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Prospects For the Development of Agricultural Crops in the Nakhchivan Autonomous Republic

Abstract

This article provides information on the development prospects of crop production areas in the Nakhchivan Autonomous Republic. It is noted that since ancient times, cereals and legumes, forage crops, tobacco, grapes, melons and vegetables, as well as industrial crops have been cultivated in the region. These crops are widely grown in the plains along the Aras River. The most promising branches of crop production in the autonomous republic are vegetable and melon growing and cereal farming, as they are cultivated in all administrative districts. Research has shown that in 2023, the total cultivated area in the Nakhchivan Autonomous Republic amounted to 40,575.7 hectares. Of this, 22,166 hectares were allocated to cereals and legumes, 1,595.2 hectares to vegetables, and 15,270 hectares to forage crops. The remaining area was used for other types of crops. It has been determined that winter and spring wheat are mostly cultivated in the Babak district, and least in the Shahbuz district. Vegetable cultivation accounts for 3.9% of the total crop area in the region. In 2023, the total area of fruit orchards in the autonomous republic reached 5,573.8 hectares, and 31,506.9 tons of fruit were harvested from fruit-bearing orchards. According to research findings, the Sharur, Julfa, and Kangarli districts stand out in terms of the area allocated to forage crops.

Keywords: *agriculture, forage crops, cereals, cultivated area, industrial crops*

Introduction

The total land fund of the Nakhchivan Autonomous Republic is 550,275 hectares, which constitutes 6.3% of the total land fund of the country (Babayev, 1999). Of the total area of the autonomous republic, 32.2% or 177,382 hectares are lands suitable for agriculture. Agricultural crop cultivation in the Nakhchivan Autonomous Republic covers an area of 40,575.7 hectares. Taking into account perennial crops as well, the amount of cultivated land per capita in the autonomous republic is 0.09 hectares, which is below the national average. Cultivated lands make up 22.9% of the agriculturally usable land (Hasanov, 2001).

The distribution of cultivated areas across administrative districts is uneven. This is influenced not only by the total area of the districts, but also by the relief conditions. Therefore, the majority of the cultivated areas are located in the districts of Sharur (14.4 thousand hectares or 28%) and Babak (13.8 thousand hectares or 26.6%). In Julfa district, there are 7.4 thousand hectares (14.4%) of cultivated land, and in Kangarli district, 6.0 thousand hectares (11.7%) (www.statistika.nmr.az). In other districts, cultivated areas are less than 2–3 thousand hectares.

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More than 90% of the cultivated land is located in the Aras River lowlands and the low mountainous zone, which are characterized by a cold semi-desert and dry-steppe climate with arid summers. However, the cultivated lands constitute only a small portion (up to 10%) of the total area (Hajiyev, 2000).

According to the soil and climatic conditions of Nakhchivan, cereal crops, tobacco, sugar beet, forage, and melon crops are grown in the Aras River lowlands; cereals, fruits, and berries are cultivated in the foothill zones; and forage crops, fruits, and berries are grown on the slopes of the low and medium mountainous areas.

The development of agriculture in the autonomous republic is ensured by natural factors. The provision of high-yield seed varieties and fertilizers to landowners with state support, the regular improvement or reconstruction of irrigation systems, and the supply of modern technical equipment to farmers through the Agro-Leasing mechanism (Hajiyev, 2001), along with other such measures, have had a significant impact on increasing agricultural production.

Research

The most valuable part of the soil is considered to be its arable portion. The dry climate conditions of the Nakhchivan Autonomous Republic have historically contributed to the development of irrigated agriculture in the region. The development of crop production sectors such as grain farming, viticulture, cotton growing, tobacco cultivation, melon and vegetable growing, forage crops, and horticulture in the autonomous republic is presented in the following table (Table).

Table. Total sown areas of agricultural crops, in hectares (2024).

Years	Cereals and grain legumes (including maize)	Vegetables	Potatoes	Melon crops	Forage crops	Technical crops	Total sown area
1970	24200.0	900	100	500	9000	6400	41100.0
1980	11600.0	1200	100	600	12100	2800	28400.0
1985	10132.0	631	105	302	11719	769	23658.0
1990	15500.0	1400	400	600	15700	1115	34715.0
1995	20715.0	210	200	128	2427.6	1796	25476.6
2000	15275.0	4863	1451	2465	10666	2395	37104.0
2005	26764.0	5686	1990	2844	9767	1759	48810.0
2010	36738.2	6006	2740.5	2819	8943.1	1957.4	59204.2
2015	39435.0	6131	2967	2753	9859	269	61414.0
2020	35436.0	6170	3183	2772	13676	294	61531.0
2023	22166,0	1595,2	989,3	490,3	15270	64,9	40575,7

Note: The table is compiled based on statistical data from the Nakhchivan Autonomous Republic. https://nstat.gov.az/sectiongraphic?id=9

Grain farming is an ancient agricultural branch with extensive cultivation areas. The grain cultivation fields are widely spread across the sloping plains of Tananam, Kangarli, Yayji, Sust, Pirjuvar and Turkesh, as well as the depressions of Lizbirt, Arazin, Badamli, Shahbuz, Iydali and the leveled surface of Buzgov. In the Autonomous Republic, the areas of winter and spring wheat cultivation vary by district.

In 2023, the area planted with winter and spring wheat amounted to 22,166 hectares, which is 6,891 hectares more compared to the 2000s. In 2023, winter and spring wheat cultivation areas by district were as follows: 4,953 hectares in Sharur, 6,919 hectares in Babak, 865 hectares in Ordubad, 2,195.5 hectares in Julfa, 2,838 hectares in Kangarli, 760 hectares in Shahbuz, 1,944 hectares in Sadarak, and 701.5 hectares in the city of Nakhchivan. The districts where winter and spring wheat are most widely grown are Babek, while the least cultivated areas are found in Shahbuz district (Geography of the Republic of Azerbaijan, 2014).

Unlike wheat, the area planted with winter and spring barley decreased in 2023 compared to the 2010s. The largest areas of winter and spring barley cultivation are found in the Babek district, covering 3,013 hectares, while the smallest cultivated area is in the Şahbuz district, with 206 hectares.

The area planted with maize for grain in the Nakhchivan Autonomous Republic was 793.5 hectares in 2023. Compared to the 2010s, the maize cultivation area increased by 66.5 hectares. The Sharur district has the largest maize cultivation area for grain, with 708 hectares, while the smallest area is in the Ordubad district, with only 2 hectares (Geography of the Republic of Azerbaijan, 2014).

Wheat accounts for 73.8% of the grain cultivation area in the autonomous republic, mainly consisting of winter wheat. This is because, in a region like Nakhchivan with limited water resources, winter wheat sown in autumn is naturally irrigated by autumn, winter, and spring precipitation, requiring less irrigation during the growing season and providing a more stable yield. Both hard wheat, used in the production of pasta, groats, and noodles, and soft wheat varieties are cultivated in the area (Aliyev, Zeynalov, 1988).

Potato cultivation. The soil and climate conditions of the mountainous and foothill zones of the autonomous republic are more favorable for growing potatoes, one of the main food crops. However, high yields are currently also obtained in the lowland areas. In 1990, the potato production per capita in the autonomous republic was 8 kg, whereas in 2015 this figure reached 90 kg. In 2015, a total of 45,042.5 tons of potatoes were produced, with a yield of 151.8 centners per hectare. The districts with the highest potato production were Ordubad (8,434 tons), Babak (8,239.2 tons), and Julfa (4,159.5 tons). In 2023, the potato cultivation area in the autonomous republic (989.3 hectares) decreased threefold compared to 2015.

In the territory of Nakhchivan, technical crops such as sunflower, tobacco, and sugar beet were cultivated. In 2015, sunflower was grown on a total area of 269 hectares for grain production, yielding 690.2 tons of product. The main production areas were the Kangarli and Babak districts. In 2023, the sunflower cultivation area sharply declined to 13 hectares. Sugar beet has not been grown in the region since 2012 (Hajiyev, 2001).

Viticulture. In ancient Nakhchivan, viticulture has deep historical roots. Archaeological excavations have uncovered fruits, especially grape seeds, as well as large jars used for making and storing wine, indicating that people living in the autonomous republic's territory were engaged in gardening and viticulture even before the Common Era. It is noteworthy that wild grapes are still widely distributed throughout the region. Since ancient times, people here have been producing products from grapes such as raisins, molasses, and pekmez, which were traded with neighboring countries (Babayev, 1999).

More than 120 grape varieties are grown in the territory of the autonomous republic. Nearly 100 of these are cultivated exclusively in the autonomous republic. Grapevine cultivation is considered one of the important agricultural crops both for its nutritional value and economic efficiency. Calculations show that one hectare of vineyard yields 3.9 times more income than cereal crops, 2.7 times more than cotton, 1.5 times more than vegetable crops, 7.5 times more than melon crops, and 2.6 times more than fruit orchards. Although viticulture is a highly labor- and cost-intensive branch of agricultural production, it has the highest yield per hectare (Hajiyev, 2002).

In 2023, the area of vineyards in the Nakhchivan Autonomous Republic was 766.5 hectares, of which 742.4 hectares were productive, bearing fruit. By district, the largest vineyard area was in Babak,

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covering 374.1 hectares, with 363.6 hectares in productive age. The smallest vineyard area was in the Ordubad district, totaling 6.7 hectares, including 5.5 hectares in productive age.

Vegetable and melon crops. In the agriculture of the autonomous republic, growing vegetables and melons is the second most important sector after grain cultivation in ensuring the population's food supply. In 2023, vegetables were planted on 1,595.2 hectares, yielding a total of [amount] tons of produce. The productivity of vegetables was 146.9 centners per hectare. Vegetable cultivation accounted for 3.9% of the total planting area in the autonomous republic (Hasanov, Iskanderova, 2013).

Compared to sales prices and production costs, vegetable production is profitable, making this sector promising for development. Vegetables are grown in almost all administrative districts of the autonomous republic. However, the highest vegetable yields were harvested in the Sharur (17,519.2 tons), Babak (3,354.3 tons), and Sadarak (1,534 tons) districts. The main vegetables grown in the region include cucumber, tomato, eggplant, and pepper. Cabbage, also a vegetable crop, is mainly cultivated in the villages of Ustupu in the Ordubad district and Jahri in the Babak district. Vegetable farming is a labor-intensive sector, requiring a large amount of manual work in both cultivation and harvesting. Therefore, the cost of production is high, which influences the sales price of the produce (East gate, n.d.).

In 2023, melon crops were planted on 7,692.6 hectares in the region, with a productivity of 156.1 centners per hectare. Among melon crops, watermelon and melon are the most widely grown. By production volume, the Babak (6,423.2 tons) and Sharur (467 tons) districts stand out (Hasanov, & Iskanderova, 2015).

