perennial herbaceous plants, mainly wild cereals. The species in the local flora are widely used in decorative floriculture and folk medicine.

Keywords**:** *Dianthus L., taxonomy, distribution areas, phytocenological properties, usage directions*

Introduction

The flora of the Nakhchivan Autonomous Republic is represented by 176 families, 908 genera and 3021 species, 124 of which belong to 29 genera are representatives of the *Caryophllaceae* family. The *Dianthus* L. genus, which has a rich species diversity in the section, has about 340 species in the world. The *Dianthus* L. genus is represented by 18 species in the flora of the Nakhchivan Autonomous Republic and constitutes 14.5 % of the total species. *Dianthus* L. species are distributed in different areas from meadows to the upper mountain belt. The species included in the genus are widely used in medicine and ornamental gardening. In addition, among the species of the *Dianthus* L. genus distributed in the Nakhchivan Autonomous Republic, useful, rare, endemic and relic species included in the "Red Book" prevail. Thus, taking into account the modern status of the species *Dianthus orientalis* Adams. [NT] in nature, it was included in the Red Book of Nakhchivan MR (Talibov & Ibrahimov, 2010) as a rare plant with a limited distribution area. In the III edition of the "Red Book" of the Republic of Azerbaijan (2023), 18 species of the genus *Caryophllaceae* are included in different statuses, some of which we define as endangered species. Among these plants, there are species of particular decorative, medicinal, food and agricultural importance. However, they are rarely used (Talibov, 2017).

Research

Considering all this, the study of taxonomic, phytocenological and bioecological characteristics of *Dianthus* L. and the search for effective methods of its use are urgent.

Materials and Methods

The aim of the study is the Shahbuz district of the Nakhchivan Autonomous Republic, and the species belonging to the species *Dianthus* L. collected by us during the field research in the region were taken as material. A.A. Grossheim's works "Flora Azerbaijan" and "Flora Caucasus" (Flora of Azerbaijan, 1952; Grossheim, 1945) were used. The latest taxonomic additions and changes are based on real materials in the funds of the Institute of Biological Resources of the Ministry of Education of the Republic of Azerbaijan and the Herbarium of Nakhchivan State University and in the III volume of the book "Conspect flora Caucasica" (Abstract of the flora of the Caucasus, 2012; AGM Plants – Ornamental, 2018), and also the taxonomic spectrum of the Nakhchivan

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Autonomous Republic by T. H. Talibov and A. Sh. Ibrahimov was carried out according to the works of T. H. Talibov (Talibov, 2008; Talibov, Ibrahimov, & Ibrahimov, 2021). Systematization of geographical elements was carried out according to Portenier (Portenier, 2012).

A systematic analysis of the *Dianthus* L. genus in the local flora was developed, taking into account the APG IV system.

By specifying the names of plants distributed in the region, the works of E.M. Gurbanov "Systematics of higher plants", A. M. Asgarov's "Plant world were used" (Gurbanov, 2016; Askerov, 2009).

Discussion and Results of the Study

Dianthus L. *Caryophyllaceae* Juss. It is one of the largest genera in the family; more than 300 species are distributed in Eurasia, the tropics and South Africa, and a few species in North America. The most widespread region of the species is the Mediterranean countries. In Azerbaijan, 18 species and 28 species are represented in the flora of the Nakhchivan Autonomous Republic, which constitute 14.5 % of the species belonging to the *Caryophyllaceae* family distributed in this region. Wild species belonging to the *Dianthus* L. genus can be found in forests and shrubs, meadows and rocky places from the low mountain belt to the upper mountain belt. *Dianthus barbatus*, *Dianthus chinensis*, garden or *Dianthus caryophyllus* are grown in Azerbaijan. In Dianthus species, the calyx leaves are adjacent, and 2-8 inflorescences surround the leaf under the calyx. The petiole is long, the curve is smooth, entire or toothed. There are 10 stamens and two stamens. It is widely used in decorative gardening (Novruzova, 2019).

As a result of the expeditions made to different regions of the Shahbuz region of the Nakhchivan Autonomous Republic in the 2024 research year, the taxonomy, distribution regions, phytocenological and bioecological characteristics of the species included in the *Dianthus* L. genus were examined.

As a result of the research conducted by us, the taxonomic composition of the *Dianthus* L. genus was determined and it was understood that there are 4 species spreading from the lower mountain belt to the high mountain belt in the Shahbuz region (*Dianthus Calocephalus* Boiss., *Dianthus aristatus* Boiss., *Dianthus cretaceus* Adams., *Dianthus orientalis* Adams) are found.

Dianthus Calocephalus Boiss.

It is a perennial plant with a stem 40-60 cm high, branched root, and a bare surface. The leaves are 15-20 mm wide, stemless, linear, wedge-shaped, sharp, dark-colored, serrated on the edges, and a 15-20 mm long sheath is united at the base. The flowers are collected at the end of the stem, gathered in a multi-flowered head, the heads are covered with a leathery cover. The inflorescence is blunt-tipped, elliptical, covered with whitish, elliptical scales. The calyx is 17-20 mm long, cylindrical, surrounded by red scales on the top, sharp, with toothed edges. The leaves are 5-6 mm long, bright red, oval, hairy on the top, with toothed edges. The box is cylindrical, up to 10 mm long. The seeds are 2 mm long, oval and short-clawed. The plant produces fruits and seeds in June-July, sometimes in August.

Dianthus Calocephalus Boiss. species grow mainly in mountainous areas, on grassy and grassy rock slopes. It is a small size type of geographical type.

Dianthus Calocephalus species are found in Kuku, Nursu and Yukhari winter villages of Shahbuz region.

It is more common in the plains, lowlands, lowland areas of mountainous and foothill regions and in the meadow-shrub areas of the middle mountain slopes in Nakhchivan Autonomous Republic. *Artemisia lerchiana, Stipa szovitsii, Eromopyrum triticeum, Geranium tuberosun, Atrophaxis spinosa, Rhamnus pappasi, Pyrus salicifolia, Onosma sericeae* and many other species are also common in these regions. 45-60 plants with different life forms have been recorded in the phytocenosis. It forms groups with other plants in the mountainous and foothill areas. It is also known that this species is distributed in various phytocenoses consisting mainly of maquis-meadow, desert-semi-desert vegetation types on the slopes of the low mountain belts.

Dianthus aristatus Boiss. (*D.preobrashenskii* Klok)

The species is described from Turkey.

The root develops directly from the rhizome, several branches, 25-50 cm high, the lower part is smooth, hairy or glabrous. The leaves are 1-2 mm wide, linear, sessile, pointed, hairy on the edges, and sheaths 1-2.5 mm long develop from the base. The flowers are located singly on the branches in the upper part of the stem. The inflorescence is scaly leathery, whitish, oval or elliptical, pointed on the upper part, whitish coated on the edges and short cilia, covering 1/3 of the calyx. The calyx is 17-20 mm long, cylindrical, the sepals are triangular-lanceolate, sharply toothed, whitish, covered with a dark red coating. The leaves are 6-8 mm long, oval, dark pink on the upper part, dark spotted on the upper part, yellowish-greenish on the lower part, comb-shaped on the edges. The plant produces flowers and fruits in July-August (RHS A-Z encyclopedia of garden plants, 2008).

Dianthus aristatus Boiss. The species grows on dry stony slopes from the middle mountain belt to the upper mountain belt, sometimes in bushes. It is included in the geographical type of Atropatan (Novruzova, 2020).

Dianthus aristatus Boiss. species is found around the villages of Kolani, Batabat and Aghbulag in the Shahbuz region. *Dianthus aristatus* Boiss. species *Papaver ocellatum, P. bracteatum, Corydalis persica,Glaucium corniculatum, G. elegans, Lonicera iberica, Caccinia macranthera, Rosa canina, Amygdalus fenzliana, Juniperus polycarpos, J. excels, Astracantha microcephala forms* formations with types.

Dianthus cretaceus Adams

The species is described from the Caucasus.

It is a perennial plant with a stem 17-45 cm high, green in color, numerous and simple branches, flat or jointed, hairy or glabrous at the bottom. Leaves 2-5 mm long, 1-2 mm wide, sessile, fused from base to sheath, narrow, pointed, hairy at the edges. Flowers are located singly on the upper parts of the branches. Inflorescence 2-part scale-like, leathery, whitish, inverted oval-oblong or elliptical, green part with double small scales. Calyx 20-30 mm long, cylindrical, narrowed at the top, green or whitish, covered with blackish-dark red scales from the part close to the inflorescence. Calyx oblong lancet-shaped, sharp, toothed at the edges, up to 1/3 of the calyx. The leaves are 6-8 mm long, oval, white, sometimes pink at the bottom, with toothed or entire edges. The calyx is the same size as the calyx or relatively short. The plant produces flowers and fruits in June-August (Novruzova, 2019; 2020).

Dianthus cretaceus Adams. The species grows in subalpine and alpine regions, meadows, stony, gravelly, grassy slopes. It belongs to the Caucasus Irradiated geographical type.

The chalk carnation species are found in the vicinity of Ucgardash Mountain, Gomur, Kecili villages of Shahbuz district. In formations formed by the *Hordeum violaceum* Boiss. et Huet., *Hordeum bulbosum* L., *Dactylis glomerata* L., *Bromus variegata* (Bieb.) Holub, *Lotus corniculatus* L., *Trifolium trichocephalum* Bieb., *Trifolium pratense* L., *Amoria hybrida* (L.) C. Persl, *Agrostis capillaris* L., *Vicia variabilis* Freyn et Sint., *Astragalus cornutus* Pall., *Helichrysum plicatum* DC., *Cephalaria procera* Fisch. et Ave, *Scorzenera latifolia* (Fisch. et C. A. Mey.) DC., *Thalictrum minus* L. are typical species.

Dianthus orientalis Adams

The species was described from Georgia.

The plant is 9-30 cm tall, woody from the base and densely branched. The branches are numerous, straight, thin, ending with flowers in the upper part. The leaves are short linear – awl-shaped, 1 mm wide, fused at the base with a sheath. Inflorescence scales 6-10, egg-shaped, whitish, 2.5-3 times shorter than the calyx, membranous edges, sharp or pointed. Calyx 22-27 mm long, cylindrical, with long lanceolate sharp teeth, glabrous, usually reddish. The leaves are red. The box has a cylindrical shape and is equal to a bowl. The plant produces flowers and fruits in June-August. Ornamental plant. It is a mesoxerophyte included in the geographic type Atropatan.

Dianthus orientalis Adams. type is widespread in rock crevices, stony and dry rocky slopes in subalpine zones (Talibov & Ibrahimov, 2010; Talibov, 2017).

Dianthus orientalis species are distributed in Kecheldağ, Salvartı Dağ, Biçenak and Kızıl Kışlaq villages of Shahbuz district. Plant gourds *Astragalus aureus*), *Acantholimon* (*Acantholimon hohenackeri*), *Achillea* (*Achillea vermicularis*), *Festuca* (*Festuca sulcata*), *Euphorbia* (*Euphorbia*

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szowitsii, *E. marschalliana*) and others. It participates in phytocenoses formed by the dominance of the species.

Picture
Dianthus orientalis Adams

Dianthus orientalis Adams. The species is widely used in decorative gardening due to its long flowering period.

Conclusion

As a result of the trips made to different regions of Shahbuz district of Nakhchivan Autonomous Republic in 2024 research year, taxonomy, distribution regions, phytocenological and bioecological properties of species included in the genus *Dianthus* L. were examined and the following conclusion was reached.

After determining the taxonomic composition of the genus *Dianthus*, it was determined that there are 4 species [*Dianthus Calocephalus* Boiss., *Dianthus aristatus* Boiss., *Dianthus cretaceus* Adams., *Dianthus orientalis* Adams.] distributed from low mountain belt to high mountain belt in Shahbuz region.

Phytocenological properties of *Dianthus Calocephalus* Boiss., *Dianthus aristatus* Boiss., *Dianthus cretaceus* Adams., *Dianthus orientalis* Adams. species were examined and the plant groups they form were determined.

Dianthus orientalis Adams. The new distribution areas of the species (around Bicenak and Gizil Gishlag villages) were determined by us.

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Industrial Importance and Greening Applications of Studied *Pyrus* L. Species in Greater Caucasus

Abstract

This work investigates the medicinal, nutritional, and industrial significance of wild pear species in the context of their diverse applications across agriculture, food, and traditional medicine. With over 800 plant species exhibiting medicinal properties in the local flora, and more than half of medications derived from plants, the conservation of these species is critical. Wild pears are rich in essential vitamins, minerals, and bioactive compounds such as antioxidants, flavonoids, and polyphenols, which contribute to their health benefits, including anti-inflammatory, anti-cancer, and wound healing properties.

The industrial role of wild pears extends to food production, pharmaceuticals, and cosmetic applications. The study highlights their use in creating beverages, dietary supplements, and skin care products, demonstrating their versatility and economic potential. Experimental investigations using Wistar albino rats showed significant wound healing activity from *Pyrus communis* extracts, suggesting their promise as natural remedies in the pharmaceutical industry.the ecological resilience of wild pears positions them as valuable resources for greening efforts, with potential applications in landscape architecture.

This research underscores the need for further exploration of their pharmacological properties to validate medicinal uses and promote sustainable industrial practices.

Keywords: *wild pear, medicinal, industrial, antioxidants, phytochemicals*

Introduction

There are over 800 plant species with medicinal effects in our country's flora. More than 50 % of the medications used are derived from plants. We can state that one of the reasons for the decline in the habitats of certain rare species is this (Iskender & Sadigova, 2017).

Typically, the pear plant lives for 70-90 years, but some species can live up to 300 years. Cultivated varieties, on the other hand, live for over 50 years. Wild pear Mspecies are rich in vitamins A, B group, as well as E, C, P, and PP. In addition to vitamins, the fruits contain ascorbic, citric, malic, and folic acids, as well as glucose, sucrose, fructose, and various trace elements. They also contain many metals, such as zinc, copper, nickel, molybdenum, iodine, manganese, iron, and fluorine. Therefore, when the body lacks food reserves, the fruits are often used in the treatment of anemia and thyroid diseases. Wild pear is also used in traditional medicine: medicines and compotes are prepared from fruits and leaves, dried and brewed teas. The use of wild pear species has proven beneficial in the treatment of prostatitis. Regular consumption of compote made from dried wild pears helps restore and normalize the function of the prostate gland. Doctors recommend that men over 50 collect dried wild pear fruits for the winter and brew them into compote or tea for preventive purposes during winter (Galitsina, 2021).