Fruit growing. The natural conditions of the autonomous republic have allowed the development of fruit growing, especially stone fruit cultivation, since ancient times. Fruit growing is one of the most profitable sectors of agriculture. The income generated from orchards on the same land area is several times higher compared to annual crops. Orchards are cultivated at elevations ranging from 700 meters to 2000 meters above sea level.

Among pome fruits, apple, pear, and quince lag behind stone fruits both in terms of cultivation area and production volume. The long storage life and ease of transportation of pome fruits create favorable conditions for expanding their cultivation areas (Geography of the Nakhchivan Autonomous Republic, 2017).

In 2023, the total area of orchards in the autonomous republic reached 5,573.8 hectares, and 31,506.9 tons of fruit were harvested from bearing orchards.

In the mountainous villages of the Ordubad, Shahbuz, and Babak districts, nut fruits such as walnut and almond are cultivated. Among them, the walnuts grown in the Ordubad district are distinguished by their high quality. Walnut and almond trees also grow wild in the mid-mountain areas (50th Anniversary of the Nakhchivan ASSR, 1975).

Tobacco Growing. Tobacco cultivation is a technical crop that is well suited to the climate of the Nakhchivan Autonomous Republic and is a profitable sector. The "Guleser" tobacco variety, traditionally grown in the region, is a local tobacco type that was used without industrial processing. Due to land reforms, like many other agricultural sectors, the area under tobacco cultivation has decreased. In 2000, 16 hectares of tobacco were planted in the Nakhchivan AR, mainly in the Sharur district. In 2006, 2007, and 2009, the tobacco planting areas declined to 2 hectares, 2 hectares, and 8 hectares respectively. Tobacco cultivation was practically halted from 2010 until 2017. Production resumed again starting in 2017. In 2023, the tobacco planting area in the autonomous republic was 51.9 hectares, of which 37.1 hectares belonged to the Kangarli district (Let's Discover Nakhchivan, 2017).

Fodder Crops. In the autonomous republic, fodder crops occupy 9,858 hectares, which is 16% of the total planting area. The main fodder crops grown are alfalfa and sainfoin. Among the perennial grasses, alfalfa and orchard grass have the largest planting areas. In terms of the area planted with fodder crops, the Sharur, Julfa, and Kangarli districts stand out (Nakhchivan Statistical Committee, n.d.).

Conclusion

During the research, the following results were obtained:

- The sown area of cereals decreased by 17,269 hectares compared to 2015. The main reason for this is the reduction of water resources due to climate warming.
- In the autonomous republic, which is under blockade conditions, sugar beet has not been cultivated since 2012 due to the lack of sugar beet exports and the cessation of operations of sugar production enterprises in the region.
- Since the territories of Ordubad and Shahbuz administrative districts are mountainous, the sown areas are limited.

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The Hormone Cortisol and its Biological Role in Metabolic Disorders

Abstract

Cortisol one of the steroid hormones, is synthesized by the adrenal gland under the control of the hypothalamus, under the stimulation of the ACTH hormone secreted by the anterior lobe of the pituitary gland. The paraventricular cells of the hypothalamus secrete the hormone CRH (corticitropin releasing hormone), which causes the secretion of ACTH by corticotroph cells from the anterior pituitary. ACTH is derived from the precursor POMC (proopiomelanocortin) consisting of 241 amino acids. In the pituitary, POMC is cleaved by prohormone convertase-1 into POMC ACTH and 2 polypeptides, the N-terminal peptide and beta-lipoprotein. After ACTH binds to the GPSR of the adrenal gland, intracellular signaling begins and hydrolyzes cholesterol in the cytosol. Cortisol levels are determined by a number of methods, ELISA, RIA, colorimetric and immunoassays.

Keywords: *cortizol, steroid hormones, glucocorticoids, liver, glukoneogenesis, carbohydrate metabolism*

Introduction

Hormones are present in the bloodstream at very low concentrations and exert their effects through a specific mechanism. This specific mechanism occurs via hormone-receptor binding. Although hormones released into the blood can reach all parts of the body, they exert their effects only on certain cells and tissues. Somatic cells are constantly exposed to many external signals. Most signal molecules (ligands) bind to receptors located on the cell membrane and initiate specific processes within the cell. The receptors that interact with these hormones are called protein hormone receptors. Some signal molecules (such as steroid and thyroid hormones), however, can pass through the cell membrane and bind to intracellular receptors, which may activate or suppress gene expression at the chromatin level (Chayakar, 2021). The pituitary gland weighed about 600 mg, it is an organ that carries out all endocrine processes together with the hypothalamus. The pituitary gland controls the secretion of hormones by the hormone ACTH, which it synthesizes. The hypothalamus is located just above the pituitary gland. The pituitary gland receives two different lobes, anterior and posterior, both anatomically and functionally. Hypothalamic nerve cells synthesize special secretory and inhibitory hormones. These hormones and are secreted into the portal blood-vascular system of the pituitary stem (Henley, Lightman & Carrell, 2016).

Research

ACTH (adrenocorticotropic hormone) is a peptide hormone composed of 39 amino acids, derived from proopiomelanocortin (POMC) and secreted by the anterior pituitary gland.

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ACTH, secreted from the anterior pituitary, stimulates the zona fasciculata of the adrenal cortex, leading to the secretion of cortisol. In healthy individuals, ACTH secretion is regulated by CRH (corticotropin-releasing hormone), which is secreted by the hypothalamus (Civan, Ozdamir, Gencer & Durmaz, 2018). CRH is a peptide hormone composed of 41 amino acids. The cells of the paraventricular nucleus (PVN) in the hypothalamus are responsible for CRH secretion (Figure 1). CRH release triggers the secretion of ACTH from the anterior pituitary, which in turn leads to the synthesis of cortisol from the adrenal glands. This interaction between the hypothalamus, pituitary gland, and adrenal gland is known as the hypothalamic-pituitary-adrenal (HPA) axis (Gundogdu, 2022). Cortisol, secreted from the adrenal gland, exerts a negative feedback effect on the pituitary and hypothalamus, thereby reducing the secretion of both ACTH and CRH. Arginine vasopressin (AVP), another hormone secreted from the posterior part of the pituitary gland, also stimulates ACTH secretion from the pituitary, similarly to CRH. Many stress-inducing conditions affect the HPA axis. When the body is exposed to stress, CRH secretion from the hypothalamus increases, which subsequently stimulates (Figure 1). ACTH secretion from the pituitary, leading to cortisol secretion from the adrenal gland (Lauren & Kevin, 2020).

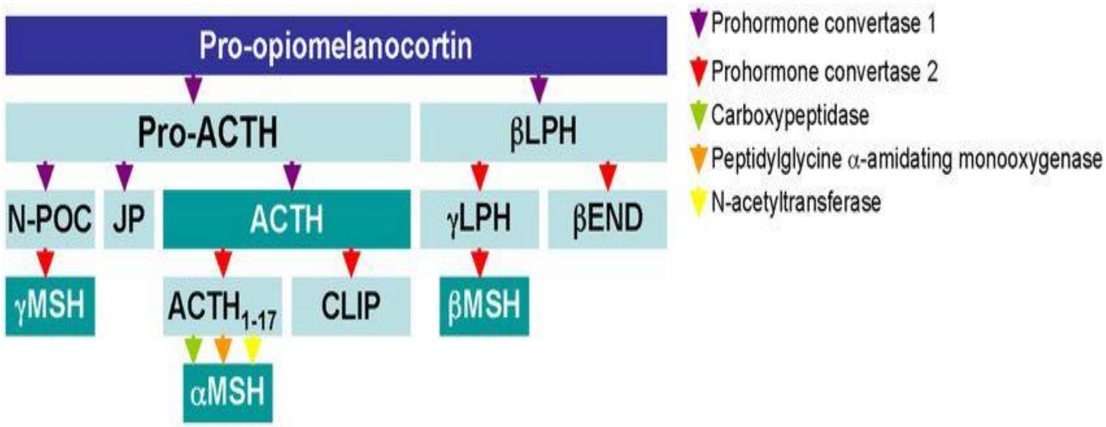

Figure 1. POMC-pro-opiomelanocortin

The first step in the cellular response to cortisol is the binding of cortisol to glucocorticoid receptors located in the cytoplasm. This binding leads to the movement of the steroid-receptor complex into the nucleus and the initiation of specific protein synthesis. Thus, a cellular response to glucocorticoids occurs. One of the target cells of glucocorticoids is peripheral mononuclear cells (MNCs), which specifically bind dexamethasone—a synthetic derivative of cortisol. Natural glucocorticoids include cortisol (hydrocortisone), cortisone, corticosterone, and 11-dehydrocorticosterone, a 21-carbon steroid. The daily secretion amount of cortisol ranges from 8 to 25 mg. In individuals with a normal sleep pattern, the secretion rate and plasma concentration of cortisol are at their highest (approximately 180 ng/ml) in the early morning hours just before waking, in accordance with the circadian rhythm (Prema, 2017, Tappy, 2008).

Cortisol exists in plasma either in free form or bound to proteins. The main plasma-binding protein is transcortin, also known as corticosteroid-binding globulin (CBG). The free fraction accounts for approximately 8% of total plasma cortisol and represents the biologically active form. Aldosterone, the most potent natural mineralocorticoid, does not have a specific transport protein; it circulates bound to albumin, with about 50% in free form. Other mineralocorticoid steroids such as corticosterone and 11-deoxycorticosterone bind to CBG. Both bound and free forms of these hormones are transported in extracellular fluid. The metabolism and clearance rate of these hormones depend on the presence or

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absence of carrier proteins. Generally, cortisol is broken down within one to two hours in target tissues, whereas aldosterone is metabolized in approximately 30 minutes. Glucocorticoids are modified and metabolized in the liver and are ultimately excreted as lipophilic steroid molecules. The conjugated metabolites of these steroids are water-soluble substances and are excreted by the kidneys. About 70% of them are eliminated in urine, 20% in feces, and 10% through sweat (skin). The protein-bound forms of these hormones are considered biologically inactive (Liu, Snidman, Leonard, Meyer & Tronick, 2016).

The major metabolite of cortisol is tetrahydrocortisol glucuronide, while for aldosterone it is tetrahydroaldosterone glucuronide (Paredes & Ribeiro, 2014). Cortisol secretion is regulated by a negative feedback mechanism. Cortisol, secreted from target organs, directly inhibits ACTH secretion. ACTH stimulates cortisol secretion from the adrenal cortex, and as plasma cortisol levels increase, ACTH secretion begins to decrease. Additionally, cortisol indirectly inhibits CRH secretion from the hypothalamus (Figure 2).

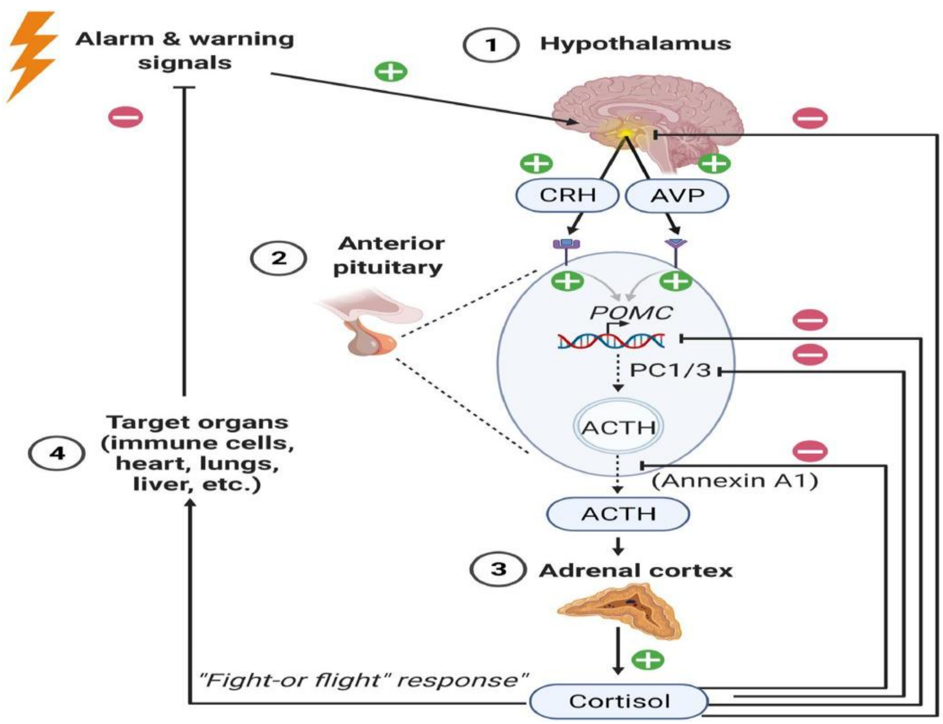

Figure 2. Regulation of cortisol synthesis

The radioimmunoassay method for measuring cortisol levels in plasma and urine is preferred for evaluating cortisol synthesis and secretion.The amount of free cortisol excreted in 24-hour urine is considered the most sensitive indicator. In a healthy person, less than 100 µg of free cortisol is excreted in urine per day. Cortisol binds to specific cytosolic receptors in target cells such as fibroblasts and hepatocytes. The hormone-receptor complex enters the nucleus and regulates the transcription of specific genes. Cortisol generally stimulates the breakdown of proteins into amino acids in skeletal muscle and promotes gluconeogenesis in the liver (Akalestou, Genser & Rutter, 2020).

Cortisol secretion is controlled by a negative feedback mechanism. Cortisol secreted from the target organ exerts a direct negative feedback effect on ACTH. ACTH increases cortisol secretion from the adrenal cortex, and when plasma cortisol levels rise, ACTH secretion begins to decline. On the other

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hand, cortisol also exerts an indirect negative feedback effect on CRH secretion from the hypothalamus (Figure3).

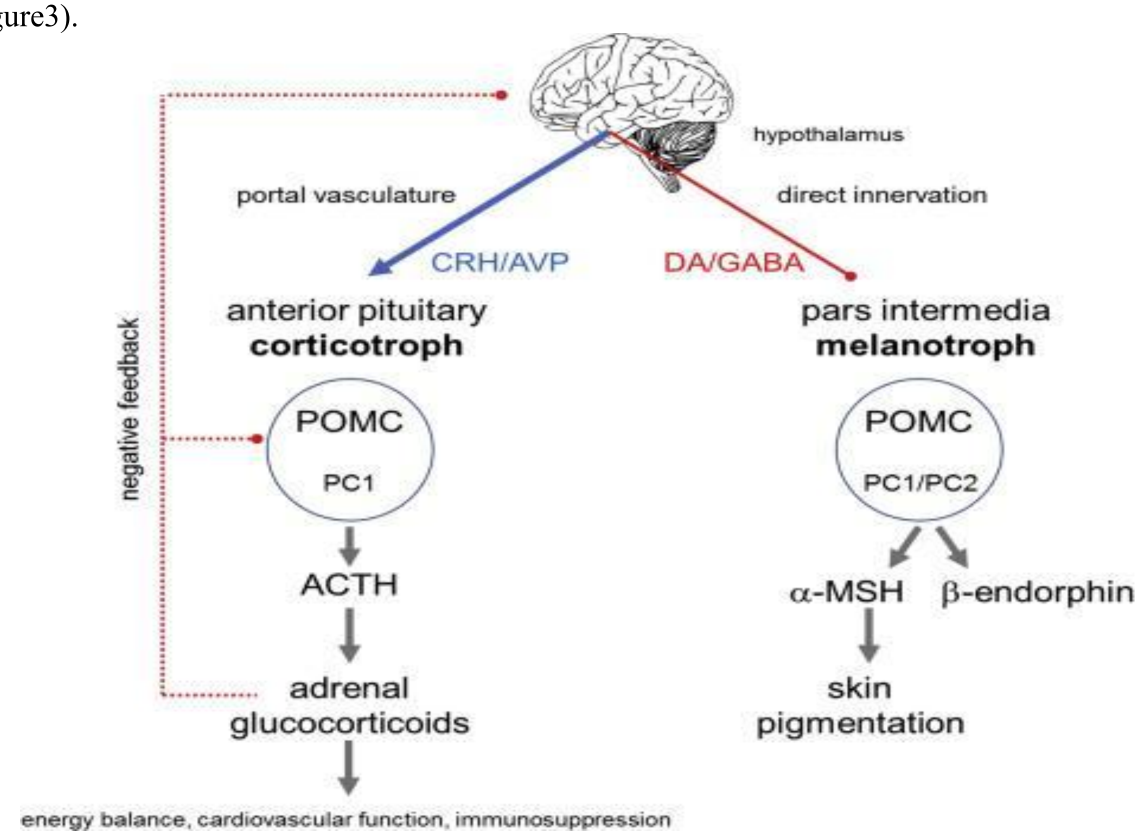

Figure 3. Synthesis of adrenal glucocorticoids by negative feedback mechanism

The excessive presence of cortisol increases blood glucose levels and enhances the process of gluconeogenesis in the liver.This increases the demand for ATP, accelerating mitochondrial activity. Electrons obtained from oxidative processes and ATP synthesis are transferred to the mitochondrial electron transport chain (ETC), but not all electrons are efficiently transferred. Due to electron and proton leakage, not all electrons can be passed to the final electron acceptor (O_2), and the energy released by transferred electrons cannot be fully used for ATP synthesis. Nevertheless, both reactive oxygen species (ROS) generated from electron leakage and uncoupling proteins (UCPs) involved in proton leakage play critical roles in cellular physiology and pathology. A high membrane potential leads to electron leakage in the electron transport chain, resulting in the production of reactive oxygen species—free radicals (Vignesh, Castro-Dominguez, James & Reis, 2024).

*Effect on carbohydrate metabolism:*The most well-known metabolic effect of cortisol and other glucocorticoids is their ability to stimulate gluconeogenesis in the liver. This is achieved by increasing all the enzymes needed to convert amino acids to glucose in liver cells, activating DNA transcription in the nuclei of liver cells, and increasing the synthesis of mRNAs for the enzymes required for gluconeogenesis. Cortisol also causes the mobilization of amino acids from extrahepatic tissues, especially muscle, meaning it facilitates the release of stored amino acids into circulation for energy production and metabolic processes. Additionally, cortisol limits glucose utilization by all body cells (Anagnostis, Athyros, Tziomalos, Karagiannis & Mikhailidis, 2009).

Effect on protein metabolism: One of the most significant effects of glucocorticoids on metabolic systems is the reduction of protein reserves in all body cells except the liver. This occurs through decreased protein synthesis and increased catabolism within cells. Both effects may be associated with reduced amino acid transport into extrahepatic tissues. The impact of glucocorticoids may also occur through decreased RNA synthesis in many extrahepatic tissues, particularly in muscle and lymphoid tissues (Knezevich, Nenich, Milanovich & Knezevich, 2023).

Conclusion

The cortisol synthesis pathway begins with cholesterol and proceeds through a series of steps involving specific enzymes. This hormone affects the metabolism of carbohydrates, proteins, and fats. During stressful situations, cortisol accelerates gluconeogenesis, thereby increasing blood glucose levels. At the same time, cortisol exhibits anti-inflammatory effects. There are several laboratory methods available for determining cortisol levels. Samples for cortisol measurement can be collected from saliva, sweat, blood plasma (serum), or interstitial fluid. Methods used to determine cortisol include ELISA, immunoassay, RIA (radioimmunoassay), colorimetric, bioluminescent, and other immunoassay techniques.

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Determination of Proline Content in Bread Wheat Varieties Under Iso-Cation Sodium Salinity Conditions

Abstract

The proline content was determined in 10-day-old seedlings of bread wheat varieties "Gobustan" and "Layagatli 80" grown under iso-cation sodium salinity conditions in both hydroponic and soil culture systems. The results showed that in both wheat varieties, the proline content in the roots and shoots of seedlings grown in hydroponic culture was higher compared to those grown in soil culture. Moreover, in both cultivation systems, the proline content in the root system of the seedlings was found to be higher than in the above-ground parts.

It was revealed that the effect of iso-cation sodium salts significantly increased the proline content in both shoots and roots of wheat seedlings grown in both hydroponic and soil cultures.

The increase in proline content due to the effect of salts was more pronounced in wheat seedlings grown in soil culture compared to those grown in hydroponic culture. At all salt concentrations, the proline content in "Layagatli 80" wheat seedlings was higher than in the "Gobustan" variety. It was revealed that proline content is one of the indicators of plant salt tolerance. The increase in proline levels under extreme salinity conditions may serve as a key parameter for selecting salt-tolerant genotypes.

Keywords: *proline, salt tolerance, hydroponic culture, soil culture, wheat seedlings*

Introduction

Soil salinization, as one of the most widespread abiotic factors, has a significant negative impact on the growth and development of agricultural crops (Sun et al., 2016), leading to oxidative stress. As a result, reactive oxygen species (ROS) are generated, photosynthetic efficiency declines, productivity decreases, and premature aging and death of plants occur (Singh et al., 2022; Mansour, Ali, 2021). Consequently, many countries around the world suffer from food shortages.

The relevance of the salinity tolerance problem lies in the fact that currently, more than 20% of the irrigated soils on Earth are affected by salinization, and this figure is predicted to rise to 50% by 2050 (Gadir et al., 2014; Ashraf Harris, 2014). Saline soils are widespread in the territory of Azerbaijan, and their extent continues to increase year by year (Mammadov, 2007).