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Research

Pears contain special phyto components, including anti-inflammatory flavonoids, anti-cancer polyphenols, and anti-aging flavonoids. They are also rich in vitamins, carbohydrates, and mineral substances. Pears contain fructose, which is especially beneficial during diarrhea in children. They are also a good source of dietary fiber and calcium, essential for maintaining strong bones and preventing osteoporosis. The use of pears in the pharmaceutical industry is widespread. The pectin in pears helps lower cholesterol levels. Due to the presence of arbutin, wild pear species can combat bacterial infections. Hydroquinone, found in pear leaves, is beneficial for protection against bacterial diseases and enhances biochemical reactions. Increased consumption of fruits and vegetables helps lower blood pressure, which normalizes heart function, and the presence of ursolic acid in pears helps prevent the risk of heart attacks. Daily consumption of pears is particularly beneficial for women during menopause to mitigate cancer risks. Pears play a significant role in the treatment of diabetes and heart diseases. Consuming fresh pears and drinking fresh juice can help lighten the skin, as they contain secondary arbutin, which prevents the formation of melanin pigment. Additionally, pear fruits play a significant role in wound healing. They are rich in secondary compounds that aid in wound healing by producing tannins, vitamins, and collagen. They improve digestion and combat constipation. Pectin acts as a natural diuretic that helps soften stools, facilitating their easy passage through the intestines. It also helps balance pH levels. Pears are also used to produce wine, and beverages obtained from the fermentation of pears can be made either fully or partially fermented. Pear wood is also used for furniture, musical instruments, and carving work. Since it does not emit any odor during processing and readily takes on color, it is also used to produce kitchenware. Pears can also be used as a dye. In terms of the cosmetic importance of wild pears, they contain nutrients beneficial for skin lightening and hair health. They are added to facial scrubs and washes for skin freshness, resulting in long-lasting hydration. Daily consumption of pears also serves as a natural scrub. These scrubs help reduce skin wrinkles and are beneficial in treating acne and other skin infections (Abbas & Bano, 2020).

The studied wild pear species are utilized in various sectors of industry. The utilization possibilities of the studied plants are reflected in Table 1.

Table 1

Industrial Importance of Studied Pear Species

No.	Species	Medicinal	Culinary	Food	Honey-Producing	Ornamental
1	*Pyrus communis* L.	+	+	+	+	+
2	*Pyrus caucasica* Fed.	+	+	+	+	+
3	*Pyrus georgica* Kuth.	+	+	+	+	+
4	*Pyrus vsevolodii* Heideman	+	+	+	+	+
5	*Pyrus salicifolia* Pall.	+	+	+	+	+

Wild pear fruits, especially in juice, contain a significant amount of sugar alcohol – sorbitol, which has disinfectant properties. The skin of wild pear fruits contains tannins, vitamins B and C, phytoncides, carotenoids, and other chemical compounds. The seeds of the studied pear species are rich in biologically active substances. The leaves of these plant species contain a considerable amount of arbutin (1.4-3.0 %), hydroquinone, and flavonoids (10-20 times more than the fruits). The presence of hydroquinone, which is formed from the breakdown of arbutin-glucoside in some species of wild pears, distinguishes them from others due to its strong disinfectant effect (on the urinary system). The hydroquinone compound in pear plants, which determines one of their medicinal properties, positively impacts diseases caused by bacteria, fungi, and other organisms. The formation of hydroquinone from arbutin only occurs in alkaline urine. Therefore, patients with urinary tract diseases are advised to use pear species containing arbutin. Furthermore, patients with leukocytes in their urine are also recommended to use these species. Pear fruits are also utilized as raw material for the preparation of compotes, kvass, and other beverages. In the Caucasus, people grind dried fruits and mix them with flour to make cakes. Dried pears have long been used in traditional medicine. A beverage made by boiling dried pears helps quench thirst during feverish illnesses. This solution has anesthetic, antiseptic, and diuretic effects and regulates diarrhea. Boiled and cooked pear fruits are also used in severe coughs, choking, and pulmonary tuberculosis. Pear fruits are especially significant in the dietary nutrition of diabetic individuals .

E. M. Novruzov conducted an analysis of flavonoid accumulation in the flowers and fruits of various wild and introduced plants and determined that the flavonoid content in *Pyrus communis* L. was 101.9 mg, and in *Pyrus salicifolia* Pall. it was 171.3 mg (Novruzov, 2004). The author discussed maintaining the medical practice base in ethnobotanical research by conducting experiments on medicinal plants characteristic of the region, conserving existing plant resources, and cultivating medicinal plants adapted to the region's ecological conditions. Due to the presence of stone cells in pear fruits, only the consumption of pear juice and cellulose-free compote is allowed in any form. It is considered beneficial for certain gastrointestinal diseases (pancreatitis). The flowers of the pear plant are a valuable source of nectar and pollen for bees, but in terms of honey production, pears lag behind cherries, plums, and apples. The honey yield of pear plants is about 20 kg per hectare of cultivated area. The nectar collected by bees from pears contains low sugar content.In the Caucasus, it has been noted that the vitamin C content in pear fruits ranges from 12-21.6 mg% and in the leaves from 150-210 mg%. Furthermore, beautiful, patterned, and colored products (cutting boards, rulers, musical instruments, etc.) can be made from the wood of wild pear species. Additionally, wild pear species are used as rootstocks for cultivated varieties. They are also used as planting material for establishing forest strips in areas with adverse soil conditions (Moghanloo et al., 2019).

To overcome neuronal damage, the brain requires a certain amount of antioxidant reserves, which can be increased by adding various antioxidants. It has been established that *Pyrus communis* is rich in flavonoids, polyphenols, and vitamin C. Therefore, all these results reflect the potential anti-obsessive-compulsive properties of *Pyrus communis* juice (Arzoo & Parle, 2017).

The authors highlight the significance of *Pyrus* L. species not only in ecological contexts but also for their industrial potential. Understanding the pollen morphology and fertility of these species can enhance breeding programs aimed at improving fruit quality and yield, which is essential for both local economies and global markets. Furthermore, insights gained from*m* and *ex situ* conditions can inform conservation strategies and sustainable agricultural practices, ensuring that these valuable genetic resources are preserved while meeting increasing consumer demands. As the horticultural industry increasingly prioritizes biodiversity and sustainability, research like this underscores the importance of *Pyrus* species in developing resilient and productive agricultural systems (Jafarzadeh & Iskandar, 2024).

Using Wistar albino rats, the study evaluated the wound healing properties of *Pyrus communis* L. fruit through various wound models. The wound healing activity of ethyl acetate and ethanol extracts of *Pyrus communis* fruits was investigated in normal rats using different wound healing models, including incision, excision, and dead space wound models. Wounds were created according to standard procedures, and parameters such as wound contraction area, epithelialization time, scar area, tensile strength, and weight of granulation tissue were assessed. Phytochemical screening and total phenolic content were determined for both extracts. The hydroxyproline content of the collected granulation tissue was estimated in all animal groups. As a result, it was found that various extracts of *Pyrus communis* exhibited significant ($p<0.01$) wound healing activity in the models. This study clarified that *Pyrus communis* is a natural remedy for treating various types of wounds (Cinnasamy & Bhargava, 2014).

It was determined from the study that using 5 mg/kg cadmium for two weeks causes severe liver damage and leads to the depression of protein synthesis, including C-reactive protein and the serum antioxidant haptoglobin. Consequently, it was clear that the extract of *Pyrus communis* seeds protects against liver damage caused by heavy cadmium and helps restore haptoglobin protein.

The studies emphasize the critical role of dendroflora in the Greater Caucasus, particularly in relation to environmental factors and conservation efforts. The analysis of cultivated dendroflora highlights how abiotic factors such as climate and soil conditions significantly influence species distribution, offering insights that can aid in forestry management and biodiversity preservation. Author's evaluation of rare and endangered tree species underlines the urgency of introducing these species into the Absheron region to bolster local ecosystems and maintain genetic diversity (Iskender et al, 2005).

The research on tree and shrub species in the Huzurlu High Plateau provides valuable information on the flora of Turkey, which can inform conservation strategies and agricultural practices in the region. Collectively, these studies advocate for a holistic approach to understanding the ecological dynamics of tree species, which is essential for effective conservation and sustainable development. They highlight the interconnectedness of environmental conditions and the health of forest ecosystems, emphasizing the importance of targeted research in informing policy and conservation strategies (Iskender et al, 2022). Additionally, the integration of local knowledge and scientific research is crucial for the successful introduction of endangered species and the management of forest resources. Overall, these works contribute to a growing body of knowledge that underscores the importance of preserving tree species for ecological balance and industrial use (Iskenderov, 1993).

Previous clinical studies on wild pear have identified a number of beneficial therapeutic properties, such as anti-inflammatory, sedative, antioxidant, hypolipidemic, hypoglycemic, and wound healing effects. This study attributed the antipsychotic effect of wild pear to the presence of antioxidants, such as glutathione, vitamins C and E, flavonoids, and polyphenolic compounds, which protect brain cells from oxidative stress. The presence of glycine and glutamine acids in pear likely leads to reduced dopaminergic transmission by activating various receptors. This beneficial effect of pear helps alleviate strange symptoms of psychosis (Li, 2016). Chronic consumption of pear inhibits acetylcholinesterase activity, and the presence of choline in the pear plant increases cholinergic transmission in the brains of rodents, aiding in the recovery from various nerve-related dysfunctions. Thus, these results suggest that chronic consumption of pear juice may be beneficial in clinical settings to alleviate foreign symptoms in the body and manage various dysfunctions of psychosis due to its multifaceted actions (Saki et al., 2014).

This research investigated the presence of several bioactive compounds in wild pear (*Pyrus communis* L.) that could be responsible for its various medicinal and food purposes. The biological activity of different parts of the plant was revealed in this study. The importance of further research on pear (*Pyrus communis*) to explore other potential pharmacological properties and validate its medicinal use was noted.

The studied pear species are significant plants for use in various fields of agriculture. They have been categorized into five use categories. The studied species are mainly used as medicinal, food, and honey-producing plants.

The fruits of the studied wild pear species are widely used in the culinary preparation of various food products. These pear species are also used in greening works due to their decorative attributes.

Given their resilience to local soil and climatic conditions, the studied wild pear species were determined to have potential uses in greening efforts in two of six use forms (single planting and group planting).

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Table 2

Forms of Use of Studied Pear Species in Landscape Architecture

No.	Species	Border	Single Planting	Group Planting	Live Hedges	Alpinar	Flower Bed
1	*Pyrus communis* L.		+	+			
2	*Pyrus caucasica* Fed.		+	+			
3	*Pyrus georgica* Kuth.		+	+			
4	*Pyrus vsevolodii* Heideman		+	+			
5	*Pyrus salicifolia* Pall.		+	+			

Overall, since most of the studied pear species need protection, it would be more appropriate to use these plants more extensively in greening efforts through single and group planting to preserve their gene pool.

Conclusion

In conclusion, wild pear species (*Pyrus communis* L.) exhibit significant medicinal and industrial potential due to their rich phytochemical composition and diverse therapeutic properties. The research highlights their effectiveness in wound healing, antioxidant activity, and various health benefits, including anti-inflammatory, hypoglycemic, and neuroprotective effects. Furthermore, wild pears play an essential role in traditional medicine and culinary applications, emphasizing their value in both health and nutrition. The industrial applications of wild pears extend beyond medicinal uses, encompassing food production, beverages, and even cosmetic formulations. Their resilience to local environmental conditions makes them suitable for cultivation in various agricultural sectors, contributing to biodiversity and sustainable practices. Given the increasing interest in natural remedies and the importance of preserving genetic resources, further research and conservation efforts are crucial. Utilizing wild pear species in greening projects and ensuring their protection will not only safeguard their gene pool but also enhance their industrial applications, benefiting both health and the economy. Overall, the study underscores the multifaceted importance of wild pears as valuable resources in medicine, industry, and agriculture.

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Entomofauna of Agricultural Crops: Roles, Impacts, and Ecological Significance

Abstract

The entomofauna of agricultural crops comprises a diverse range of insect species, each playing a distinct role in crop ecosystems. This diversity includes pollinators, natural predators, and pest insects, all of which contribute to crop productivity, health, and ecological stability. Pollinators, such as bees, butterflies, and certain beetles, enhance crop yield by facilitating cross-pollination, which is essential for the reproduction of many crop plants. On the other hand, pest species, including aphids and caterpillars, can cause substantial crop damage and loss. However, natural predators like ladybugs, predatory beetles, and parasitic wasps act as biological control agents by preying on these harmful insects. This paper highlights the importance of fostering beneficial insects as a sustainable approach to pest management and reducing reliance on chemical pesticides, which can harm ecosystems and beneficial insect populations. Integrated Pest Management (IPM) strategies that incorporate biological control can help maintain a balanced agricultural environment, enhance biodiversity, and improve crop productivity. This study concludes that a comprehensive understanding of entomofauna and their interactions with crops is crucial for advancing sustainable agriculture, supporting ecological health, and promoting resilience in agroecosystems (Altieri, 1999, pp. 19-31).

Keywords: *entomofauna, pollinators, pest management, biological control, ecological significance*

Introduction

Agricultural systems rely heavily on various interactions between plants and insects, which together form an intricate network essential for crop health, productivity, and sustainability. This complex network of insect life associated with crops, known as entomofauna, encompasses pollinators, natural enemies of pests, and the pests themselves. The study of entomofauna in agriculture is crucial for developing sustainable practices that increase yield while minimizing ecological impact. With the intensification of agriculture to meet the growing global demand for food, the balance of entomofauna has become increasingly delicate, necessitating a deeper understanding of how these organisms contribute to ecosystem services (Bianchi, Booij, & Tscharntke, 2006, pp. 1715-1727).

Research

Pollinators, including bees, butterflies, and various beetles, are instrumental in the reproduction of many crop plants by transferring pollen from one flower to another, enabling fruit and seed production. Approximately 75 % of leading global food crops depend, at least in part, on animal pollination, making these species vital to both food security and biodiversity. Without adequate pollination, yields of many crops such as almonds, apples, and tomatoes would decline, posing a significant threat to both farmers and consumers. Pollinators thus represent a critical component of entomofauna, driving productivity in agricultural landscapes and contributing to the resilience of these ecosystems (Gurr et al., 2004).

In contrast, pest insects, including aphids, caterpillars, and beetles, feed directly on crops, often causing significant damage that leads to reduced yield and crop quality. The economic impact of crop losses due to pest infestations is substantial; for example, the damage caused by aphids alone accounts for billions of dollars in lost revenue each year worldwide. Traditionally, pest management has relied heavily on chemical pesticides, but over time, this approach has presented numerous challenges. The indiscriminate use of pesticides has led to the development of pesticide-resistant pest populations, contamination of soil and water, and detrimental effects on non-target organisms, including beneficial insects. These unintended consequences have underscored the need for more sustainable pest management solutions (Landis et al., 2000, pp. 175-201).

Natural enemies of pests, often termed biological control agents, offer an effective, eco-friendly alternative to chemical pesticides. These beneficial insects, which include ladybugs, predatory beetles, and parasitic wasps, naturally regulate pest populations by feeding on or parasitizing them, reducing pest numbers and limiting crop damage. Integrated Pest Management (IPM) has emerged as a holistic strategy that combines biological control, habitat manipulation, and careful pesticide use to manage pest populations in an ecologically sound manner. IPM not only mitigates pest damage but also preserves beneficial insect populations, creating a balance within agricultural ecosystems that supports long-term sustainability.

The importance of entomofauna in agriculture extends beyond individual benefits to crops; it plays a vital role in the greater ecological balance. By fostering diverse entomofauna populations, farmers can enhance the resilience of their agroecosystems, reduce dependency on synthetic inputs, and contribute to broader conservation goals. Understanding the relationships between pollinators, natural enemies, and pests is essential for managing agricultural systems that are both productive and ecologically sustainable. This paper seeks to explore the roles of these insect groups within agricultural systems and to highlight strategies for enhancing beneficial entomofauna in crop fields. Through this examination, the study aims to underscore the importance of entomofauna in promoting agricultural sustainability and the urgent need for policies that protect and support these essential species (Losey & Vaughan, 2006, pp. 311-323).