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It should be noted that in Azerbaijan, chloride, sulfate, or sulfate-chloride types of salinization are the most widespread. There is evidence that the Na^+ and Cl^- ions have the most harmful effects on plants (Wang et al., 2007; Abdiyev, 2017). The accumulation of Na^+ cations in the soil severely degrades its physical properties. As a result, the soil structure deteriorates, its water and air regimes worsen (Mammadov et al., 2010), and ion homeostasis is disrupted in plants, leading to the accumulation of various toxic substances in the cells (Balnokin, 2005).

The negative effects of salts on plants are more pronounced during the early stages of ontogenesis, as plants are less tolerant to salinity at this phase. Therefore, studying the physiological and biochemical processes during the initial stages of seedling development is of great importance for understanding the mechanisms by which salts affect plant organisms. This is because the initial physicochemical processes occurring in plant cells significantly influence the subsequent changes in intracellular metabolism throughout the plant's development.

Research

It is known that a significant portion of the plant kingdom completes its life cycle under conditions of high salt concentration (Gasymov, 2012). Therefore, a comprehensive study of the issue of plant salt tolerance is of great theoretical and practical importance. It should be noted that various defense systems exist within plant organisms. One such defense component is proline, which possesses antioxidant properties. In addition to serving as a source of nitrogen, carbon dioxide, and reduced equivalents in plants, proline functions as an antioxidant, osmolyte, and energy substrate (Kuznetsov, Shevyakova, 1999; Kharitonova, Goncharova, 2010), and plays a role in protecting plants from superoxide stress (Shevyakova, Bakulina, 2008).

Taking the aforementioned points into account, the aim of the present study was to comparatively investigate the proline content in the shoots and roots of 10-day-old bread wheat cultivars grown under extreme salinity conditions in both hydroponic and soil cultures.

Materials and Methods

Taking the above into consideration, the aim of the present study was to comparatively investigate the proline content in the shoots and roots of 10-day-old bread wheat cultivars grown under extreme salinity conditions in both hydroponic and soil cultures.

As research subjects, 10-day-old seedlings of widely cultivated wheat varieties “Gobustan” and “Layagatli 80” (*Triticum aestivum* L.) were used. The seedlings were grown in Knop’s solution and in solutions containing 25–100 mM NaCl and Na_2SO_4 under normal aeration conditions (0.04 mg O_2/min) at a temperature of 20°C.

Besides, the plants were grown in saline dark gray-brown soils containing 0.2–1.0% (NaCl, Na_2SO_4) salts.

In the green plants cultivated under light and laboratory conditions, the level of illumination was measured with a luxmeter (420–480 lx) (Luxmeter Type 102; with a measurement error of 10%).

The amount of proline in the roots and shoots of the plants was determined using a modified spectrophotometric method proposed by Bates et al. (1973). Optical density was recorded at 520 nm. The proline concentration (0.01–0.02 mM) was calculated based on a calibration curve using the following formula:

$$y = 0.031x + 0.041$$

The experiments were conducted with 3–4 replications, and the obtained results were statistically processed (Kerdyashov, 2018). The experimental data showed a precision level of less than 5%, confirming the statistical reliability of the results.

Conclusion

Based on the obtained results, the amount of proline in the roots and shoots of wheat seedlings grown in hydroponic culture was higher compared to those grown in soil culture. It should be noted

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that, in general, physiological and biochemical processes in plants grown in hydroponic culture occur more rapidly than in those grown in soil culture (Abdiyev, 2017).

In both hydroponic and soil cultures, the amount of proline in the root system of wheat seedlings was higher than in the above-ground parts.

As shown in Figures 1 and 2, in the roots and shoots of 10-day-old "Gobustan" seedlings grown in hydroponic culture, the proline content increased with rising salt concentrations from 25 to 75 mM. Although it decreased with a subsequent increase in salt concentration (100 mM), it still remained higher than in the control.

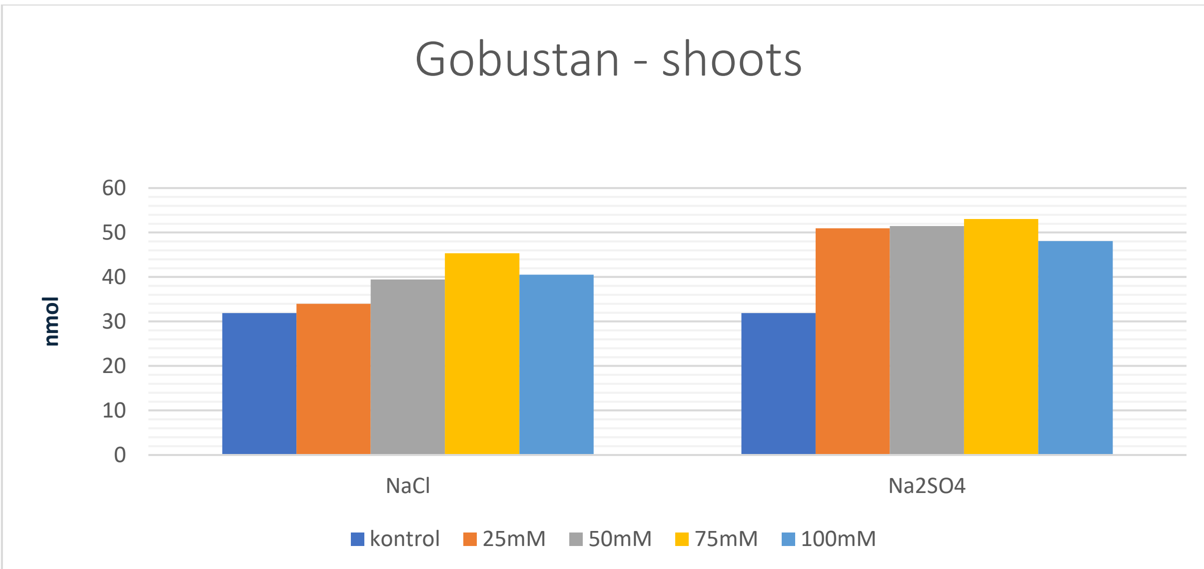

Figure 1. Effect of various NaCl and Na_2SO_4 concentrations on the amount of proline in the shoots of 10-day-old seedlings of the "Gobustan" variety grown in a hydroponic environment.

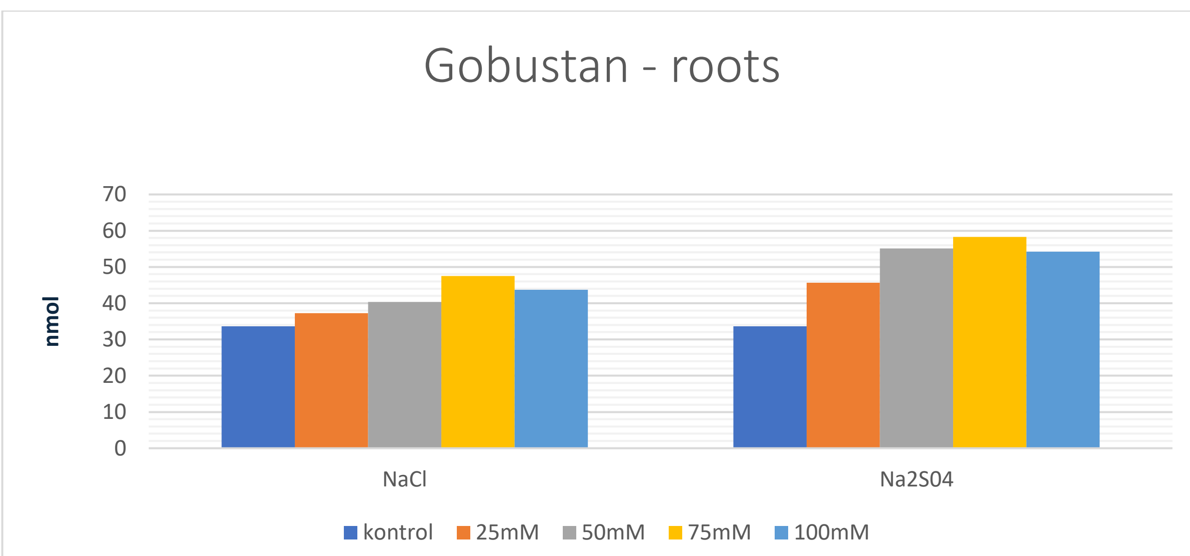

Figure 2. Effect of various NaCl and Na_2SO_4 concentrations on the amount of proline in the roots of 10-day-old seedlings of the "Gobustan" variety grown in a hydroponic environment.

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Under the influence of 75 mM NaCl, the proline content in the shoots and roots of wheat seedlings increased by 1.4 times. Exposure to 75 mM Na_2SO_4 led to a 1.7-fold increase in the shoots and a 1.73-fold increase in the roots. Similar results were observed in the “Layagatli” seedlings: 75 mM NaCl caused a 1.6-fold increase in proline content in the shoots and a 1.55-fold increase in the roots. Upon treatment with 75 mM Na_2SO_4, the proline content in both the shoots and roots of the “Layagatli” seedlings increased by 1.8 times.

A different pattern was observed in the shoots and roots of 10-day-old “Gobustan” seedlings grown in soil culture. When the salt concentration in the soil ranged from 0.2% to 0.6%, the proline content increased; however, at higher concentrations (0.8–1.0%), it decreased, though still remained above the control level. Thus, under the influence of 0.6% NaCl, the proline content in the shoots increased by 2.13 times and in the roots by 1.57 times. In response to 0.6% Na_2SO_4, the proline content in the shoots rose by 1.84 times and in the roots by 1.75 times.

A somewhat different result was observed in the 10-day-old “Layagatli” seedlings grown in soil culture. In both the roots and shoots of these seedlings, the proline content increased as the salt concentration rose from 0.2% to 0.8%. With a further increase to 1.0%, the proline level declined but remained higher than that of the control (Figures 3 and 4).

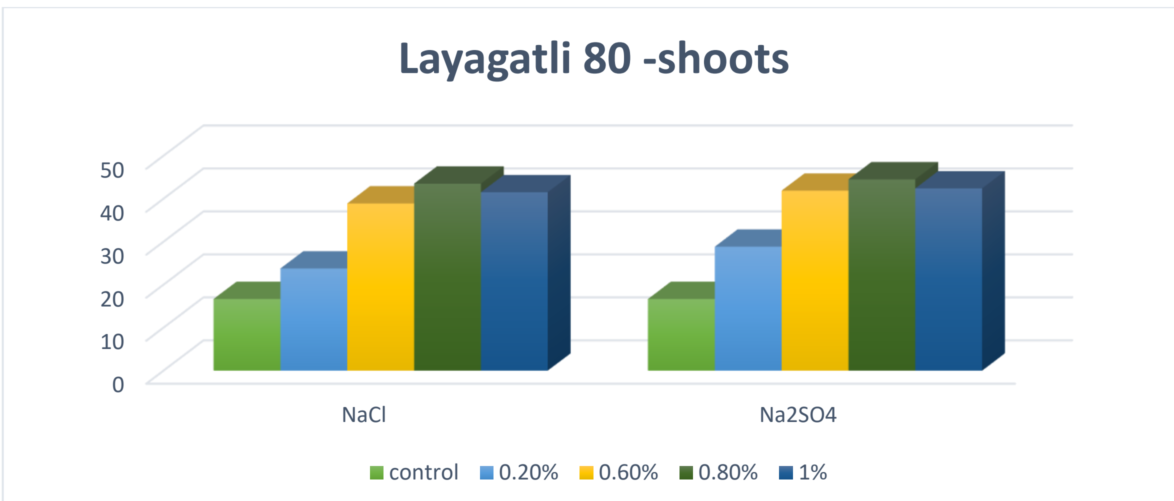

Figure 3. Effect of various NaCl and Na_2SO_4 concentrations on the amount of proline in the shoots of 10-day-old seedlings of the "Layagatli 80" variety grown in a soil culture.

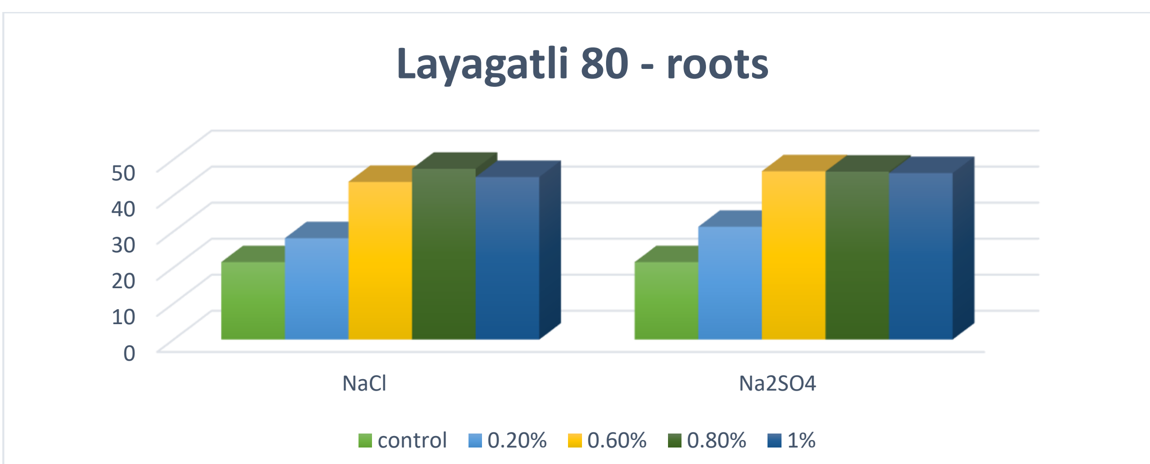

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Figure 4. Effect of various NaCl and Na_2SO_4 concentrations on the amount of proline in the roots of 10-day-old seedlings of the "Layagatli 80" variety grown in a soil culture.

It should be noted that under the influence of 0.6% NaCl, the proline content in the shoots increased by 2.3 times and in the roots by 2.0 times. In response to 0.6% Na_2SO_4, the proline content rose by 2.5 times in the shoots and 2.1 times in the roots.

Although a decrease in proline content was observed in the roots and shoots of "Layagatli 80" wheat seedlings grown in soil culture with increasing salt concentration (1.0%), the levels still remained significantly above the control. Specifically, under the influence of 1.0% NaCl, the proline content in the shoots increased approximately 2.4 times, and under 1.0% Na_2SO_4, by 2.5 times. In the roots, proline levels increased 2.0 times with NaCl and 2.1 times with Na_2SO_4.

The research revealed that in wheat seedlings grown in soil culture, the proline content increased more significantly under the influence of salts compared to plants grown in hydroponic culture.

It should be noted that at all salt concentrations, the proline content in the seedlings of the "Layagatli 80" variety was found to be higher compared to the "Gobustan" variety. This suggests that proline accumulation may serve as one of the indicators of salt tolerance in plants.

Our findings are consistent with data reported in the literature. The increase in proline content under conditions of extreme salinity may be considered one of the key parameters for identifying salt-tolerant genotypes (Chondarzi, Pakniyat, 2021).

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Mathematical Modelling and Optimization of Alkyl-Phenol Based Additive – Aki-56 for Motor Oils: a Full Factorial Design Approach

Abstract

Motor oil performance enhancement is excessively crucial, as the industrial demand and the need for electrical vehicles evolve. In this context, the development and optimization of multi-functional alkyl-phenol based additive – AKI-56 (as detergent and dispersant) as part of the lubricant performance packages can potentially serve for the mentioned objective, as has been studied in this chemical engineering analysis. The study covered the Full Factorial Design methodology where the impact of the mass of formaldehyde (CH_2O), amino acid (glycine – NH_2CH_2COOH) and $Ca(OH)_2$ on the total base number of final product after the one-stage condensation and neutralization reactions was mathematically analysed. The harmony of chemical, mathematical and engineering analysis has indicated the critical ranges for reagent proportions, achieving a total base number of 105.1 mgKOH/g while minimizing the acceptable levels of corrosion. The research findings can be utilized as a foundation for further advancements in dispersant-detergent based additive performance optimization and therefore, longevity of the modern engines.

Keywords: *FFD, modelling, TBN, motor oil additives, detergents, dispersants*

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Introduction

1.1 Introduction to Tribology and Modern Lubricant Performance Packages

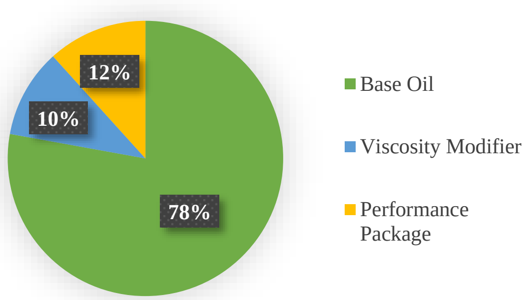
Moving further to the Industrial era 4.0, with the considerable forecasted rise in electrical vehicles, the perspective of lubricant and its performance improvement has become vital. The specific science called "tribology" provides essential insights on this perspective of optimizing the engine performance by studying the friction, wear and lubrication (Tribology – Lubricants and Lubrication, 2011).

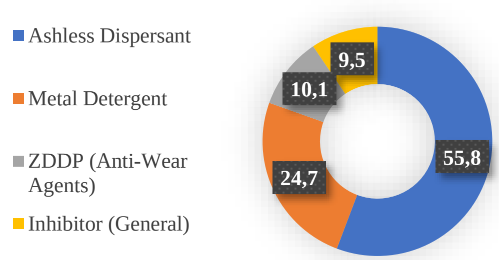
ABBREVIATIONS & DEFINITIONS

FFD	Full Factorial Design
TBN	Total Base Number
PPD	Pour Point Depressant
AKI-56	Name of the product
MATLAB	MATLAB is simulation software employed to solve the mathematical equations with more than 3 unknowns.
ASTM	American Society for Testing and Materials
ANOVA	Analysis of Variance

The particular demands of various machinery, such as automotive engines, industrial equipment, even wind turbines or food-processing machinery form the design specifications of modern lubricants that are indeed the sophisticated blends of base oils and additives. These additives are critical in ensuring that the lubricant can perform multiple roles, including minimizing wear, controlling temperature through efficient heat transfer, preventing corrosion, and maintaining cleanliness by controlling soot, sludge, and deposit formation (D'Amico, Rinaldi, 2023; Effect of Additives on Lubrication, 2014). These sophisticated blends are inevitable components of lubricants called "performance package". The development of a performance package is not straightforward, it instead is a complex process which demands vigorous expertise and robust performance testing (Rudnick, 2017). To provide vivid imagination on the importance of performance package in lubricants, the following figure can be worked out. The figure illustrates that the finished engine oil includes the addition of two essential additive categories – performance package (~ 12.0%) and viscosity modifier (~ 10.0%) in addition to its base oil (~ 78.0%) (D'Amico, Rinaldi, 2023; Handbook of Industrial Catalysis, 2011).

Figure 1. Lubricant and Performance Package Compositions (Average for Motor and Heavy Duty Diesel Oil) [2]





1.0 Literature Review

2.1 Detergent and Dispersant-based Additives for Lubricants

The performance package as part of finished engine oil can compose of several additives serving for the various specific functions contributing to the overall effectiveness of the lubricant. Key additives include: detergents, dispersants, pour point depressants (PPDs), foam depressants, anti-wear additives, friction modifiers, oxidation and rust & corrosion inhibitors, extreme pressure additives, etc. (Vasudevan, Rao, 2013).

As can be seen from figure 1, the majority of additives in performance package for lubricants consists of combination of detergents (~ 56.0%) and dispersants (~ 25.0%) which play a crucial role in maintaining the performance and longevity of motor oils, particularly in the demanding environments of modern engines. These additives are designed to neutralize acidic by-products formed during combustion with the following primary functions (D'Amico, Rinaldi, 2023):

- **Neutralizing Acidic Combustion By-Products**
- **Neutralizing Oxidation Products**
- **Cleaning High-Temperature Surfaces**

The effectiveness of these additives is strongly interconnected to maintaining a high total base number which primarily refers to the oil quality being a measure of oil's acid neutralization capacity (Lubricant Science and Technology, 2010; Naghiyeva, 2022).

The historical background behind the optimized detergents is comprehensive and includes various modification phases. Referring to the patent developed by the Institute which has a dedicated structure of laboratory to develop multifunctional alkyl-phenol based additives that can be used as part of performance package for lubricants, the additives formed after the one-staged condensation perform essentially well in modifying the motor oil properties (Patel, 2014).