Garibaldi et al. (2013) conducted a landmark study on wild pollinators, showing that wild species contribute more significantly to crop pollination than previously understood, often exceeding the efficiency of managed honey bees. This research demonstrates that increased pollinator diversity correlates with improved crop yield, underlining the need for habitat conservation to support wild pollinator populations. Garibaldi's work emphasizes the economic impact of biodiversity loss in pollinators and advocates for strategies that protect wild habitats surrounding farmlands (Garibaldi et al., 2013, pp. 1608-1611).

Landis, Wratten, and Gurr explored habitat management as a tool for enhancing the populations of beneficial insects that naturally control pests. Their study revealed that integrating strips of native vegetation or cover crops near agricultural fields promotes the presence of natural pest predators such as ladybugs and parasitic wasps. This research has led to widespread adoption of Integrated Pest Management (IPM) practices that minimize pesticide use by incorporating biological controls, reducing environmental harm, and maintaining ecological stability in agricultural systems (Landis, Wratten, & Gurr, 2000, pp. 175-201).

Heimpel and Mills have further advanced the field by focusing on the ecological and economic benefits of biological control methods. Their research demonstrates that natural predators can provide long-term pest management solutions without the drawbacks of chemical pesticides, such as pest resistance or non-target impacts. By promoting natural pest suppression through biological control, Heimpel and Mills highlight the importance of incorporating beneficial insect populations as a part of a sustainable agricultural strategy that minimizes costs and ecological risks (Heimpel & Mills, 2017).

In a related study, Losey and Vaughan (2006) examined the economic contributions of entomofauna to pest control, estimating that natural pest predators save the agricultural industry billions of dollars each year in reduced pesticide costs. Beyond financial savings, their study underscores the broader ecological value of maintaining healthy entomofauna populations, which contribute to water quality and soil health by reducing the need for chemical inputs that can degrade these resources (Losey & Vaughan, 2006, pp. 311-323).

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Kremen and Miles compared biologically diversified and conventional farming systems, showing that diversified systems provide stronger ecological services. Their findings suggest that biodiversity-focused farming practices, which support a variety of insects within the entomofauna community, enhance both pest control and pollination, leading to more stable yields and sustainable production systems. This research highlights the long-term advantages of diversified farming for resilience and productivity, advocating for agricultural practices that foster biodiversity (Kremen & Miles, 2012, p. 4).

Ongoing research emphasizes the value of entomofauna in promoting a sustainable balance between crop production and ecosystem health. As entomofauna play essential roles across pollination, pest management, and biodiversity, these studies reveal the importance of conservation strategies that protect beneficial insect populations in agricultural landscapes.

Conclusion

The study of entomofauna in agricultural systems underscores the critical roles that insects play in maintaining ecological balance, enhancing crop productivity, and promoting sustainable farming practices. Pollinators, such as bees and butterflies, are indispensable to the reproduction of many crops, significantly impacting agricultural yields and food security. Their conservation is vital, as their decline poses serious threats to biodiversity and the viability of agricultural landscapes.

In contrast, the presence of pest insects can lead to significant crop damage and economic loss. However, integrating biological control methods through the promotion of natural enemies provides an effective strategy for managing pest populations sustainably. Research has demonstrated that habitat management practices can enhance the abundance and diversity of beneficial insects, creating a more resilient agroecosystem that minimizes the reliance on chemical pesticides. By adopting Integrated Pest Management (IPM) approaches that consider the entire entomofauna community, farmers can achieve a balance between maximizing productivity and minimizing ecological harm.

Moreover, the economic value of entomofauna extends beyond direct contributions to crop yield. The services provided by beneficial insects, such as pest regulation and pollination, can lead to substantial cost savings for farmers and foster a healthier environment. As society increasingly recognizes the importance of ecological sustainability, the integration of biodiversity-friendly practices into agriculture will be essential for the long-term viability of food production systems.

Future research should continue to explore the complex interactions among pollinators, pests, and their natural enemies, aiming to develop innovative strategies for enhancing entomofauna diversity in agricultural landscapes. By understanding these dynamics, we can promote practices that ensure both agricultural productivity and environmental health, ultimately supporting the resilience of our food systems in the face of global challenges such as climate change and habitat loss.

In conclusion, fostering a diverse entomofauna in agricultural settings not only supports the essential ecosystem services required for successful crop production but also contributes to the overall sustainability of our agricultural practices. As we move forward, prioritizing the health and diversity of entomofauna will be crucial for building resilient agricultural systems that can thrive in an ever-changing world.

The study of entomofauna in agricultural systems highlights the indispensable roles that insects play in maintaining ecological balance, enhancing crop productivity, and fostering sustainable farming practices. Pollinators, such as bees, butterflies, and beetles, are critical for the reproduction of many crops, significantly impacting agricultural yields and food security. Their conservation is vital, as their decline poses serious threats to both biodiversity and the viability of agricultural landscapes. The interdependence between plants and pollinators emphasizes the need for comprehensive strategies that prioritize habitat preservation and restoration to ensure the persistence of these essential species.

Conversely, the presence of pest insects can lead to substantial crop damage and economic loss. However, research has demonstrated that integrating biological control methods through the

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promotion of natural enemies – such as predatory insects and parasitoids – provides an effective strategy for managing pest populations sustainably. Habitat management practices, such as planting cover crops and creating floral diversity in agricultural fields, can enhance the abundance and diversity of beneficial insects, thereby reducing the reliance on chemical pesticides. By adopting Integrated Pest Management (IPM) approaches that consider the entire entomofauna community, farmers can achieve a balance between maximizing productivity and minimizing ecological harm.

Furthermore, the economic value of entomofauna extends beyond their direct contributions to crop yield. The services provided by beneficial insects, such as pest regulation and pollination, lead to substantial cost savings for farmers and foster a healthier environment. Studies indicate that investing in biodiversity-friendly practices can enhance overall farm resilience, improve soil health, and promote water quality, thereby supporting the long-term sustainability of agricultural ecosystems. The acknowledgment of these multifaceted benefits reinforces the argument for integrating biodiversity into agricultural policy and practice.

As society increasingly recognizes the importance of ecological sustainability, the integration of biodiversity-friendly practices into agriculture will be essential for the long-term viability of food production systems. To achieve this, policymakers, researchers, and farmers must work collaboratively to create frameworks that support sustainable practices. This includes funding for research on ecological farming methods, incentives for farmers who adopt biodiversity-friendly practices, and educational programs that promote awareness of the value of entomofauna.

Looking ahead, future research should continue to explore the complex interactions among pollinators, pests, and their natural enemies. Investigating the effects of climate change, habitat fragmentation, and agricultural intensification on entomofauna will provide crucial insights into their resilience and adaptability. Understanding these dynamics will be key to developing innovative strategies for enhancing entomofauna diversity in agricultural landscapes.

In conclusion, fostering a diverse entomofauna in agricultural settings not only supports the essential ecosystem services required for successful crop production but also contributes to the overall sustainability of our agricultural practices. As we navigate the challenges of the 21st century, prioritizing the health and diversity of entomofauna will be crucial for building resilient agricultural systems that can thrive in an ever-changing world. By championing policies and practices that protect and promote insect diversity, we can ensure a productive and sustainable agricultural future for generations to come.

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Rhizosphere Bacteria

Abstract

The review is devoted to the analysis of modern literature data on rhizosphere bacteria and their role in the vital activity of plants. The structure of the rhizosphere is characterized, the role of plants as centers of formation of microbial communities is shown, data on the taxonomic affiliation of the main groups of microorganisms inhabiting the rhizosphere are presented. The associative relationships of rhizobacteria with a partner plant and the modern concept of a holobiont as a combination of a plant organism and associated microorganisms are considered. The role of rhizobacteria in the processes of azo fixation is discussed in detail. The mechanisms of direct stimulation of plant growth through the synthesis of phytohormones, improvement of phosphorus and nitrogen nutrition and increase in stress resistance, as well as indirect stimulation through antagonism with respect to phytopathogenic microorganisms are presented. The criteria for the selection of rhizobacteria for practical purposes are discussed.

Keywords: *plants, rhizosphere, PGPR bacteria, nitrogen fixation, growth stimulation, antagonism*

Introduction

Microbiological studies of soil, which were actively developed in the second half of the last century, were focused primarily on achieving practical goals. Such issues as microorganisms and soil fertility, microorganisms as the basis for biological methods of combating plant diseases, microorganisms as sources of biologically active substances – plant growth stimulants were developed (Babu et al., 2015; Berg et al., 2016, pp. 995-1002). In the process of studying the microbiocenosis of the root zone of plants (rhizosphere), fundamentally new data on plant-microbial interactions were obtained, which have not lost their relevance today. Both this knowledge and the practical developments based on it became possible thanks to the work of more than one generation of scientists and researchers. In this regard, within the framework of this brief review, studies of rhizosphere bacteria are considered from a retrospective position (Dobereiner, 1983, pp. 330-350).

Research

Active release of various organic compounds by plant roots into the environment provides soil microorganisms with nutrients, which creates favorable conditions for their existence in the rhizosphere and rhizoplane zones. Root secretions, or root exudates, are low-molecular organic substances that are products of photosynthesis and plant metabolism: sugars, organic acids, amino acids, alcohols, as well as physiologically active substances – vitamins, enzymes, hormones, alkaloids, glucosides, flavonoids, etc. In general, the nutrition of microorganisms in the rhizosphere is provided by root rhizodeposits, which include, in addition to root exudates, high-polymer mucus of polysaccharide and protein nature, lost parts of the plant (root cap, root hairs, dead parts of the root). The phenomenon of a higher density of microorganisms in the root zone due to the consumption of root exudates and rhizodeposits is called the rhizosphere effect. Bacteria, actinobacteria, and micromycetes are concentrated in significant quantities in the rhizosphere and rhizoplane, significantly exceeding the content of these same organisms in root-free soil (Dinesh et al., 2010, p. 252).

The population of the rhizosphere by microorganisms is characterized by the ratio R/S (rhizosphere/soil – rhizosphere/soil), which is calculated for different species, genera and families of rhizosphere inhabitants. The R/S value shows how many times the number of microorganisms of

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a certain taxonomic group in the rhizosphere of a given plant exceeds the number of these microorganisms in the soil. For bacteria, this value varies from 10 to 100 (Berg et al., 2016, pp. 995-1002). The microflora of the rhizosphere and rhizoplane is characterized by the presence of gram-negative bacteria of the genera Azospirillum, Azotobacter, Agrobacterium, Enterobacter, Klebsiella, Pseudomonas, Xantomonas, etc., gram-positive bacteria of the genus Bacillus, actinobacteria of the genera Nocardia, Micromonospora, Streptomyces, etc., microscopic fungi of the genera Penicillium, Gliocladium, Talaromyces, Humicola, etc. However, within the framework of this review, we will limit ourselves to considering rhizosphere bacteria, most of which, according to modern data, belong to the phyla Actinobacteria, Bacteroides, Firmicutes, and Proteobacteria. Bacteria inhabiting the rhizosphere and rhizoplane form strong associations with the root system of plants and form specific rhizosphere bacterial communities.

The diversity of rhizosphere microbial communities is determined by both the qualitative and quantitative composition of root secretions, which depends on the species, age and growing conditions of plants, and soil and climatic conditions (soil type, illumination, air temperature, precipitation, geographic zone, etc.). Thus, during the vegetation of a plant, a regular change in the bacterial components of the rhizosphere is observed, which was pointed out by Russian researchers back in the 50-60s of the 20th century (Coleman et al., 1984). Plant development is accompanied by changes in the composition of root exudates and root rhizodeposits, which affects rhizosphere bacteria. In the root zone of young plants, gram-negative bacteria of the genera Pseudomonas, Flavobacterium, Azotobacter and others dominate, which, as the plants age, are replaced by gram-positive bacteria – bacteria of the genus Bacillus and actinobacteria of the genera Mycobacterium, Streptomyces. In essence, bacteria that feed on root exudates are replaced by hydrolytic bacteria (that produce hydrolytic enzymes) that decompose root litter, old roots, and microbial biomass.

As for the quantitative content of bacteria, the rhizosphere effect increases after seed germination and reaches its maximum during the flowering and fruiting period of plants. It should be noted that within one root, microorganisms are distributed unevenly: their abundance increases in the area of young apical roots, where the maximum release of soluble organic compounds occurs (Chapparo et al., 2013). The content of the rhizosphere bacterial community is very costly for the plant – in the form of root exudates and rhizodeposits, it loses 30-50 % of the products of photosynthesis (Berg et al., 2016, pp. 995-1002). What does the plant gain from the proximity of rhizobacteria? What function do they perform? The discovery in the 1970s of increased nitrogen-fixing activity in the rhizosphere and phyllosphere of non-legumes played a key role in answering this question. This type of nitrogen fixation, carried out by associative bacteria, is called associative, in contrast to symbiotic, which is characteristic of bacteria living in the nodules of leguminous plants (Balandreau, 1983, pp. 851-859).

Mechanisms of the positive influence of rhizobacteria on plants Moving on to the consideration of these mechanisms, we will add that in modern literature, along with previously accepted terms ("rhizosphere", "rhizoplane"), there is also a slightly different approach to defining the rhizosphere, which is divided into narrower layers: endorhizosphere (internal root tissues), rhizoplane (the surface of plant roots) and ectorhizosphere (the soil zone on the outer side of the root) (Raynaud, 2010, pp. 210-219).

Bacterial synthesis of the auxin class hormone, indole-3-acetic acid (IAA), has been well studied. Biochemical pathways and genes responsible for IAA synthesis have been characterized, and a positive effect of bacterial IAA on the development of the plant root system (initiation and elongation of roots, development of lateral roots and root hairs) has been shown, contributing to improved consumption of nutrients by the plant, acceleration of its growth, and the formation of resistance to stress. For the formation of IAA by rhizobacteria, the presence of its metabolic precursor L-tryptophan in root secretions is necessary. However, superproducers of IAA, which include phytopathogens, have an inhibitory effect on plants. In general, producers of various phytohormones have been found among rhizobacteria of the genera Azospirillum, Azotobacter, Agrobacterium, Enterobacter, Klebsiella, Pseudomonas, Clostridium, Bacillus (Schlaeppi & Bulgarelli, 2015, pp. 212-217).