2.2 Optimization of Multifunctional Alkyl-phenol Additives for Enhanced Oil Performance

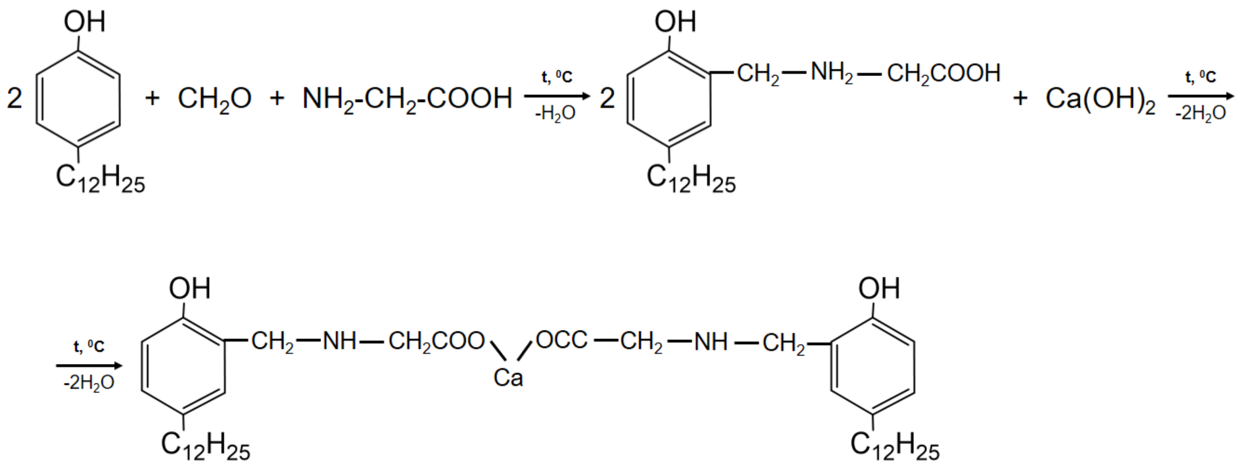
The alkyl-phenol based additives do serve the multi-functional advantages where detergent and dispersant functions are more effective (Naghiyeva, 2022). The Institute's dedication in the field of optimized lubricants for motors has resulted in various products formulated over the years. This chemical and engineering research paper has the clear objective of optimizing the already formed additives where it takes the condensation stages as the reference and employing the full factorial design (FFD) – statistical evaluation technique. It is necessary to note that FFD is only the first step for optimization studies and the findings from this mathematical modelling will form a basis for further chemical and simulation-based engineering analysis (Kazimzadeh et.al., 2006).

FFD model has referenced the one-stage condensation and neutralization reaction experimental values on AKI-56. AKI-56 is synthesized with the base reaction feeds of dodecyl phenol, formaldehyde and glycine (amino acid). The first stage is called the condensation process where the intermediate product is formed from three compounds. The second stage of the reaction is neutralization where the intermediate is treated with proper portion of $Ca(OH)_2$ to produce the calcium salt of condensation product.

Research

The statistical approach was dedicated to the optimization trials on the reactions described below where the total base number – TBN of product (additive) was the primary output of the mathematical model (Naghiyeva, n.d.).

Following the analysis of the experimental values of TBN resulted from the various proportions of the major reagents – CH_2O and NH_2CH_2COOH, the optimization trials were carried out on the neutralization stage of intermediate with $Ca(OH)_2$ (Naghiyeva, n.d.).



3.0 Method Statement

MATLAB two-level full factorial design together with DataTab software was employed to analyze experimental values results from above reaction. As mentioned above, the total base number of the product formed after one-stage condensation and neutralization was modelled referring to the experimental data.

The purpose of optimizing / modelling the TBN was to comprehend the impact of reagent proportions. In addition to this objective, the study focused on the provision of the most affecting one and the best proportion of reagents leading to the minimum level of corrosion.

FFD as a statistical model can be employed in various experiments to express the simultaneous impact of multiple factors – independent variables on the final dependent variable (AKI-56 TBN). The model involves utilization of every plausible combination of the factors together with their levels. The levels in the context refer to the various trials on the factors (Naghiyeva, n.d.). For instance, mass of formaldehyde is one of the factors, the different mass combinations (13 and 14 gram) employed in this study is called level.

The factors and their levels chosen for this study are as follows:

Table 1. The factors and their levels used in experimental setup

Factors and Levels	TBN Optimization	
	Formaldehyde mass, gram	13.0
		14.0
	NH_2CH_2COOH mass, gram	7.4
		8.0
	$Ca(OH)_2$ mass, gram	14.0
		15.0

This setup resulted in eight experimental runs, each corresponding to a unique combination of the factor levels which was resulted from $N = 2^k = 2^3 = 8$ where (Tribology – Lubricants and Lubrication, 2011):

- N – number of experimental runs;
- k – number of factors.

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TBN (referring to ASTM D2896) of the resulting mixture was measured for each run. Developing the possible combinations of each factor and level below table was formed before the analysis:

Table 2. Design of Experiment on the combination of factors – TBN *Data taken from [9]*

Run Order	Formaldehyde mass, gram	NH_2CH_2COOH mass, gram	$Ca(OH)_2$ mass, gram	The Total Base Number (mg KOH/g)
1	14.0	7.4	15.0	84.5
2	14.0	7.4	14.0	72.0
3	14.0	7.0	15.0	77.6
4	14.0	7.0	14.0	81.2
5	13.0	7.4	15.0	73.2
6	13.0	7.4	14.0	70.0
7	13.0	7.0	15.0	101.5 (non-effective result due to corrosion effect of product)
8	13.0	7.0	14.0	72.8

The response variable (the refractive index and TBN) was taken as the major output from a multiple linear regression model which incorporated the main effects of each factor as well as the combined influence of factors on the dependent variable.

The analysis involved fitting a multiple linear regression model to the data, with the refractive index as the response variable. The model incorporated the main effects of each factor as well as interaction terms to capture the combined influence of factors on the response. The model was expressed as:

$$TBN = \beta_0 + \beta_1(m_1) + \beta_2(m_2) + \beta_3(m_3) + \beta_{12}(m_1 \text{ x } m_2) + \beta_{13}(m_1 \text{ x } m_3) + \beta_{23}(m_2 \text{ x } m_3)$$

Where:

- m_1, m_2, m_3 – CH_2O, NH_2CH_2COOH & $Ca(OH)_2$ mass;
- β_0 – intercept;
- $\beta_1, \beta_2, \beta_3$ – coefficients of main effects; $\beta_{12}, \beta_{13}, \beta_{23}$ – coefficients of interactions.

The impact factor of each variable and the potential effect of their interaction has been analyzed using ANOVA (Analysis of Variance) and the standardized effects were simulated via Pareto chart to visually represent the influence of each factor on the major dependent variables – the refractive index and TBN. In addition to the analysis carried out, the main and interaction plots were generated to form a detailed perspective image which can be further implemented in upcoming chemical process interpretation and analysis. The following section of the report clearly outlines the primary outcomes of the FFD study on the mathematical modelling development and optimization of the refractive index in first and TBN in second reactions.

4.0 Results & Discussion

Using the input data containing the two-levels of every factor with the experimental TBN results, the FFD model was driven using Analysis of Variance and Pareto standardized effects for clearly demonstrating the influence of each factor on total base number of AKI-56. The analysis has shown that the optimal mass range for glycine (NH_2CH_2COOH) analysis should be between 7.0 and 8.0 grams. Within this range, there is a specific optimal mass value that has the most significant impact on TBN value. Experimental results indicate that this value is 7.4 grams. However, mathematical analyses suggest that repeating the experiments with 7.6 and 7.8 grams of glycine may further optimize the results.

Additionally, it appears that an excessive amount of $Ca(OH)_2$ does not necessarily increase the total base number of the additive. Therefore, the optimal range for $Ca(OH)_2$ is between 14 and 15 grams. Although the 7th experiment achieved a TBN of 105.1 mgKOH/g, the corrosion rate was high. This phenomenon can be explained by the lower amount of $Ca(OH)_2$ acting as a neutralizing agent in the

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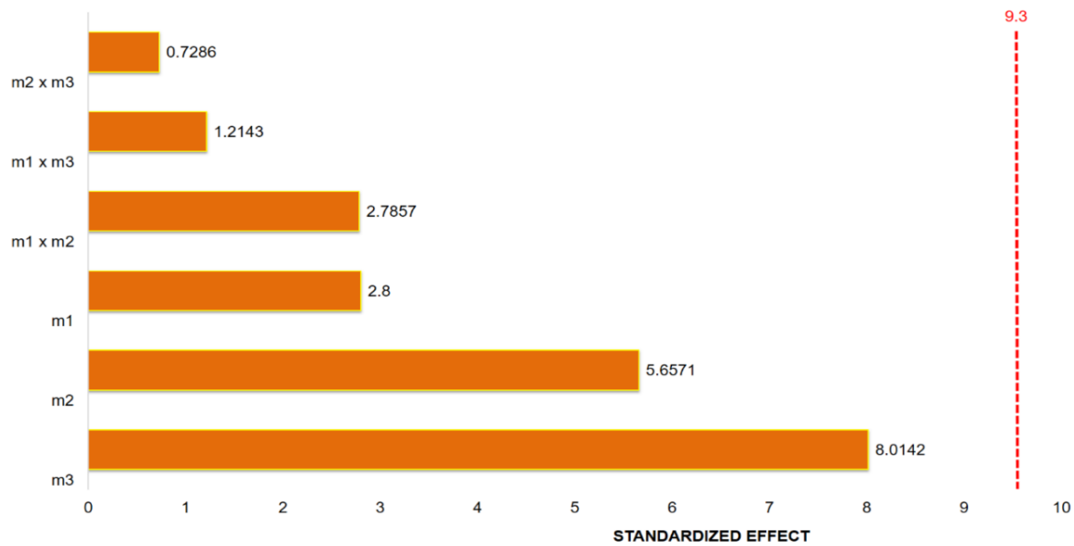
reaction. The results also indicate that the CH_2O-$Ca(OH)_2$ combination has a synergistic effect on the TBN value. To optimize this mechanism, the following conditions should be applied:

- **Optimal range for CH_2O:** 12–14 grams
- **Optimal range for $Ca(OH)_2$:** 14–15 grams

The Pareto chart of standardized effects have been developed to express the above-mentioned effects.

Figure 2. Pareto Chart of Standardized Effects for Impact Analysis (TBN).



The figure above known as a Pareto diagram, is used as a mathematical tool for optimizing reactions or effects. The x-axis represents a standardization effect within the range of 0–10, where a higher value indicates a stronger impact. For instance, according to our analysis, the mass of m_3 (i.e., $Ca(OH)_2$) is the most critical parameter for this reaction. Following this, the mass of glycine and CH_2O also significantly influence the TBN. Based on mathematical modeling, the amount of $Ca(OH)_2$ is the most important factor in optimizing the base number. Selecting its optimal quantity will directly contribute to the overall optimization of the reaction.

The results received from FFD analysis was used as a basis to develop a mathematical regression model for optimized TBN of the final product. The factors which excessively influence the magnitude of this significant additive property as represented in figure 1 are mathematically combined in below regression model. This model can be further employed for promoting the higher TBN for the final product by manipulating the factors determined via the carbonization stage of AKI-56:

$$\mathrm{TBN} = \frac{[10{,}1234 + 0{,}5678(\mathrm{m_1}) + 1{,}2345(\mathrm{m_2}) + 0{,}6789(\mathrm{m_3}) + 0.1234(\mathrm{m_1\,x\,m_2}) + 0.2345(\mathrm{m_1\,x\,m_3}) + 0.3456(\mathrm{m_2\,x\,m_3})]}{1.63056}$$

Conclusions

This study explored the key factors influencing the Total Base Number (TBN) of AKI-56 using a Fractional Factorial Design (FFD) approach, supported by variance analysis and Pareto effect evaluation. The results indicate that glycine (NH_2CH_2COOH) within 7.0–8.0 grams plays a crucial role in optimizing TBN, with 7.4 grams emerging as the most effective amount. However, additional trials at 7.6 and 7.8 grams may offer further refinements. Similarly, while $Ca(OH)_2$ is essential in neutralization, excessive amounts do not proportionally increase TBN. The optimal range for $Ca(OH)_2$

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is 14–15 grams, balancing efficiency and minimizing corrosion risks. Additionally, the interaction between CH_2O and $Ca(OH)_2$ has a noticeable synergistic effect, reinforcing the importance of keeping CH_2O between 12 and 14 grams for optimal performance.

The Pareto analysis confirmed that $Ca(OH)_2$ has the most significant influence on TBN, followed by glycine and CH_2O. The mathematical regression model developed in this study provides a structured approach to fine-tuning these factors for maximum effectiveness. By leveraging this model, the TBN of AKI-56 can be further optimized, improving overall additive performance while maintaining process stability. Future research could explore additional variables or advanced modeling techniques to enhance the predictive accuracy and adaptability of the formulation process.

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Bioecological Characteristics and Impact of Pest Insects on Ornamental Plants in the Absheron Region

Abstract

In recent years, alongside native ornamental plants, a wide variety of exotic species introduced from other countries have been planted and continue to be cultivated on the Absheron Peninsula, particularly in Baku city and its surrounding areas. With increased state attention and care, the protection and preservation of these plants have become a priority. However, despite these efforts, ornamental plants widely cultivated in Absheron suffer significant damage from insect pests each year, affecting 45–50% of plantings, and in some cases up to 80%. Research has shown that in the parks, boulevards, alleys, streets, and sports complexes of cities and settlements within the region, a total of 85 insect species belonging to 22 families and 4 orders cause damage to both native and introduced ornamental plants. Among these, 11 species are newly recorded for the natural region of Absheron, and 19 species are reported for the first time in the fauna of Azerbaijan. The bioecological characteristics, distribution, and economic importance of 30 species have been studied, along with the phenology of 10 species and the flight dynamics and natural enemies of 6 species.
Keywords: *Absheron region, bioecological, insect, plant, ornamental, pest*

Introduction

The unique geographical position and climatic conditions of the Absheron region, along with the diversity of its vegetation cover, have created favorable conditions for the formation of a rich entomofauna. Ornamental plants play a key role in the cultural development of the Absheron Peninsula, contributing significantly to urban landscaping, environmental improvement, and the mitigation of pollution in urban ecosystems. However, a wide range of ornamental plants cultivated across Absheron suffer extensive damage from insect pests annually, with infestation levels reaching 45–50%, and in some cases up to 80%. Ineffective and untimely application of chemical control measures has largely failed to reduce the damage caused by these pests. Given this situation, the protection and sustainable cultivation of ornamental plants require a scientifically grounded approach. This includes comprehensive studies on the biodiversity, bioecological characteristics, seasonal dynamics, and natural enemies of insect pests. Developing ecologically sound and integrated pest management strategies based on such studies is one of the most pressing issues in ensuring the long-term health and aesthetic value of ornamental plantings in the region (Balakhanova, 2024).

Research

Based on field research conducted on the Absheron Peninsula, 85 species of insect pests have been identified as harmful to ornamental (decorative) plants. Among them, 30 species have been classified as dominant due to their widespread distribution and significant economic impact.

These species cause considerable damage to both native and introduced ornamental plants, leading to a noticeable decline in their aesthetic appearance, visual appeal, and overall landscape value. Given the severity of the infestation and its detrimental effects, these dominant pest species have been studied in detail. Their **bioecological characteristics**—including life cycles, reproductive biology, feeding behavior, and host plant preferences—have been investigated. For a subset of key species, additional research has focused on their **phenology**, **flight activity patterns**, and **spatial distribution** across urban and peri-urban green spaces (Beibutov, 1965). Moreover, the study has also identified and documented the **natural enemies** of these pests, including parasitoids and predators, which play a crucial role in regulating pest populations in the local ecosystem. By integrating this knowledge, scientifically grounded principles for **integrated pest management (IPM)** and **biological control** strategies have been developed. These approaches aim to reduce reliance on chemical pesticides, enhance ecological balance, and ensure the sustainable protection of ornamental plants in the Absheron region. The findings of this research contribute to the broader understanding of urban entomofauna and provide a foundation for implementing environmentally friendly pest management practices in ornamental horticulture. The following provides detailed information on several key pest species (Valiyeva, Hasanova, 2022).

Trialeurodes vaporariorum **Westw. – *Greenhouse Whitefly.*** *Trialeurodes vaporariorum* is a highly damaging pest of ornamental and vegetable crops cultivated under greenhouse conditions in household plots across the Absheron Peninsula. Eight species of whiteflies are currently known in Azerbaijan, among which *T. vaporariorum* is the most widespread and economically significant. The adult (imago) has a pale-yellow body with white wings. The body length of females reaches approximately 1.1 mm, while males measure about 0.9 mm. The legs are initially pale yellowish-grey, but within 8–10 days they darken and become black. The first instar larva (approximately 0.3 mm) has visible legs and antennae. By the third instar, the larvae measure around 0.5 mm, and in the fourth instar, they reach 0.73 mm. During the transition to the nymphal stage, the red eyes become visible in mature larvae. The nymph is greenish-white in color (Porchinsky, 1911). The development of *T. vaporariorum* proceeds through seven distinct stages: egg, four larval instars, nymph, and adult. Females lay their eggs in clusters on the undersides of leaves, with clutch sizes ranging from 30 to 500 eggs. After 8–10 days, the eggs hatch into larvae that feed on plant sap by inserting their mouthparts into the leaf tissue. Larvae continue to feed and develop until they reach the adult stage. After emerging from the pupal stage, adults feed for a short period before mating. Fertilized females then begin to oviposit (Mammadov, 2004). It has been observed that in the absence of mating, unfertilized eggs produce only male offspring. *T. vaporariorum* feeds and reproduces on over 300 plant species, including at least 20 species of ornamental plants. Feeding by whiteflies disrupts the photosynthetic activity of plants, significantly reducing both their productivity and ornamental value. This pest presents a serious threat to horticultural aesthetics and yields, especially in greenhouse environments (Moiseeva, Polyakova, 1970).

Aphis craccivora **Koch – *Acacia Aphid*.** The acacia aphid (*Aphis craccivora* Koch) is a widely distributed pest species in the Absheron Peninsula, particularly affecting ornamental plants in urban and suburban parks, alleys, and residential gardens. This aphid primarily infests species from the *Rosa* genus, the Malvaceae family, and is especially common on *Syringa* (lilac) species. The apterous adult forms are pale green with three dull longitudinal stripes running along the dorsal surface (Meyer, 1933-1936). The head is elongated and covered with a waxy coating. The eggs are small, elongated, and black. The pest overwinters in the form of fertilized eggs, usually deposited in crevices of bark or between buds on host plants. In early spring, nymphs hatch from overwintered eggs and migrate to newly emerging shoots, where they begin feeding on plant sap. By the end of the flowering period, these nymphs complete development and give rise to parthenogenetic females that reproduce viviparously. The first generation generally consists of a low number of individuals, but population density increases significantly from the second generation onward. Nymphs often aggregate in large colonies on the undersides of leaves (Rubtsov, 1948). Beginning in June, winged forms from subsequent generations disperse to ornamental plants in household gardens and areas near water sources, where they establish new colonies. As a result, the pest continues to reproduce and develop simultaneously on both woody and herbaceous ornamental plants throughout the entire summer season. In September and October, females lay up to 10 eggs before dying. The resulting nymphs develop into sexual females, which mate with males. After mating and fertilization, these females lay 3–5 overwintering eggs over a period of 10–12 days, often covering them with a waxy substance (Safarova, Ismayilova, 2024). Feeding damage by *A. craccivora* causes leaf curling, significantly reducing the photosynthetic area of the plant. In severe cases, mass abscission of leaves and flowers can occur. Additionally, the aphid secretes a sticky honeydew during feeding, which promotes the growth of saprophytic fungi (sooty mold). This leads to contamination and deterioration of branches and foliage, further reducing the aesthetic and physiological quality of the infested ornamental plants (Ben-Yehuda, Assael, Mendel, 2000).

Chrysomela populi* L.– *Poplar Leaf Beetle. The poplar leaf beetle (*Chrysomela populi* L.) is a significant defoliator of poplar and willow trees in the Absheron Peninsula. It is commonly found in urban green spaces, including parks, alleys, and household gardens, where it primarily infests various species of *Populus*. The adult beetle measures approximately 10–12 mm in length, with a dark green dorsal surface and elytra that exhibit a reddish hue. Under Absheron's climatic conditions, both larvae and adult beetles feed on the foliage of poplar and willow species, often causing considerable damage (Shapiro, 1960). In certain years, infestations have led to a reduction of 40–50% in leaf cover on affected trees, negatively impacting their aesthetic and physiological condition (Mirzoeva, 2001). Adults emerge from overwintering sites in early April. After a feeding period of 10–15 days, females begin oviposition. Each female lays between 200 and 350 eggs, typically in clusters of 20–60 on the undersides of leaves. Larvae hatch towards the end of April and pass through three instar stages. Larval development lasts approximately 12–14 days. By mid-May, mature larvae pupate in the soil or on sheltered parts of the plant. Adult beetles emerge from the pupae within 4–5 days and begin laying eggs by early June, initiating the second generation (Toth, Schmera, Imrei, 2004). Depending on annual climatic conditions, *C. populi* may produce two or even three generations per growing season in the Absheron region. Due to its multivoltine life cycle and high reproductive potential, *Chrysomela populi* represents a significant threat to ornamental and urban forestry plantings, particularly in areas dominated by poplar species. Effective monitoring of its population dynamics and the implementation of timely management strategies are essential to prevent large-scale defoliation and long-term damage to green infrastructure (Mamedov, 2004).