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Rhizobacteria antagonism towards phytopathogens is realized in various ways, including through competition for such a vital nutrient as iron (Dessaux, Hinsinger, & Lemanceau, 2009, pp. 1-3). More than 500 siderophores are known to be formed by soil microorganisms, including rhizobacteria. Siderophores are low-molecular substances of various chemical natures (hydroxamates, α-hydroxycarboxylates, catechols and pyoverdins). In the soil, siderophores form complexes with Fe3+, which are then returned to bacterial cells, and a specific receptor on the cytoplasmic membrane is responsible for recognizing the Fe-siderophore complex. Accordingly, Fe-siderophores of rhizobacteria are inaccessible to phytopathogens, the growth of which slows down under conditions of iron deficiency (Igiehon, Babalola, & Aremu, 2019, pp. 1-22). Thus, by producing siderophores, rhizobacteria satisfy their needs for iron and inhibit competitive microflora by forming Fe-siderophore complexes that are inaccessible to them. It is important that these complexes can be absorbed by plants and stimulate their growth. It should be noted that competition for iron is effective only at low iron content in the soil and not in acidic soils, where the solubility of iron and its availability for all microorganisms increase. Excess iron leads to repression of siderophore synthesis. An important mechanism of biocontrol is the formation of antibiotics. Antibiotics and toxins produced by rhizobacteria directly affect phytopathogens, leading to inhibition of their growth or death. It has been shown that antibiotics of bacteria of the genus Pseudomonas – groups of phenazines, phloroglucins, oomycin A, etc. – play an important role in suppressing plant diseases. A wide range of antifungal antibiotics of peptide nature are formed by bacteria of the genus Bacillus, which is of particular importance for biocontrol, since microscopic fungi are the most harmful pathogens of plant diseases.

Conclusion

In conclusion, we would like to note that a significant contribution to the study of various aspects of soil microbiology, including the issue of the influence of soil microorganisms on higher plants, was made by Russian scientists S. P. Kostychev, N. A. Krasilnikov, E. N. Mishustin, V. T. Emtsev, G. V. Dobrovolsky, D. G. Zvyagintsev, T. G. Dobrovolskaya, M. M. Umarov and many others. Great attention was paid to the study of symbiotic and associative nitrogen fixation, the development of drugs based on nitrogen-fixing bacteria (Zilber-Rosenberg & Rosenberg, 2008, pp. 723-735). The rhizosphere of plants is an inexhaustible reservoir of microorganisms with practically useful properties. Research on rhizobacteria, laying the scientific foundations for the creation of biological products as an environmentally friendly alternative to chemical plant protection products and mineral fertilizers, remains relevant and promising.

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Cultivation of Pea Varieties Suitable For Soil and Climate Conditions of Nakhchivan Autonomous Republic

Abstract

Increasing the production and improving the quality of chickpeas plays a key role in ensuring the food security of the Autonomous Republic, as chickpeas have high nutritional value and healing properties. Therefore, today's human nutrition depends mostly on plants. In particular, legumes, which contain a high amount of protein, are the main component of human and animal food. In the article, suitability of 2 varieties of pea (*Cicer arietinum* L.) planted for research purposes to the conditions of Nakhchivan Autonomous Republic, planting technology, care rules and productivity were mentioned. At the same time, the soil and climate conditions of the pea plant, vegetation period, irrigation technology were also mentioned. Also, the results obtained from pea varieties planted for research purposes in the Nakhchivan Autonomous Republic were also mentioned.
Keywords: *chickpea, pest, control, phenological observations, quality, protein, productivity*

Introduction

The pea plant is the most widespread among the cereal-legume crops cultivated in the Nakhchivan Autonomous Republic. Chickpea belongs to the family of legumes (Fabacea) and belongs to the genus Cicer arietinum L. The yellow pea was cultivated around 7,000 years ago, B.C. In the 5000s, it began to be planted in the Middle East, especially in the regions of Iran and Iraq. This period is a period of time when peas were recognized by people as an agricultural product and began to be widely used. These regions are considered to be one of the oldest places in the cultural history of peas. At the same time, peas are an indispensable source of protein cultivated in India, America, Western Asia, North Africa, and Australia. The pea plant, which is rich in protein, sugar and trace elements, is of great importance (The farmer's annual activity calendar, 2019, p. 40).

Research

Pea is an annual herb. The color is white, yellow, pink, green. The leaves are short-stalked, compound unipinnate, without whiskers. There are 9-15 pairs of leaves on the leaf stalk. The leaves of different varieties differ in size. Depending on the variety, the plant is 30-90 cm tall. The fruit is

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swollen, 1-3.5 cm long. Each pod contains 1-2 occasionally 3 grains. Peas contain a high amount of protein (about 20-25 %), carbohydrates (40-60 %), fat (3-8 %), calcium, iron, potassium and a high amount of sodium. The main composition of peas is irreplaceable acids – methionine and tryptophan. Yellow peas are the third largest leguminous plant in the world, after green peas and beans. The amount of proteins in peas is very close to the amount of proteins in eggs. Its composition is rich in vitamins A, B1, B2, B6, C, D, PP and minerals. Peas are considered beneficial for the intestines due to the fiber they contain. The role of peas in the health of the body is great. It improves the functioning of the nervous system and normalizes sleep. It can be used in the prevention of cardiovascular diseases. Fresh chickpea juice is very beneficial for skin and hair. Peas have the ability to nourish cells and heal skin scars. It has the ability to protect the lens of the eye. Thus, the contents of peas eliminate fatigue in the crystalline membrane and improve vision (Valiyeva, 2024, p. 414).

There is a growing demand for chickpea due to its nutritional value. In the semi-arid tropics, chickpea is an important component of the diets of those individuals who cannot afford animal proteins or those who are vegetarian by choice (Singh, 1985, p. 23).

Soil requirements of the pea plant: The pea plant is not very demanding on the soil. It grows and yields well in sandy, light loamy and even saline soils. The pea plant gives the highest yield on black soil and dark chestnut soils (Amirov, 1968, p. 12).

Climatic requirements of the chickpea plant: Chickpea is a plant adapted to arid climatic conditions. In hot and dry climates, the plant can grow faster, but in cold weather, the growth process can be prolonged. Peas begin to germinate at 2-5°C. Pea tolerates weak frosts in autumn and spring relatively well, its sprouts can withstand -7°C (Yusifov, 2011, p. 134).

Water Requirement of Pea Plant: Pea plant needs moderate amount of water to get the best results. Water supply during the first 4-6 weeks is important for plant development. Later, plant roots go deeper and can catch water resources themselves (Hajiyev & Huseynov, 2009, p. 216).

Vegetation period of the pea plant: This plant is a very demanding plant, and the vegetation period lasts 70-100 days, depending on the time of sowing, cultivation conditions and variety characteristics, and 140-200 days in late-ripening varieties (Valiyeva, 2024, p. 415).

Applying fertilizers: Fertilizing the chickpea plant is important for its healthy growth and productivity. The following fertilizer types and application methods are suitable for peas:

Phosphorous fertilizer increases the yield of peas and accelerates its ripening. In addition to giving 90-100 kg of P_2O_5 per hectare, it significantly increases the productivity of rye and wheat, which will be planted after peas. Phosphorus and potassium fertilizers are applied to the soil at the rate of 40-60 kg per hectare before frost plowing, and in light soils, 75-120 kg (according to the effective substance) are applied at that time. It is purposeful to give nitrogen fertilizer in the amount of 40-60 kg before planting plants (Humbatov, Mammadov, & Nazaraliyeva, 2023, p. 48).

Applying granular superphosphate to the soil with seeds gives a positive result. It is recommended to give 250 kilograms of superphosphate in physical weight per hectare (Amirov & Amirov, 2011, p. 92).

Weed control: Using chemical methods, 1.5-2.0 kg of promethrin herbicide per hectare is dissolved in 300-400 liters of water, a working solution is prepared and sprayed on the field with POU, ON-400 or OBT-1A sprayers (The farmer's annual activity calendar, 2019, p. 42).

Fighting against diseases: In our country, the disease is widespread in cereal and leguminous plants, causing considerable damage to the crops. Pea diseases are as follows.

1) Alternaria-Alternaria alternata (Fr.) Keissl. It cannot cause significant damage to the pea plant, but the ability of the seeds to germinate is reduced. For the purpose of control, seeds are sprayed with TMTD (3 kg/t) a few months before sowing (Jafarov, 2024, p. 60).

2) False powdery mildew-Peronospora viciae (Berk.) Casp. A characteristic sign of the diffuse form of the disease is dwarfing of plants and a gradual change in color. For the purpose of control, when the initial symptoms of the disease appear in the seedbed, monico burgundy 4.0 kg/ha, curzat 1.8 kg/ha, iteral 0.2 kg/ha, spraying with one of the drugs ridomil gold MS 2.0 kg/ha is carried out (Jafarov, 2024, p. 61).

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3) There are 2 types of ascocytosis. A) Pale spotted ascochytosis-Ascochyta pisi Lib. It mainly infects beans and seeds, and to a lesser extent stems and leaves. B) Dark spotted ascochytosis-Ascochyta pinodes L. K. Jones. It infects all organs of the plant. For the purpose of control, seed material should be collected in time, and deep plowing should be done in autumn. Sustainable varieties should be grown. Seeds should be treated before sowing. During medication, hopper (60 g/l tebuconazole), vial (60 g/l dinicamazol-M+80 g/l thiabenazole), vitaros (198 g/l, carboxin+198 g/l thiram), TMTD (400 g/l thiram) type of modern seed fungicides provides high biological efficiency (Jafarov, 2024, p. 62).

4) Rust disease-Uromyces pisi-sativi (Pers.) Liro. During severe infection, the leaves dry up and fall off, and the pods fail to develop. For the purpose of control, deep plowing, early sowing, destruction of intermediate host plants, planting of fast-growing varieties, application of fungicides are important. The application of copper-containing fungicides (burgundy solution, copper chloride, monico burgundy, copper) in seed areas provides high biological efficiency in the fight against rust disease (Khalilova, Ismayilzadeh, & Safarova, 2016, p. 60).

5) Bacterial blight-Pseudomonas syringae pv.pisi (Sackett.) Young et al. Bacteriosis causes vascular disease of peas. For the purpose of control, the seeds should be sprayed before sowing. TMTD 400-10 l/h; tachi-garen-6 l/t; vitoros-3 l/t, etc. When the initial symptoms of the disease appear in the seed pea fields, spraying with one of the copper-containing fungicides with a contact effect (1 % burgundy solution, 0.5 % monica burgundy) is carried out (Ibanez, Rinch, & Amaro, 1998, p. 55).

Pest control: Yellow peas are susceptible to a number of pests. The main pests are:

1) Moths Aphidadae – Moths disrupt physiological processes in plants by sucking cell sap, and as a result, their development is weakened. Weevils are active carriers of viral diseases in peas (Amirov, 2015, p. 188).

2) Pea leaf fly (Liriomyza cicerina Rondani) – both larval and adult forms cause serious damage to the plant.

3) Pea greenworm (Heriothis viriplaca) – damages plants by feeding on seeds, leaves, stems and flowers.

4) Gray worms (Agrotis spp.) – feed on the stems and leaves of the plant and cause serious damage to the plant.

5) Lentil weevil (Sitona crinitus Herbst) – the main pest of lentils, this weevil also causes serious damage to the pea plant (Lev-Yadun, Gopher, & Abbo, 2000, p. 146).

These are the pest control methods. It is necessary that the seeds of the plants selected for planting meet the standards, the correct selection of the sowing time, the timely and correct care of the plants, and the correct fertilization of the plants. Against pea leaf fly Diaulinopsis arenaria, Diglypus areae, Chrysocharis longitarsus, Tetrastichus spp., against pea greenworm Telenomus sp., Trichogrammatidae sp., Campoletis chlorideae, Hyposoter Didymater; Against gray worms Apantheles ruficrus Haliday, Macrosentrus Collaris Spincla, Bracon kitcheneri, Fleanda Ruficanda, Beauvaria bassiana; Opius monilicornis can be used in biological control (Hasanova, 2024, p. 69).

Academician Hasan Aliyev, Nakhchivan Agricultural Scientific-Research Institute, scientific worker of the field of working with cereals, legumes, technical and other plants and junior researcher, according to the 5-year planning program, 2 varieties of peas (Sultan and Narmin) were planted on 0.08 ha on 14.03.2024 in the experimental area of the Sharur base station of the Institute according to the 5-year planning program.

The methodology "Collection of world genetic resources of grain bean viruses: replenishment, preservation and study (ВИР)" was used in the research.

Before planting, the field was prepared by plowing to a depth of 18-25 cm. 15 days after plowing, the cuttings were split and softened with a toothed trowel. Rows were opened 1 week before planting. After the rows were opened, they were watered and plowed. Immediately after planting, the research area was irrigated, agrotechnical measures were implemented. The first sprout was after 1 week. Flowering began 25-35 days after germination and lasted 30-40 days. During the vegetation period, the pea plant was watered 4 times, cultivated 3 times and sprayed with burgundy

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solution in order to take preventive measures against diseases. Biometric and phenological measurements were carried out during the vegetation period of the study. Peas were harvested on 23.07.2024.


The indicators of the researched pea plant are reflected in the table below.

Table
Pea yield table

S/No	**The name of the variety**	**Area (ha)**	**Planting scheme**	**Vegetation period**	**Plant height (cm)**	**Mass of grain per plant (g)**	**Mass of 1000 grains (g)**	**Productivity (kg)**
1	Sultan	0,05	30 x 15	180-200 days	20-25	10-15	343	14
2	Narmin	0,03					350	14,600

The purpose of the study is to study productive varieties in the conditions of the Autonomous Republic based on a 5-year plan-program and recommend them to farmers.

Conclusion

The technology of planting peas, maintenance rules, productivity, soil and climate conditions, vegetation period, irrigation technology were studied, and at the same time, the amount of protein in the samples of the pea plant, cooking time, water absorption capacity, moisture, etc. were studied signs have also been studied.

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Quality Indicators of Seed Received From Buffalo Breeders at the Artificial Insemination Center of Nakhchivan Autonomous Republic

Abstract

The main objective of the study is to investigate and determine the factors affecting the productivity of the seed obtained from buffalo germplasm. In the research work, different factors affecting the productivity of the seed were identified. These are genotype, fodder and feeding systems, buffalo feeding.

Keywords: *buffalo, germ, artificial insemination, seed, Nakhchivan*

Introduction

Artificial insemination is considered the most efficient of the biotechnical methods applied in improving the genetic composition of buffalo breeding, intensification and improvement of reproduction, and raising the quality of breeding (Mammadov, 2021, p. 24).

In most agriculturally developed countries of the world, artificial insemination and embryo transfer are used to ensure the health of buffaloes, cattle and many other animals, to increase production in animal husbandry, to create animal breeds, to improve the breed composition of animals and to create new breeds of animals. Different factors affect the fertility of buffaloes. These factors include the following (Nasibov, Abbasov, & Abbasov, 2016, p. 26).

Research

Genotype. Genotype is one of the most effective factors affecting reproductive characteristics. First of all, genotype differs from race to race and from individual to individual within each race (Alacham et al., 1998).

Feeding of canes. Special attention should be paid to the feeding, feeding and maintenance of buffaloes in order to buy more productive breeds and to ensure the quality of the seed obtained (Seyidov, 1975, p. 18).

In order to maintain the sexual activity of buffaloes at the same level, their feed should contain enough mineral salts, proteins, vitamins and animal feed (Tandle, 2017, p. 62).

There should be a hole in the middle of the floor where the litter box is kept so that the urine can flow under the plank (Abdullayev et al., 2012, p. 102).

The data obtained as a result of our observations and research at the Nakhchivan Artificial Insemination Center are listed in the following tables.

Table 1
Effect of season of the year on seed yield of buffalo germs

Originator	Ejaculate Volume, ml	Motile (total activity)	Progressive (straightforward movement)	Morphology	Density (ml)
In winter					
Bella	1.8	86	78	88	768
In the spring					
Bella	2.5	86	58	89	2195
In the summer					
Bella	5.2	81	57	93	1214
In the fall					
Bella	2.8	79	69	92	602

As can be seen from Table 1, the seasonal change of the year affects the tissue in different ways. The volume of ejaculate was 1.8 ml in the summer season, slightly increased to 2.8 ml in the autumn season, decreased again to 1.8 ml in the winter season, and increased to 2.5 ml in the spring season. Also, sperm motility, i.e. total activity, was 81 in summer, 79 in autumn, 86 in winter, and 86 in spring. The progressive movement of sperm was 57 in summer, 69 in autumn, 78 in winter, and 58 in spring. The density of sperm was 1214 ml in the summer season, in the autumn season its density decreased slightly to 602 ml, in the winter season its density increased slightly to 768 ml, and in the spring season it increased again to 2195 ml (Nasibov, Ahmadov, & Verdiyeva, 2014, p. 71).

Table 2
Effect of age of buffalo germs on seed yield

Originator	Age of originator	Ejaculate volume, ml	The density of the seed is billion/ml
Bella	2-3	2,8	3046
	3-4	2	2543
	4-5	1,8	1287

The volume and thickness of the ejaculate in buffaloes varies with age. As a result of our tests, we determined that the volume of the ejaculate was 2.8 ml, and its concentration was 3046 billion/ml in the causative agents at the age of 2-3. However, the volume of ejaculate in the seeds of 3-4-year-old progenitors decreased to 2 ml compared to 2-3 years, and the density of the seed decreased to 2543 billion/ml. The volume of the ejaculate of the seed obtained from the 4-5-year-old germs decreased to 1.8, and the density of the seed decreased to 1287 billion/ml (Abdullayev, 2020, p. 35).

The purpose of the study. The current operational accounting and reporting documents of the Artificial Insemination Center of the Nakhchivan Autonomous Republic, State Veterinary Service, annual statistical and production reports on artificial insemination, artificial insemination work carried out in individual locations, private and farm farms were organized as research material. Also, the examination of buffaloes brought to the Artificial Insemination Center of the Nakhchivan Autonomous Republic, the methods of obtaining seeds from these agents, examination and storage after obtaining seeds, filling and freezing of the seeds after inspection, quality inspection after freezing, and the work of the artificial insemination technician were analyzed (Tahirov & Huseynova, 2022, p. 85).

The object of the study is two head of breeding buffaloes kept in the Artificial Mayalana Center of the Nakhchivan Autonomous Republic. For the experiment, a clinically healthy, 3-4-year-old,

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750-800 kg live weight bald breeder was used. The feeding, feeding and care of the germs stored in the Artificial Insemination Center, as well as the work done in this center, i.e., taking seeds from breeding germs, checking and filling them in poyets, and placing them in the deep-frozen seed bank, were carried out in accordance with all zoohygienic rules (Tahirov & Huseynova, 2022, p. 87).

Material and research methods. Seed collection from buffaloes: The seed is attached to the machine where the seed will be collected. The agent attached to the bench must be completely healthy. It is not recommended that the pathogen that is closed to receive seeds is too large (Special Issue on Buffalo Nutrition, Breeding and Diseases).

The seed is taken through an artificial vagina. The artificial vagina used for insemination should be different for each agent and the name of the agent should be written on the artificial vagina. All tools used are stored in special cabinets (Buffalo).

The artificial vagina is cleaned and disinfected after taking seeds both times. The air pressure should be equal to 35-45 mm of mercury, and the temperature should be 40-42 degrees. The surface of the artificial vagina used for seed collection should be smooth and covered with vaseline (Taghiyev, 2010, p. 94).

If one of the rules used in seed collection is violated, then the ejaculation process of the causative agent will weaken and temporary impotence will occur. The following rules are used to prepare the artificial vagina: first, the vagina is washed, then the seed collector is prepared, disinfected, hot water is filled between the walls of the artificial vagina, the seed collector and the artificial vagina are connected, the artificial vagina is filled with air and measured, the pressure is measured with a pressure gauge, and the temperature measured with a thermometer (Taghiyev, 1978, p. 93).

If the used artificial vagina is new, it is first disinfected and its inner walls are cleaned with 96 percent alcohol-refined. Depending on the air temperature, 60-80 degree hot water is poured into the artificial vagina. The amount of water varies depending on the type of animal. The amount of water in the artificial vagina should be 500-600 milliliters for heads (Perry, 1960, p. 179).

Vaseline is rubbed into the artificial vagina with a special tool. The seed collector is first washed, then disinfected and hot water of 35-40 degrees is poured into the seed collector. The seed collector, which is ready to receive seeds, is connected by means of a special rubber holder. The hole through which water is poured into the seed collector is closed with a plug. After these processes are finished, air is injected into the artificial vagina. When using the artificial vagina, it should be held so that the seed collector is behind and above. The artificial vagina is kept in a horizontal position at an angle of 35-40 degrees to the pelvic area of the agent, which is attached to the machine to receive seeds. As soon as the germinator produces seeds, the seed collector should be lowered, and the air tap should be opened so that the seeds are poured into it. The sperm collector is gently removed from the artificial vagina and the mouth is tightly closed. If the seed is collected from the same source a second time, another artificial vagina prepared in advance is used. After all these works are finished, artificial vaginas are cleaned according to veterinary-sanitary rules. A 2-3 percent soda solution is used to clean petroleum jelly, then it is washed with hot water, wiped with a towel, disinfected with a swab soaked in 96 percent alcohol, and placed in a special cabinet (Abdullayev, 2020, p. 29).

To buy seeds, the following rules should be followed:

The seed should always be taken at the same time (2-3 hours after feeding the pathogen).

Before taking seeds, the pathogen should be moved for 15-20 minutes.

It is advisable to take seeds from the bald head twice with an interval of 5-10 minutes. The seed bought the second time is often of better quality than the first (Mammadov & Yusifov, 2004, p. 13).

Research results and their discussion. The artificial insemination center covers an area of 2 hectares. Quarantine buildings, a veterinary clinic, an administrative building, a dormitory, a stable, fodder warehouses, a seed collection area, a technical park and other service buildings were built in this center. In the administrative building there is a training center equipped with an electronic board and an archive, a warehouse and a storage place for pathogens, a canteen and work rooms, a

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veterinarian's room in the quarantine building, an animal storage area and an examination room in the veterinary clinic. A laboratory has been established in the field of seed collection. The most modern equipment imported from France was installed in the laboratory created here.

"Holstein-Friesian", "Simmental", "Caucasian buffalo", "Balbas", "Mazex", "Romanov", "Aleppo", "Saanen" and local breeds of large and small cattle are stored in the center in the dairy and meat-dairy direction (Tahirov & Huseynova, 2022, p. 91).

Picture 1 Artificial Insemination Center

Picture 2 Azerbaijani buffalo

Artificial insemination was performed on 83 thousand 610 head of cattle in the autonomous republic in 2002-2019, and 53 thousand 584 calves were purchased. "Holstein-Fries" in the dairy direction, "Swiss" in the dairy-meat direction, "Aberdeen Angus", "Limousin", "Charolle" in the meat direction, and "Simmental" in the meat-dairy direction were used in the artificial insemination of the mother cattle. In 2015-2019, 2 million 448 thousand AZN subsidies were paid to entrepreneurs for 24 thousand 485 calves purchased (Tahirov & Huseynova, 2022, p. 97).

Currently, there are 23 artificial insemination centers in the autonomous republic. There is also a liquid nitrogen production enterprise that fully meets the needs of those stations. The newly created center will further improve the work in this area, and the actions carried out in other locations will be managed from a single center.

Conclusion

1. The seasonal change of the year has different effects on the seed of buffalo germs. The volume of ejaculate was 1.8 ml in summer, slightly increased to 2.8 in autumn, decreased again to 1.8 in winter, and increased to 2.5 ml in spring.

2. As a result of our tests, we determined that the volume of ejaculate in buffaloes is higher at 2-3 years than at 3-4 and 4-5 years.

3. As a result of our observations and studies, 85 % of the spermatozoa of the sperm we received from buffalo breeders were normal, 0.14 % had a deformed head, 2.5 % had a deformed tail, 2.86 % had a twisted tail, 1.8 % had a thickened tail, 1, Adhesion of head and tail was observed in 2 % and severed head and tail in 3 %.

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Nutritional and Biological Value of Poultry Products

Abstract

Food is one of the important elements for human life, like air and water. Nutrition rich in high-quality protein, fat, carbohydrates, vitamins, and minerals is the basis of the body's development, immune system, intellectual and reproductive activity. The connective tissue in poultry meat is easily digestible (up to 80 %) by the human body due to the fact that it is composed of delicate muscle fibers. Bird eggs are also very useful for the body. However, in addition to the amount and chemical composition of food, its microbiological indicators should also be under strict control. Eggs, which have a rich biochemical composition and useful biological properties, can be a source of danger to human health if veterinary-sanitary and hygiene rules are not followed. That is, the fall of various disease-causing agents, chemical and biological toxic substances into food products can cause mass illness and poisoning.

Keywords: *poultry, poultry meat, eggs, poultry products*

Introduction

Poultry – meeting the population's demand for poultry meat and eggs. The largest poultry complexes are located in major cities such as Baku, Ganja and Nakhchivan. Egg layers are used to obtain eggs from chicken breeds. Chickens of this breed differ in rapid maturity and have a relatively small mass (2 kg). They have a noticeable broad chest, a long, light body, a straight back and a light head. Their legs are thin, wings are long, feathers are dense (Gadimova, 2013, pp. 9-10)

Meat from naturally raised and naturally fed chickens has a high nutritional value. The high nutritional value of poultry meat is related to its chemical composition. Poultry meat therefore contains proteins, fats, vitamins, minerals and carbohydrates that are easily digestible by the human body. These substances that make up poultry meat have a special importance in the quality of poultry meat. The chemical composition of poultry meat includes 72 – 75 % water, 18 – 22 % protein, 1.5 – 5 % fat, 1 – 1.2 % minerals, 1.7 – 1.9 % extractive nitrogenous substances, 0.9 – 1.2 % nitrogen-free extractive substances. it also contains vitamins, enzymes and other substances formed during metabolic processes. Poultry meat is dominated by vitamins A, D, E, B1, B2, B12 and PP. However, it should be noted that the amount of vitamins in poultry meat is low compared to other substances. Unlike beef, poultry contains more vitamin B6 and biotin. One of the components in poultry meat is carbohydrate (glycogen). The amount of this substance in poultry is less than in other substances. The amount of this substance in poultry meat is up to 0.5 %. Poultry meat contains all the essential amino acids – tryptophan (the most deficient amino acid in the human diet), threonine, valine, isoleucine, leucine, lysine and methionine, in optimal proportions. It also contains a complex of essential amino acids – alanine, histidine, aspartic acid and a number of other amino acids (Bessarabov, Bondarev, & Stolya, 2005, p. 72; Isfandiyarov & Akhmedov, 1982, pp. 23-25; Zhuravskaya, 1985, pp. 40-42).

Research

A distinctive feature of young poultry is that the breastbone of birds at this age is not ossified, the beak is soft and the skin is soft and elastic. In addition, the feet of birds at this age are smooth, dense and covered with scales. Spurs do not grow for a long time. Older poultry meat includes goose, duck, chicken and turkey, as well as products from their processing. Birds at this age are characterized by complete ossification of the breastbone and hardening of the beak. The scales covering the legs of chickens and turkeys are hard. The skin of the feet of ducks and geese is thick and rough.

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More extra substances (0.9–2.1 %) are found in the meat of competent birds. Nitrogenous extractive substances include: carnosine, anserine, carnitine, creatine phosphate, creatine, adenosine monophosphate, adenosine diphosphate, adenosine triphosphate, purine acids, substituted amines, carbamide, etc. One of the main nitrogenous extractors is carnosine. It strengthens the excretion and separation of mədə syrup (Gabrielyants & Kozlov, 1986, p. 189).

Poultry is one of the fastest growing industries. Large quantities of high-value food products, especially eggs and meat, are produced in a short time. The flavor and fullness of poultry meat is due to the wealth of extractive substances in it. The amount of these substances has a decisive influence on the taste and aroma of poultry. Among birds, turkey is considered the most protein-rich meat, while goose meat is considered the least nutritious. The nutritional value of poultry meat is shaped by its main composition and the importance of its individual components in the human diet. Poultry meat has many benefits. In general, it has dietary properties (except for duck and goose meat) and is easy to digest, rich in biologically active substances (non-substitutable amino acids, essential fatty acids, etc.). It also contains high amounts of tryptophan, which gives the body comfort. Since poultry meat is rich in unsaturated fatty acids (olein, linole, arachidone, etc.), it helps prevent atherosclerosis and hypertension by removing harmful cholesterol from the body. It is also useful in the treatment of gastrointestinal diseases. It also accelerates the healing processes of anemia and circulatory disorders thanks to its easily absorbed iron content. It has a metabolism-regulating effect in diabetics and plays a role in the treatment of colds and respiratory diseases by strengthening the immune system (Pozdnyakovskiy, Ryazanova, & Motovilov, 2007, s. 31).

The protein content of lean and young poultry meat is higher than that of fatty and old poultry meat. However, the total amount of protein does not fully reflect the nutritional value of the bird. Because poultry meat contains complete proteins as well as incomplete proteins. Therefore, the nutritional value of poultry meat is evaluated according to the amount of complete protein. This shows that poultry meat is different from beef.

The fats in poultry meat are mostly unsaturated fatty acids and are therefore easily digested by the body. The amount of unsaturated fatty acids is 5-20 times higher than in beef and mutton. Also, the presence of mineral substances in poultry meat is particularly important (Ahmadov & Hasanova, 1982, pp. 12-16; Isfandiyarov & Ahmadov, 2006, pp. 23-25; Mirzayev, 2006, pp. 32-33).

An egg is a structure in which new life is born in a frame, separated from the world that surrounds it. This means that each egg contains all the components a bird needs. The world's largest egg is considered to be an ostrich egg, but an ostrich egg weighs less than the weight of the bird itself. The smallest bird in the world is the hummingbird, but its egg weighs more than 6 % of its own weight (Jabbarov & Hajiyev, 2017, p. 34).

It is accepted that inclusion of xanthophyll containing feedstuffs in the diet of laying hens is required to produce egg yolks with a normal color appearance. In addition to widely used feedstuffs such as yellow corn and alfalfa, various other materials that contain xanthophyll have been evaluated for pigmentation of egg yolks (Janky et al., 1982).