Conclusions

Comprehensive field and laboratory investigations conducted across various urban and suburban areas of the Absheron Peninsula revealed a total of **85 insect pest species** associated with ornamental plants, belonging to **4 orders and 22 families**. Among these, **30 species were identified as dominant**, exhibiting high population densities and causing significant economic and aesthetic damage to both native and introduced ornamental plant species (Safarova, Jabrailzadeh, n.d.). The presence of natural enemies such as *Encarsia* spp. and *Macrolophus caliginosus* was documented, providing a foundation for future biological control efforts. Another key pest, the **acacia aphid** (*Aphis craccivora*), was widely distributed in city parks, alleys, and household gardens. It caused damage primarily to species in the genera *Rosa*, *Syringa*, and the family Malvaceae. The aphid overwinters in the egg stage and produces multiple parthenogenetic generations during the growing season. By **June**, winged morphs were observed dispersing to new host plants, establishing fresh colonies. Infestations led to **leaf**

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deformation, **reduced photosynthetic area**, and in some cases, **mass leaf and flower drop**. The aphid's production of honeydew facilitated the growth of sooty mold fungi, further diminishing plant health and appearance (Asian, Warchalowski, 2001). Phenological observations and trapping studies enabled the identification of **flight periods** for several major species and allowed for the determination of peak activity periods. Overall, the findings demonstrate that insect pests pose a serious and widespread threat to ornamental plantings across Absheron. The need for region-specific, ecologically sound pest control strategies—based on thorough knowledge of pest biology and ecology—is urgent and essential for sustainable landscape management.

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Effect of Saffron Extracts on Reproductive Function

Abstract

Saffron (*Crocus sativus L.*), a historically valued medicinal plant, has garnered modern scientific interest due to its diverse bioactive compounds and therapeutic potential. Rich in crocin, crocetin, picrocrocin, and safranal, saffron exhibits antioxidant, anti-inflammatory, antidepressant, and neuroprotective effects. Recent clinical studies have demonstrated its effectiveness in improving symptoms of premenstrual syndrome (PMS), premenstrual dysphoric disorder (PMDD), menopausal discomfort, and female sexual dysfunction. Standardized extracts like Affron® have been shown to enhance mood, reduce anxiety and depression, and improve sleep and hormonal symptoms in women, with minimal side effects. Despite its safety at therapeutic doses, dosage control remains essential to avoid toxicity. This review synthesizes the pharmacological properties and clinical evidence supporting saffron's role in women's health, underscoring its potential as a safe, non-hormonal, plant-based treatment for various gynecological and psychological conditions.

Keywords: *bioactive compounds, saffron extract, reproductive system, female sexual dysfunction, therapeutic potential*

Introduction

Saffron (*Crocus sativus L.*) has long captivated researchers and practitioners for its unique chemical profile, therapeutic versatility and historical prominence across cultures. In recent years, growing scientific attention has focused on its health-promoting properties, particularly in the context of women's reproductive and emotional well-being. Supported by clinical studies and regulatory evaluations, saffron emerges as a promising natural intervention with both traditional and modern medical significance.

Saffron and its Benefits for Health

The history of using the perennial, stemless herbaceous plant from the iris family—saffron crocus (Crocus sativus)—goes back over 3,000 years and spans several continents (Hasheminasab et al, 2024). From Persia, saffron spread to India and China, and only in the 8th–9th centuries, following the Arab-Muslim conquests, did its cultivation begin in Spain and North Africa. Due to to the Crusades of the 11th–13th centuries, it later appeared in France.

Research

For centuries, saffron production has been considered one of the most labor-intensive processes—almost entirely reliant on manual labor. Saffron (Crocus sativus L.) is an extremely delicate crop that requires strict adherence to specific conditions for successful growth. It is sterile due to its polyploidy and can only reproduce vegetatively through daughter corms. Moreover, saffron blooms only three weeks per year—in October. The flowers are harvested exclusively by hand; after about a day of drying in a low-light, dry place at a specific temperature, the stigmas are also removed manually and then dried.

The quality of saffron depends on this processing technique, which must comply with international quality standards—ISO 3632-1:2011 and ISO 3632-2:2011 [14, 15]. As a result, 1,000 Crocus sativus L. flowers yield about 25 grams of stigmas, and after drying, only 5 grams of saffron are obtained (Aucante, 2000).

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Saffron contains around 150 volatile and non-volatile compounds. The main biologically active components of saffron are crocin, crocetin, picrocrocin (which are carotenoids and apocarotenoids derived from zeaxanthin), and safranal (a terpene with an aldehyde functional group) (El Midaoui et al, 2022).

The quality of saffron is associated with its low moisture content, distinctive aroma (due to safranal), reddish-orange color (from crocin and crocetin), and bitter taste (from picrocrocin) (El Midaoui et al, 2022). Because of its vibrant color and high cost, saffron is often referred to as "red gold" and the "golden spice" (Siddiqui et al, 2022).

It is worth noting that crocin, when taken orally, does not enter the bloodstream; instead, it is converted into crocetin in the intestine or excreted unchanged in the feces. Therefore, nanotechnology-based approaches are being developed to improve the stability and bioavailability of crocin. Additionally, the concentration and ratio of saffron's biologically active compounds vary depending on the country of origin, making its effects difficult to interpret in clinical studies (EFSA, 2021).

The water-based extract Affron® is a natural ingredient derived from Spanish saffron (*Crocus sativus L.*), which is considered the highest quality saffron in the world. It is standardized to contain specific amounts of crocin, picrocrocin, and safranal (the total content of crocin and safranal typically ranges from 3.5% to 3.9%).

In early 2021, the European Food Safety Authority (EFSA) panel on Nutrition, Novel Foods and Food Allergens (NDA) concluded that Affron® has health benefits. An interventional study showed that taking 28 mg/day for 4 weeks improved mood in adults (EFSA, 2021).

Saffron has been used for therapeutic purposes since ancient times, including references in the Ebers Papyrus (1550 BCE), Avicenna’s Canon of Medicine (11th century), and Indian Ayurvedic literature (Siddiqui et al, 2022). For instance, Avicenna described its use in treating inflammatory and respiratory conditions, as well as its effect on sexual activity (aphrodisiac properties). Many of these effects are now supported by scientific evidence.

Clinical trials indicate that *Crocus sativus* improves sleep in postmenopausal women (Taavoni et al, 2017). Results from a double-blind, randomized, placebo-controlled trial involving 60 postmenopausal women who took either a placebo or 30 mg/day of saffron for 6 weeks demonstrated that saffron is a safe and effective remedy for reducing hot flashes and depressive symptoms in healthy postmenopausal women. It may serve as a non-hormonal alternative treatment for women experiencing hot flashes (Kashani et al, 2018).

In a 12-week double-blind, randomized, controlled trial conducted in Australia with parallel groups, 86 perimenopausal women experiencing menopausal symptoms received either a placebo or 14 mg of saffron extract (Affron®) twice daily. Outcome assessment included the Greene Climacteric Scale, the Positive and Negative Affect Schedule (PANAS), and the Short Form-36 Health Survey (SF-36).

The results showed that the use of saffron extract (Affron®) led to significantly greater improvements in mood and psychological symptoms compared to placebo. Specifically, there was a statistically significant reduction in the psychological score on the Greene Scale ($p = 0.032$), with anxiety levels reduced by 33% and depression scores decreased by 32% compared to baseline. The saffron extract was well tolerated, and no serious side effects were reported (Lopresti & Smith, 2021).

The improvement in psycho-emotional and neurovegetative symptoms is likely linked to the effects of crocin and safranal on the synaptic transmission of monoamine compounds, changes in the levels of neurotransmitters such as serotonin, dopamine, and noradrenaline, as well as increased levels of brain-derived neurotrophic factor (BDNF), the neuropeptide VGF, and the transcription factors CREB and P-CREB (Cerdá-Bernad et al, 2022).

In addition, the biologically active compounds in saffron exhibit anti-inflammatory, antiallergic, antidepressant, antihypertensive, antibacterial, nephroprotective, hepatoprotective, antigenotoxic, antiatherogenic, cardioprotective, and antidiabetic properties, which are especially important in managing women during the peri- and postmenopausal periods.

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The Role of Saffron in Female Reproductive Health

A study by Kashani et al. (2022) conducted in Iran explored the impact of saffron on female sexual dysfunction. The research included married women between the ages of 18 and 55 who were experiencing severe sexual difficulties. Participants received either 15 mg of *Crocus sativus* extract or a placebo, taken twice daily for six weeks. The primary outcome assessed was improvement in the Female Sexual Function Index (FSFI) score. Results showed a significant increase in FSFI scores among those in the saffron group compared to the placebo group, especially in the areas of sexual desire, lubrication, and satisfaction. These results indicate that saffron could be a safe and potentially effective treatment for female sexual dysfunction, though further well-designed studies are recommended to confirm these findings (Kashani et al, 2022).

The therapeutic potential of saffron in addressing gynecological conditions has been extensively examined. Notably, saffron has demonstrated effectiveness in alleviating symptoms associated with premenstrual syndrome (PMS) and premenstrual dysphoric disorder (PMDD). Its beneficial effects are attributed to multiple mechanisms of action, including anti-inflammatory, anti-nociceptive, anticonvulsant, and antidepressant properties (Maleki-Saghooni et al, 2018). Saffron's impact on PMS is largely due to its modulation of serotonin, a key neurotransmitter.

Hormonal fluctuations—particularly changes in testosterone and estradiol levels linked to elevated cortisol during the follicular phase—are significant contributors to PMS symptoms (Hosseinzadeh et al, 2008). A double-blind, placebo-controlled study involving 35 female college students with regular menstrual cycles and PMS symptoms found that brief exposure to the scent of saffron led to significant symptom improvement by reducing cortisol levels (Maleki-Saghooni et al, 2018).

Another randomized, double-blind clinical trial assessed the efficacy of 30 mg of saffron daily for PMS and PMDD. Approximately 70% of women of reproductive age in the saffron group reported a 50% reduction in PMS severity, as measured by a standardized questionnaire. Some mild and tolerable side effects, such as headaches and reduced appetite, were noted (Agha-Hosseini et al, 2008).

Additionally, a 2020 clinical trial involving 120 women diagnosed with PMDD confirmed that saffron effectively reduced depressive symptoms associated with the disorder, with minimal side effects (Rajabi et al, 2020).

Overall, saffron is generally considered safe when used within standard therapeutic doses. However, excessive intake can result in toxic effects, making it crucial to carefully monitor and regulate the dosage to ensure safety.

Conclusion

Saffron (*Crocus sativus L.*) represents a powerful natural remedy with centuries of traditional use now supported by modern scientific evidence. Its unique combination of bioactive compounds offers a range of therapeutic effects, particularly in the context of women's health. Clinical studies confirm saffron's potential to alleviate symptoms of PMS, PMDD, menopause, and female sexual dysfunction, with minimal adverse effects when used in appropriate doses. As research progresses, further high-quality clinical trials are essential to validate its broader applications and optimize dosing strategies for therapeutic use.

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