Chickens start laying eggs at 5 months of age. 10 chicken eggs have the same nutritional value as 1 kg of beef. However, not all birds' eggs can be used in the kitchen. Goose and duck eggs are only recommended for use in desserts, as they must be cooked at high temperatures and their freshness is also very important. Otherwise, it can lead to paratyphoid (an infectious stomach disease similar to flatulence) in the human body. Chicken eggs are the most common product in the kitchen and contain protein, fat and carbohydrates. In short, chicken eggs contain 74 % water, 12-13 % protein, 11-12 % fat and 1 % carbohydrates. The calorie content of 100 grams of chicken eggs is 150-160 kcal. Chicken eggs, especially the yolk, contain enzymes and unsaturated fatty acids. The yolk is rich in carotene, which can only enter the human body through food. Quail eggs are much more valuable than chicken eggs. As long as they are fresh, they are germ-free and harmless for children. In general, quail eggs contain 2 times more vitamins than chicken eggs, 5 times more phosphorus and calcium, and 4 times more iron than chicken eggs. By consuming quail eggs, it is possible to boost immunity, mobilize stamina and mental strength, as well as cure abdominal diseases. These eggs also contain calcium carbonate, which plays an important role in the uptake of

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calcium needed by the human body. Eggs are nutrient-rich and a valuable source of high-quality proteins and are low in harmful fats and calories. High-quality protein helps to maintain normal body mass or reduce excess weight; therefore, it plays an important role against obesity (Jabbarov & Hajiyev, 2017, pp. 180-188; Corsello et al., 2015).

Currently, a number of preservatives, ionizing radiation, ultraviolet rays, carbon dioxide and antibiotics are used to preserve the quality of poultry meat in line with the high demand of the population. Thanks to these preservatives, it is possible to extend the shelf life of poultry meat. Each of them is of particular importance in maintaining the quality of poultry meat.

Ionizing radiation has a very strong bactericidal effect and is one of the most effective methods against microorganisms that cause deterioration of poultry meat quality during storage. Ionizing radiation consists of radioactive γ-rays with high transmittance. Two types of γ-radiation are used during product storage: high dose (0.8 million rad) radopreservation and low dose radiopreservation. When a high dose is applied to poultry meat, the microorganisms contained in the meat are destroyed, thereby eliminating the danger of meat spoilage (Didenko, 1972; Sidorov, 1986).

The beneficial signs we have listed apply to chickens and their eggs that are raised naturally in villages and gardens. We witness the conditions under which these chickens are raised. When buying chickens, it is important to choose village chickens because their meat is rich in vitamins and minerals, as they are fed natural rather than artificial feed. It takes 12-16 weeks for a chicken to grow naturally, and chickens raised earlier than this period may contain harmful substances.

Birds have their own growth period and should be fed with natural products. However, the extent to which these conditions are complied with in our factories should be checked. There may be factories where chickens are fed food that they would eat in nature (barley, wheat, millet, grass, earthworms, etc.). There are also factories where chickens are fed genetically modified feed or hormonal preparations. Therefore, care should be taken when choosing products.

It is extremely important to comply with veterinary health rules during the transportation and sale of poultry products. Such products should not be transported openly in vehicles without observing the appropriate temperature regime and without veterinary documents. Compliance with hygiene rules when using products is of great importance for our health.

Conclusion

This article provides information about the benefits of poultry products to the human body, the vitamins, proteins and minerals contained in these products. One of the most important food products that form the basis of human nutrition is meat and meat products. Therefore, meat and meat products, including poultry and eggs, are recognized as complete protein sources. Poultry farming is a very useful field in terms of agriculture, and poultry meat and eggs offer significant benefits for the body. In recent years, many poultry farms have been established in different regions of Azerbaijan. These facilities are equipped with the latest technology and equipment of leading companies from developed countries of the world.

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The Effect of Light on the Synthesis of Silver Nanoparticles in Biological Systems

Abstract

This study explores the influence of light on the synthesis of silver nanoparticles (AgNPs) within biological systems. Silver nanoparticles are known for their unique properties, including antimicrobial, anti-inflammatory, and catalytic activities, making them valuable in various biomedical and environmental applications. Biological synthesis methods, which are eco-friendly and sustainable, often involve the use of plants, microorganisms, and enzymes as reducing agents. The role of light in enhancing or controlling the synthesis of AgNPs is particularly significant. Light can influence the size, shape, and distribution of the nanoparticles by affecting the reduction processes. Different wavelengths of light (UV, visible, etc.) can accelerate or modulate the synthesis, offering a tool for optimizing nanoparticle characteristics for specific applications. The study highlights that light-assisted synthesis not only provides a greener alternative by reducing the need for harsh chemicals but also offers precise control over nanoparticle formation.

Keywords: *silver nanoparticles, biological synthesis, light-assisted synthesis, bioreduction, photochemical effects, eco-friendly nanotechnology*

Introduction

Nanotechnology has emerged as one of the most revolutionary fields of scientific research, with silver nanoparticles (AgNPs) standing at the forefront due to their versatile properties and wide range of applications. Silver nanoparticles exhibit remarkable antimicrobial, anti-inflammatory, and catalytic activities, making them invaluable in various sectors such as medicine, environmental science, and industry. In recent years, the synthesis of AgNPs has garnered significant attention, particularly with a growing interest in sustainable and environmentally friendly methods (Abdollahi, Zare, & Dehghanian, 2021, p. 209). Among these, biological synthesis has emerged as a green alternative to conventional chemical methods, utilizing biological entities such as plants, fungi, bacteria, and algae as reducing and stabilizing agents. Traditional methods for synthesizing silver nanoparticles often involve toxic chemicals and harsh conditions, posing risks to both the environment and human health. Biological synthesis offers a safer and more sustainable route by relying on naturally occurring reducing agents found in biological systems. These biological agents, including enzymes, proteins, and phytochemicals, not only reduce silver ions (Ag+) to elemental silver (Ag0) but also act as capping agents to stabilize the nanoparticles, preventing aggregation (Rai, Yadav, & Gade, 2009, p. 76).

Research

Relevance of the Research

The synthesis of silver nanoparticles (AgNPs) in biological systems has gained increasing attention due to its eco-friendly and sustainable nature. This method minimizes environmental hazards and offers biocompatible nanoparticles, which are valuable in fields such as medicine, biotechnology, and environmental science. The use of light in controlling the synthesis process adds a new dimension to green nanotechnology, enabling the fine-tuning of nanoparticle properties.

Problem Statement and Level of Study

The main problem addressed in this study is the limited understanding of how light affects the biological synthesis of silver nanoparticles. Although biological methods for nanoparticle synthesis are widely studied, the role of light in enhancing and controlling this process is not yet fully explored. However, there is a significant gap in comprehensive studies that systematically investigate the effects of light parameters in the biological synthesis of AgNPs (Kim et al., 2007, p. 95).

Research Aim and Objectives

The aim of the research is to investigate the effect of light on the synthesis of silver nanoparticles in biological systems. The specific objectives are:

1. To explore how different wavelengths of light (UV, visible) influence the size, shape, and yield of silver nanoparticles.
2. To analyze the interaction between light and biological reducing agents during nanoparticle synthesis.
3. To optimize the light-assisted synthesis process for producing silver nanoparticles with specific properties.

Research Object and Subject

The object of the research is the synthesis of silver nanoparticles using biological systems. The subject of the research is the role of light in influencing the biological synthesis process, including its effects on nanoparticle characteristics such as size, shape, and stability.

Research Question

How does light, in terms of wavelength and intensity, influence the synthesis of silver nanoparticles in biological systems, and how can this process be optimized to enhance nanoparticle properties?

Theoretical Perspectives of the Research

The theoretical framework for this study draws on principles from nanotechnology, green chemistry, and photochemistry. It integrates the concept of biological synthesis with light-mediated photochemical reactions to understand how light can control nanoparticle formation.

Information Base of the Research

The information base of this research consists of existing literature on silver nanoparticle synthesis, biological methods for nanomaterial production, and studies on the photochemical effects of light on chemical reactions.

Research Limitations

The study is limited by the availability of biological materials and the specific light sources required for the experiments. Additionally, variations in biological reducing agents may affect the reproducibility of results across different biological systems.

Scientific Novelty of the Research

The research presents a novel approach to nanoparticle synthesis by systematically investigating the effects of light on the biological formation of silver nanoparticles. It introduces the concept of light-assisted synthesis as a method for optimizing nanoparticle properties, providing new insights into how photochemical reactions can be integrated into biological processes for sustainable nanomaterial production.

Practical Significance of the Research

The practical significance of this research lies in its potential to develop a more efficient, environmentally friendly method for producing silver nanoparticles. The findings could have broad applications in medicine, particularly in the development of antimicrobial agents, as well as in environmental remediation and industrial catalysis.

Literature Review

Abdollahi et al. (2021) emphasized the role of plant extracts in silver nanoparticle (AgNP) synthesis, noting that light exposure accelerates silver ion reduction, resulting in smaller nanoparticles and enhanced properties. Light also reduces reaction times and increases efficiency.

Ahmed et al. (2016) investigated AgNP synthesis using Azadirachta indica extract, demonstrating that UV light, especially shorter wavelengths, speeds up synthesis and yields smaller nanoparticles.

Amina and Guo (2020) reviewed metallic nanoparticle synthesis, focusing on silver and gold. They highlighted the photochemical aspects, where light intensity affects surface plasmon resonance, essential for nanomedicine applications.

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Ashraf et al. (2020) explored AgNP synthesis with Vitex trifolia extract under different light conditions, finding that light exposure enhances both particle size control and antimicrobial efficacy, useful for biomedical applications.

Banerjee et al. (2014) studied AgNP synthesis with leaf extracts, concluding that visible light exposure yields more uniform and stable nanoparticles, beneficial for drug delivery applications.

Das et al. (2021) discussed the role of biological entities like plant extracts in nanoparticle synthesis, showing that light exposure enhances biomolecule activity, improving nanoparticle yield and quality.

Materials and Methods

This study focused on the green synthesis of silver nanoparticles (AgNPs) using biological reducing agents, such as plant extracts and microorganisms. Silver nitrate ($AgNO_3$) was used as the silver ion source for the nanoparticle formation. The experiments were designed to investigate the effect of different light sources, including ultraviolet (UV) and visible light, on the size, shape, and yield of the nanoparticles. Control experiments without light exposure were conducted to establish baseline conditions.

Table 1

Expanded Influence of Light Wavelength on Silver Nanoparticle Size and Shape

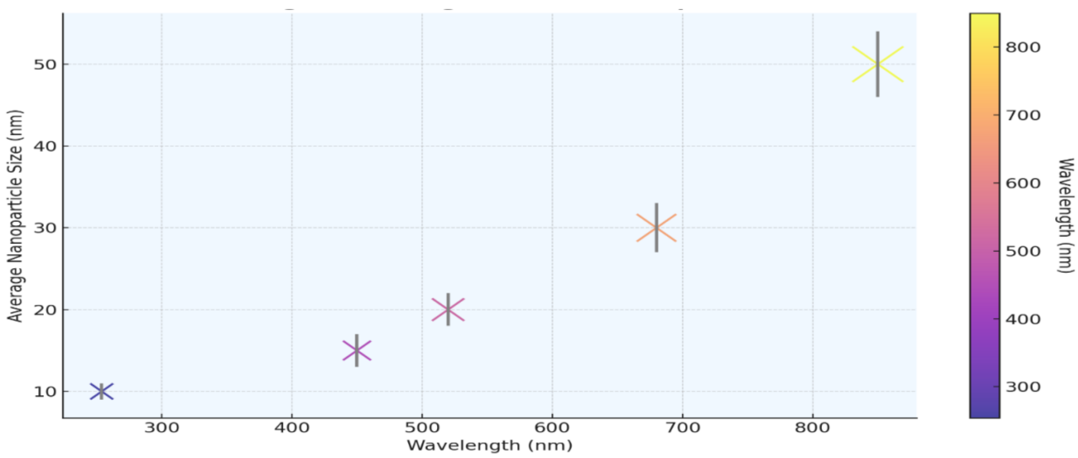
Wavelength (nm)	Average Nanoparticle Size (nm)	Shape	Size Distribution (nm)
UV (254 nm)	10	Spherical	8-12
Blue (450 nm)	15	Spherical	12-18
Green (520 nm)	20	Spherical	18-25
Red (680 nm)	30	Irregular	28-35
Infrared (850 nm)	50	Irregular	45-55

Source: Gherbawy, Y., & Elhariry, H. (2016). Biological synthesis of AgNPs and biofilm inhibition. *Frontiers in Microbiology*, 7, 1-11.

The table demonstrates the effect of different light wavelengths on the size, shape, and distribution of silver nanoparticles (AgNPs). Wavelengths from UV (254 nm) to IR (850 nm) were tested. As wavelength increases, average nanoparticle size grows: UV light yields ~10 nm particles, while IR light produces ~50 nm particles. Shapes also vary, with UV, blue, and green light generating spherical nanoparticles, while red and IR light produce irregular shapes. Size distribution broadens with longer wavelengths; UV light creates a narrow range (8-12 nm), whereas IR yields a wider range (45-55 nm).

Chart 1

Effect of Light Wavelength on Silver Nanoparticle Size



Source: Banerjee, P., Satapathy, M., et al. (2014). Leaf extract synthesis of AgNPs: Antimicrobial properties. *Bioresources and Bioprocessing*, 1(3), 1-10.

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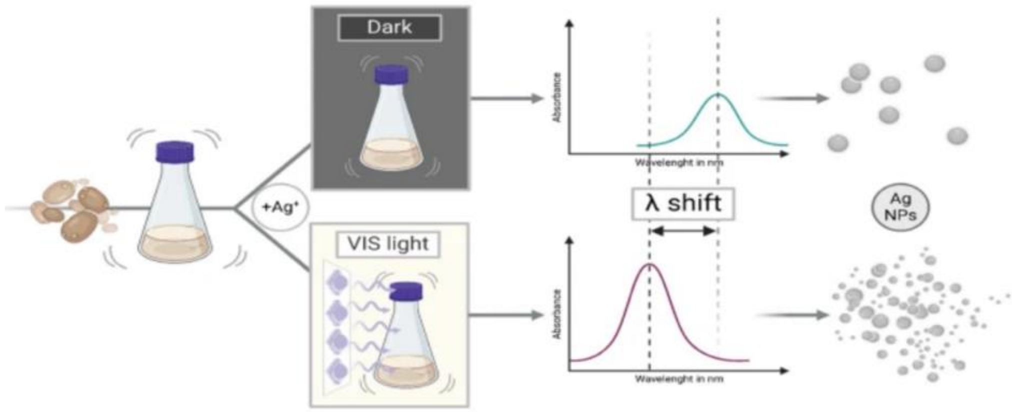
The graph illustrates the relationship between light wavelength and the size of silver nanoparticles synthesized biologically. The x-axis represents light wavelengths from 254 nm (UV) to 850 nm (IR), while the y-axis shows the average nanoparticle size in nanometers. A clear trend is observed: as the wavelength increases from UV to IR, nanoparticle size also grows. For instance, UV light (254 nm) produces the smallest particles (around 10 nm), while IR light (850 nm) results in larger particles (about 50 nm). This indicates that shorter wavelengths favor smaller nanoparticles, while longer wavelengths encourage larger particles (Gherbawy & Elhariry, 2016, p. 11).

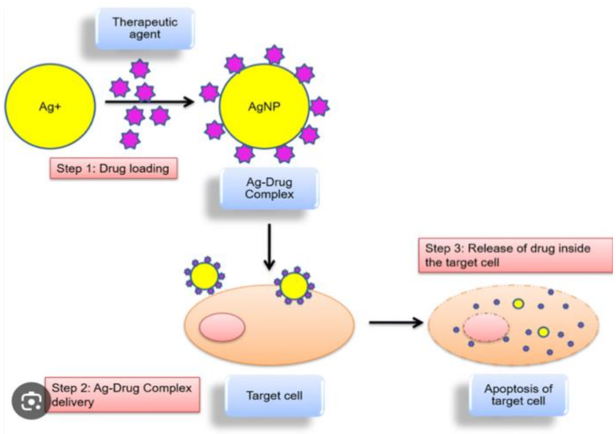
Figure 1
Comparison of Silver Nanoparticle Synthesis: Dark vs. Visible Light Exposure



Source: Ashraf, J. M., Ansari, M. A., & Khan, H. M. (2020). Green synthesis of AgNPs from Vitex trifolia. *Materials Science and Engineering: C*, 113, 110966.

The image shows the effect of light on silver nanoparticle (AgNP) synthesis in biological systems, comparing two pathways: synthesis in the dark and under visible light (VIS). In the dark, silver ions (Ag^+) react slowly with biological reducing agents, producing larger, fewer nanoparticles, shown by a higher absorbance peak at a longer wavelength. Under visible light, nanoparticle formation is faster, yielding smaller particles with an absorbance peak at a shorter wavelength, reflecting optical properties in the visible spectrum (Kim et al., 2007, p. 95).

Figure 2
Light-Enhanced Silver Nanoparticle-Mediated Drug Delivery System



Source: Amina, S. J., & Guo, B. (2020). A review of AgNPs synthesis and nanomedicine. *Journal of Pharmacy and Pharmacology*, 72(9), 1147-1160.

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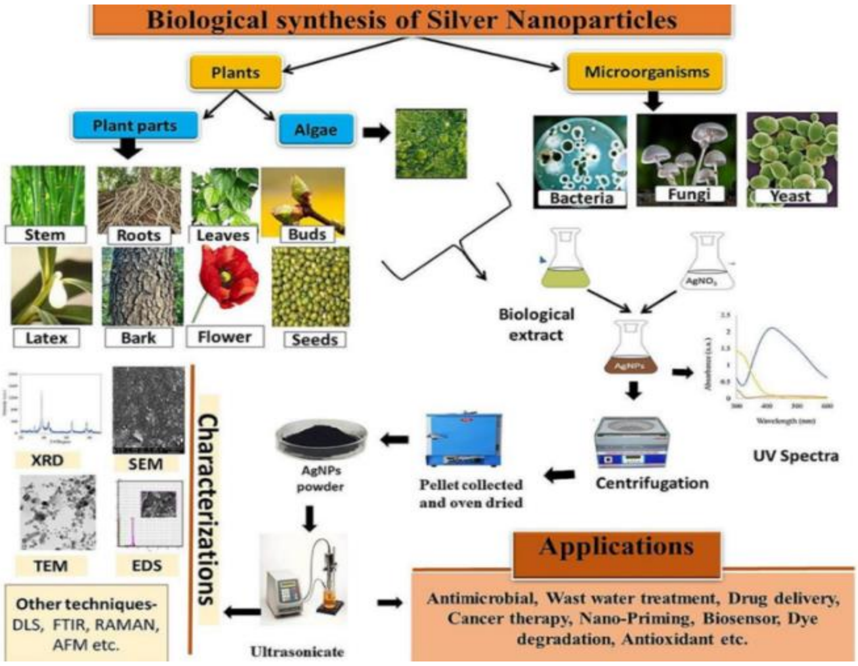
The image depicts a process flow for the synthesis and application of silver nanoparticles (AgNPs) as drug delivery agents, which is relevant to understanding the effect of light on silver nanoparticle synthesis in biological systems. Step 1: Drug Loading – Silver ions (Ag+) are reduced to form silver nanoparticles (AgNPs), often through a synthesis process that can be influenced by light. In this context, light can serve as a catalyst, enhancing the efficiency and control over the formation of AgNPs. The therapeutic agents are then loaded onto the AgNPs, creating an Ag-Drug Complex. Step 2: Ag-Drug Complex Delivery – The Ag-Drug Complex is delivered to the target cell. Light-mediated synthesis may enhance the biocompatibility and stability of AgNPs, which is critical for ensuring safe and effective delivery within biological systems. Step 3: Drug Release and Apoptosis – Upon reaching the target cell, the drug is released, initiating cellular responses that lead to apoptosis (cell death) in the target cell.

Figure 3

Biological Synthesis of Silver Nanoparticles with Light Influence



Source: Ahmed, S., Saifullah, M., Ahmad, M., et al. (2016). Green synthesis of AgNPs using Azadirachta indica extract. *Journal of Radiation Research and Applied Sciences*, 9(1), 1-7.

Biological Sources: Silver nanoparticles (AgNPs) can be synthesized from biological extracts of plants (stems, roots, leaves, etc.) and microorganisms (bacteria, fungi, yeast). Light enhances synthesis efficiency and nanoparticle properties by promoting silver ion reduction.Synthesis Process: Mixing biological extracts with silver nitrate ($AgNO_3$) forms AgNPs. Light exposure serves as a catalyst, impacting particle size, shape, and yield. Characterization Techniques: Techniques like XRD, SEM, TEM, and UV-Vis spectroscopy assess nanoparticle properties, with light aiding control over size and morphology. Applications: AgNPs are applied in antimicrobial activity, wastewater treatment, drug delivery, cancer therapy, and antioxidant activity.

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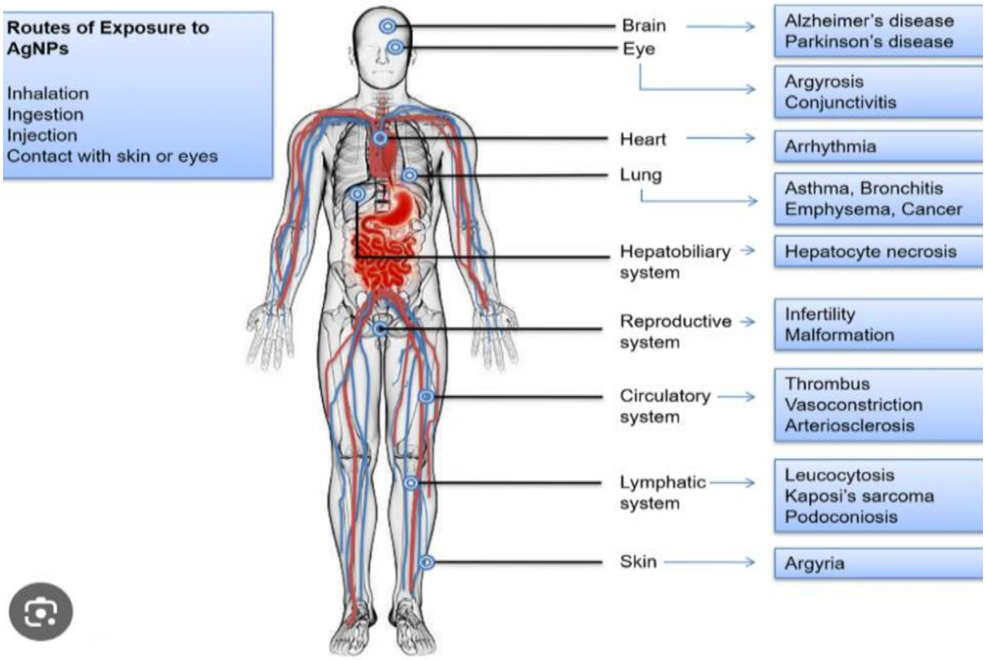
Figure 4
Silver Nanoparticle Exposure and Health Effects



Source: Abdollahi, Z., Zare, S., & Dehghanian, F. (2021). Green synthesis of silver nanoparticles using plant extracts. *Journal of Nanostructure in Chemistry*, 11(2), 209-220.

The image shows routes of silver nanoparticle (AgNP) entry into the human body – via inhalation, ingestion, injection, and skin or eye contact – highlighting potential adverse effects on organs, like the brain, lungs, and heart, possibly leading to conditions such as Alzheimer's and argyria. This emphasizes the need for controlled synthesis methods. Light-assisted synthesis offers a way to enhance AgNP safety and efficacy by controlling size, shape, and surface properties, reducing toxicity risks, and improving biocompatibility. This approach makes AgNPs safer for biomedical uses, including drug delivery, cancer treatment, and antimicrobial applications.

Conclusion

This study has provided significant insights into the role of light in the biological synthesis of silver nanoparticles (AgNPs), highlighting how UV and visible light can enhance and control nanoparticle formation. The results demonstrate that light exposure can accelerate the reduction of silver ions by biological reducing agents, such as plant extracts and microorganisms, leading to the formation of nanoparticles with specific properties tailored for various applications. Key to this study were advanced characterization techniques, which enabled a detailed analysis of the synthesized nanoparticles. The scanning electron microscope (SEM) provided high-resolution images, allowing for precise observation of nanoparticle size, shape, and surface morphology. Using UV-Vis spectroscopy, the absorption peaks of the synthesized nanoparticles were analyzed to assess their optical properties and confirm the formation of AgNPs. The presence of distinct surface plasmon resonance (SPR) peaks, particularly in the range of 400–450 nm, indicated successful nanoparticle synthesis and provided insights into the size distribution of the nanoparticles.

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Study of the Antibacterial Activity of Levofloxacin Biocomplexes Based on Natural and Synthetic Polymers on Medical Meshes

Abstract

In the presented article, a model system was created and tested on cultures to determine the antibacterial activity of composites without metal nanoparticles, as well as those containing silver (Ag^o) and magnetite (Fe_3O_4) nanoparticles. During surgical operations for abdominal hernias, special antisterile synthetic meshes made of polyvinylidene fluoride were impregnated with polymer matrices, their homopolymer mixtures, and solutions with levofloxacin. The polymer- and polymer/drug-impregnated meshes were placed in bacterial media in Petri dishes, and their antibacterial activity was compared based on the diameter of the resulting lysis zones. For control purposes, levofloxacin alone was also impregnated into synthetic meshes with a size of 1 cm^2 and a mass of 30-40 mg, and experiments were conducted. Each synthetic mesh was impregnated with polymer samples comprising about 15-20 % of the mass, a metal oxide-metal nanoparticle coated with a polymer chain, and approximately 5 micrograms of levofloxacin. It was found that the homogeneous systems containing metal nanoparticles both levofloxacin free and the levofloxacin-loaded samples had a stronger microbial effect. This led to an increase in the area of the lysis zone. This effect is naturally related to the antibacterial properties of the metal nanoparticles themselves, which make the composite more effective in killing microbes. Additionally, compared to samples without nanoparticles, the lysis zone remains stable for a longer period.

Keywords: *levofloxacin, lysis zone, magnetite, polymer, composite, nanoparticle*

Introduction

The convergence of nanotechnology and medicine has led to the active development of a new field of research – nanobiotechnology – which creates interesting opportunities for the discovery of new materials.

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It is known that the synthesis of Ag and Fe_3O_4 nanoparticles in biological media without using chemical reagents is widely applied. The simplicity, non-toxicity, and environmental compatibility of this method are noteworthy. The synthesis of Ag^o nanoparticles in the presence of biomolecules such as starch, dextran, gum arabic, chitosan, enzymes, amino acids, and fungi allows for stable long-term maintenance, a primary principle for biocompatibility. Ag^o nanoparticles have also been synthesized using bacterial proteins and plant extracts as reducing agents, with positive results in drug delivery applications in medicine (Park et al., 2012; Xiliang et al., 2014). The bactericidal and antimicrobial activity of Ag^o nanoparticles depends on the chemical and biological coating surrounding their surface. For instance, the positive charge on the surface of Ag^o nanoparticles enables them to remain in the bloodstream for a long time, a crucial requirement for drugs and reagents used against cancer (Hiramatsu et al., 2004).

Research

Recently, the bactericidal property of Ag^o nanoparticles has been linked to their slow oxidation upon contact with the environment, resulting in an excited state. For example, the impact of 3-25 nm Ag^o nanoparticles on the survival times of Gram-negative microorganisms like E. coli, V. cholerae, and P. aeruginosa has been studied (More et al., 2023). The physical and chemical properties of Ag^o nanoparticles make them suitable for use as carriers and protective materials in medicine, either alone or in compositions with various natural polymers (Humbatova et al., 2017). The field of application of Ag^o nanoparticles depends on their synthesis method and the nature of the compound used as a stabilizer (Helmlinger et al., 2015; Huang et al., 2008; Schlinkert et al, 2015; Hengbo et al., 2004). When natural polymers are used both as reducing and stabilizing agents, the physical stability of the Ag^o nanoparticles obtained is high, and the toxicity of the final product is lower, facilitating its application in green synthesis in medicine. The physicochemical properties of the obtained nanoparticles affect their biological indicators, so factors like size, distribution, surface area and energy, aggregation tendency, solubility, toxicity, and biocompatibility must be evaluated after the synthesis of Ag^o nanoparticles (Ping-Chang et al., 2014; Richard et al., 2008).

Ag^+ ions and Ag^o-based compounds are highly effective against microorganisms, demonstrating strong biocidal activity against 12 types of bacteria, including E.coli (Shankar & Rhim, 2015; Xi-Feng Zhang et al., 2016). Modern dressing materials can gradually release silver, helping to prevent toxicity and ensure a therapeutic dose of silver for wounds (Sangiliyandi et al., 2016; Cabrini et al., 2011). Research results show that these dressings can destroy common wound pathogens, including Staphylococcus aureus and Pseudomonas aeruginosa (Thakkar et al., 2010). The antibacterial activity of chitosan tripolyphosphate nanoparticles loaded with various metal ions has been investigated by Du and colleagues, showing increased antibacterial activity due to the loaded metal ions (Wen-Li et al., 2009).

In this regard, Fe_3O_4-based composites among metal oxide nanoparticles also form the foundation of highly effective antibacterial preparations (Prabhu et al., 2015). Although these composites have wide applications in optics, mechanics, biotechnology, engineering, microbiology, electronics, and other fields, research on green synthesis and their antimicrobial activity has rapidly increased in the past decade (Khwaja et al., 2016; Pelgrift & Friedman, 2013).

Fe_3O_4 nanoparticles possess unique properties, including small size, high conductivity, surface modification, and others. These nanoparticles are significant in delivering antibacterial drugs to infected sites, increasing effective drug concentrations, thereby enhancing antibacterial effects, reducing drug doses, and overcoming bacterial resistance (Bharathi et al., 2019). Studies have shown that iron oxide nanoparticles coated with chitosan have antioxidant activity and exhibit potential antibacterial activity against both Gram-positive and Gram-negative pathogens (Vallabani et al., 2020; Bhuiyan et al., 2020).

Experimental Section

In this research, poly-N-vinylpyrrolidone (PVPr) with an average molecular weight of 360,000 was used, obtained from Fluka. Gum arabic (GA), with a chemical purity sufficient for biological research (98 %), was used in synthesis processes without further purification (CAS number 9000-01-5, obtained from Sigma Aldrich).

Arabinogalactan (AG), with sufficient chemical purity for biological research, containig less than 15 % moisture, was used in synthesis processes without further purification (CAS 9036-66-2).

The preparation of magnetite (Fe_3O_4) nanoparticles was performed according to the methodology in reference (Mahdavi et al., 2013), using $FeCl_2$ and $FeCl_3$ salts as the iron oxide source.

Levofloxacin (Lfx) with the chemical formula $C_{18}H_{20}FN_3O_4$ and ATC code J01MA12, has 99 % bioavailability, with 83 % excreted unchanged by the kidneys (CAS number 100986-85-4). It is a white-yellowish solid crystal with a molar mass of $M(C_{18}H_{20}FN_3O_4)$ = 361.368 g/mol, and a density of 1.5 g/cm³. Commercially known as Levaquin, it is used in drug form as a hemihydrate $C_{18}H_{20}FN_3O_4 \times ½ H_2O$ and was obtained as a hemihydrate from Sigma Aldrich for use as a reagent.

Chitosan (CS) is a white, yellowish solid called deacetylated chitin or poly-D-glucosamine, CAS number 9012-76-4, average molecular weight 230 kDA, insoluble in water, well soluble in 1 % acetic acid, polyaminosaccharide with a linear structure with 85 % degree of deacetylation.

Meshes containing polyvinylidene fluoride, used for abdominal hernia treatment, were impregnated with Lfx alongside synthesized hydrogels to test their antibacterial activity in vitro. The method for impregnating polymer gel-antibiotic onto the mesh and evaluating its antimicrobial activity was improved according to reference (Kuleshova, 2015).

The impregnation of the polymer gel-antibiotic into the meshes was performed according to the methodology proposed by us, and the assessment of its antimicrobial activity was performed using the traditional method. So, meshes of 1 cm^2 size and 0.02 g mass were cut in sterile conditions. First, suspensions of synthesized gels with a concentration of 50 mg in 15 ml of distilled water are prepared. On the other hand, 10 ml of solution containing 5 μg of Lfx is prepared. Meshes are soaked with the appropriate hydrogel sample and released from the solvent at 35-40ºC. 20-25 % of the mass of nets has gel. At the end, 0.2 ml of Lfx was absorbed into the mesh-gel composite over the entire surface and dried again at low temperature. Then, the mesh-gel-drug composite is stored under sterile conditions and directed to the next antibacterial tests.

Results and Discussion

The antibacterial properties of homopolymers and graft copolymers used in this study were examined by the disk diffusion method. To evaluate these properties, Staphylococcus aureus (Gram-positive bacteria) and Escherichia coli (Gram-negative bacteria), Pseudomonas aeruginosa, and Candida were used as test cultures, which are the main causative agents of purulent-inflammatory processes. In the disc diffusion method, a suspension with 0.2 billion microbial cells per 1 ml is prepared from the daily culture of the microorganism, i.e., a small amount is taken from the daily microbial culture on the skew agar surface with a bacteriological loop on a sterile physiological solution, and a suspension with 1 billion microbial cells per 1 ml is adjusted to the standard and brought to the limit. This was then poured into Petri dishes containing nutrient agar (Meat-Peptone Agar, MPA) and spread evenly. The dishes are gently moved so that the suspension is spread equally in all directions. After that, the remaining suspension is sucked through a pipette and placed in the disinfectant solution. The dishes are kept at 37°C for 10 min to allow the solution to dry slightly. After that, the dishes are removed from the thermostat, divided into 2 or 4 parts with a pencil, 1 cm^2 meshes impregnated with polymer gel-levofloxacin are placed on the surface (sectors) of the nutrient medium where the microbe is planted, with a distance from each other, and gently pressed with tweezers so that the squares are well let it get wet. Then the MPAs are placed in a thermostat with a temperature of 37°C. As the meshes absorbed moisture, the impregnated substances diffused into the agar, killing the microbes. After 24-48 hours, the plates were removed, and results were recorded. The results were compared with those of meshes impregnated without levofloxacin. Antimicrobial indicators were determined based on the area of the lysis zone. Larger lysis zones indicate higher antimicrobial properties.

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Homopolymers and graft copolymers samples are CS, AG, PVPr, and their mixtures. Visual images of the lysis zones around the meshes observed over a one-week period are shown in Figures 1 and 2.

Figure 1

Effect of natural and synthetic homopolymers, graft copolymers, and their mixtures with Levofloxacin, absorbed onto synthetic meshes, on Staphylococcus, Pseudomonas aeruginosa, and Escherichia coli microbes

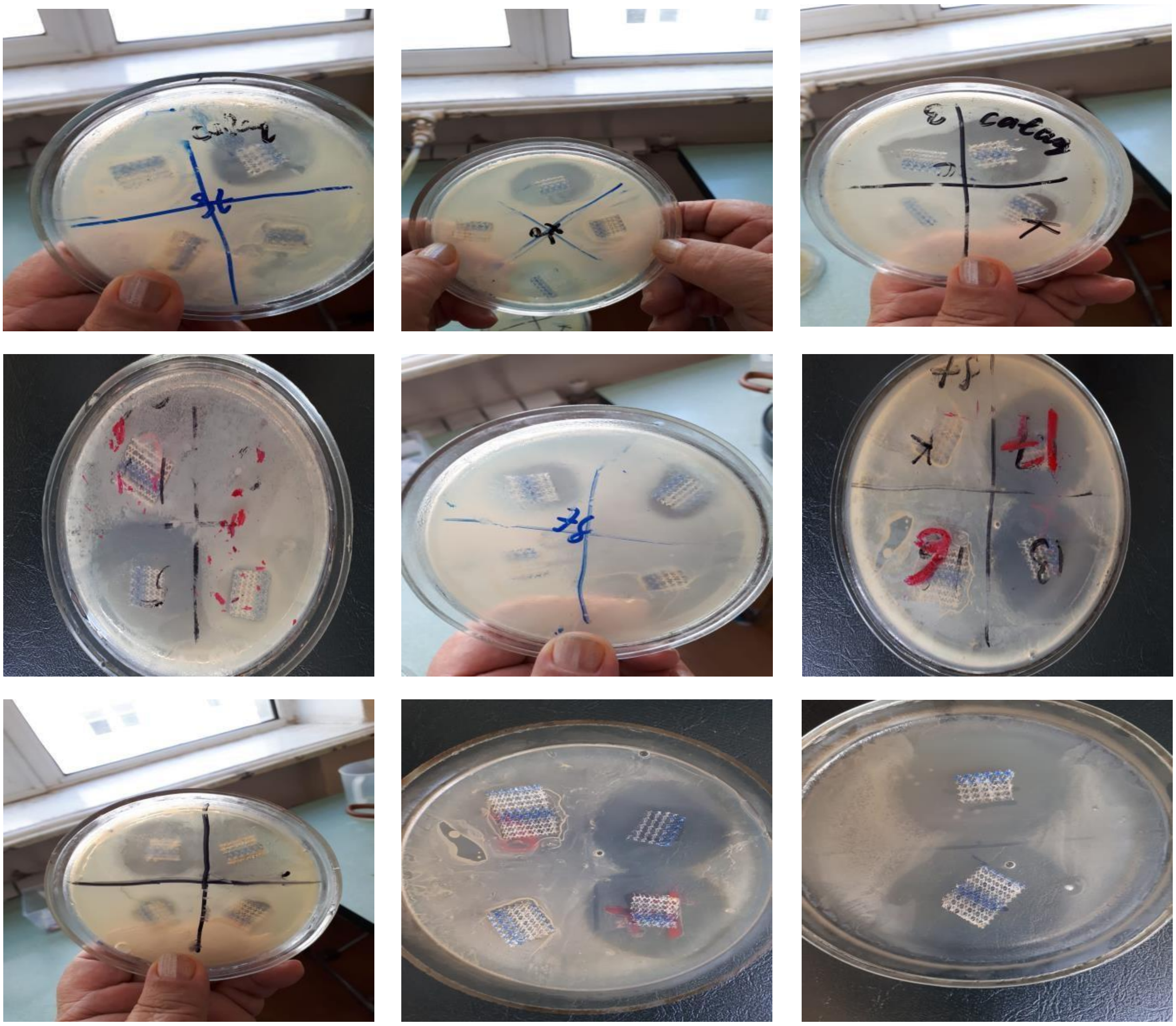

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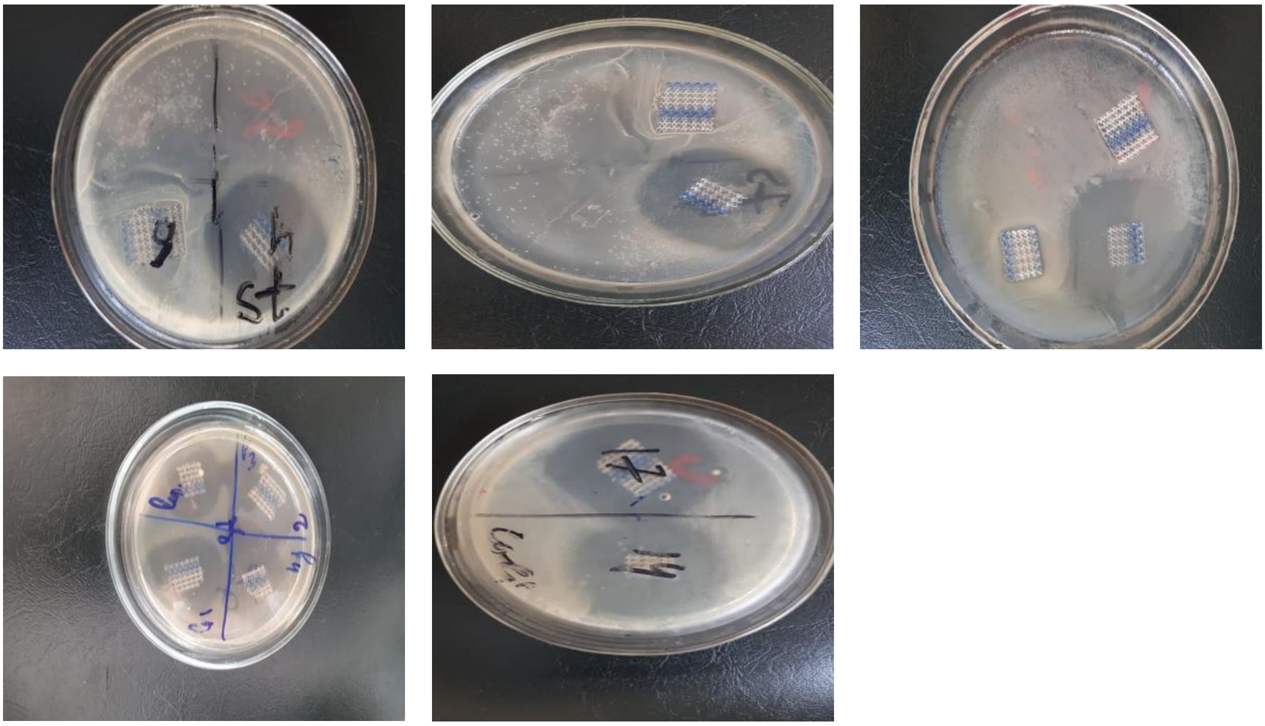
Figure 2

The effect of biocomplexes of colloidal solutions containing Ag^o and Fe_3O_4 nanoparticles coated with natural and synthetic polymers, infused with levofloxacin, on Staphylococcus, Pseudomonas aeruginosa, and Escherichia coli bacteria



Various polymer and graft copolymer blends impregnated into mesh were initially cut into square shapes, and their antibacterial properties were studied using the disk-diffusion method. To assess these properties, standard test cultures were selected, representing common causative agents of purulent-inflammatory processes: Staphylococcus aureus (as a Gram-positive bacterium), Escherichia coli (a Gram-negative intestinal bacterium), and Pseudomonas aeruginosa (a Gram-negative, pigment-producing bacterium). Additionally, homopolymer samples combined with silver nanoparticles were impregnated into mesh and tested for antibacterial activity. The antibacterial efficacy observed over a 3-week period was evaluated by measuring the lysis zone area (Table 1).

Table 1

Determination of antibacterial properties of natural and synthetic-based polymers, their graft copolymers, Ag^o and Fe_3O_4 nanoparticle complexes, and Lfx -immobilized samples

Substances		**Test cultures**		
		Staphylococcus aureus(mm)	Esherichia coli (mm)	Pseudomonas aeruginosa, (mm)
1	AG	20	18	20
2	AG-Lfx	24	20	24
	AG-Ag^o	21	19	21
	AG-Ag^o-Lfx	28	27	25
	AG-Fe_3O_4- Lfx	29	28	23
3	CS	+ (5-7)	+ (4-6)	+ (2-3)

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	CS-Ag^o	11	9	8-9
4	CS-Lfx	24	28	28
5	CS-Ag^o-Lfx	37	34	39
6	CS-Fe_3O_4-Lfx	35	38	40
7	PVPr	+ (7-9)	+ (5-6)	+ (4-6)
	PVPr-Ag^o	24	39	40
8	PVPr-Lfx	35	25	35
9	PVPr-Ag^o-Lfx	38	41	39
10	PVPr-Fe_3O_4- Lfx	36	43	46
	CS-PVPr-Lfx-Ag^o	41	48	52
Physiological solution (control)		+	+	+

Note: *The numbers indicate the diameter of microbe-free zones in millimeters, while "+" indicates full inhibition.*

As shown in the table, most of the newly developed formulations (meshes) demonstrated varying degrees of antimicrobial effects against bacteria. The most active bactericidal agents were the samples containing Ag^o and Fe_3O_4 nanoparticles. These samples exhibited strong lethal effects on both Gram-negative (Ps. aeruginosa and E. coli) and Gram-positive (St. aureus) bacteria, with the sterile zones around the mesh measuring between 35–40 mm.

In all trials, complete inhibition was observed in the control samples. Due to their biological activity, these samples demonstrated antibacterial activity even without nanoparticles, making them valuable components in materials with bactericidal properties. All experiments were repeated three times for accuracy.

Conclusion

Based on previous and recent test cultures with the above samples, it can be concluded that free arabinogalactan, poly-N-vinylpyrrolidone, CS, and its graft copolymers with poly-N-vinylpyrrolidone exhibit bactericidal properties even without antibiotic immobilization. This feature enhances the antibacterial effect of the final product, requiring a smaller amount of drug for immobilization. It was found that antibiotic-free AG formed a lysis zone of 20 mm against Staphylococcus, while Ag^o- and nanoparticle-containing polymer composites created a 30 mm lysis zone. Free PVPr formed lysis zones of 32–34 mm against all three microbes. Additionally, the graft copolymer of PVPr and CS exhibited bactericidal effects, forming lysis zones of 30–40 mm. After Lfx immobilization on these polymer samples, bactericidal activity increased, surpassing the activity of free Lfx. These findings suggest that drug formulations structured with these polymers, or their graft copolymers with nano metal oxides and metal nanoparticles, can maintain their biological activity for at least three weeks. This stability makes them suitable for long-term drug delivery application.

Research also determined that when homogeneous systems containing Ag^o and Fe_3O_4 nanoparticles were loaded with and without Lfx, antimicrobial efficacy increased. The lysis zone expanded, indicating enhanced bactericidal properties attributed to the inherent antibacterial effects of silver and magnetite nanoparticles. This improvement makes the composite more effective against microbes, with the lysis zone remaining stable for longer periods compared to samples without nanoparticles.

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