

## Use Of Vitamins in Pharmacotherapy of Tuberculosis: Retrospective and Marketing Analysis

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**Abstract.** This paper explores the impact of antioxidant vitamins on the prevention and pharmacotherapy of tuberculosis. The author aims to assess the potential advantages and applications of vitamins A, C, and E in treating tuberculosis, especially among individuals at high risk of Mycobacterium tuberculosis infection and those with active disease. The analysis indicates that these vitamins may offer significant benefits in both preventing and managing tuberculosis. Known for their antioxidant properties and immune system support, vitamins A, C, and E are crucial in combating tuberculosis infections. A marketing analysis of the antioxidant vitamin market in Ukraine reveals their availability and popularity among the general population and medical institutions. The study provides valuable insights for medical practice and could serve as a

foundation for future research aimed at improving the prevention, diagnosis, and treatment of tuberculosis. Moreover, incorporating antioxidant vitamins into standard tuberculosis treatment protocols could enhance patient outcomes and reduce the disease burden. The research underscores the necessity for further clinical trials to validate the efficacy of vitamins A, C, and E as adjunct therapies. Understanding the accessibility and public perception of these vitamins in Ukraine aids in designing effective public health strategies. By emphasizing their immunomodulatory effects, the study highlights the potential role of antioxidant vitamins not only in pharmacotherapy but also in preventive healthcare measures against tuberculosis.

**Keywords:** tuberculosis, vitamins, antioxidants, marketing, pharmacotherapy.

**Introduction.** Tuberculosis remains one of the most pressing problems of modern medicine, despite significant progress in the diagnosis, treatment and prevention of this disease in recent decades. According to the World Health Organization, tuberculosis continues to cause a large number of cases of illness and death worldwide, especially in low- and middle-income countries. The spread of multidrug-resistant forms of Mycobacterium tuberculosis, the decrease in the effectiveness of traditional antibiotics and the deterioration of socio-economic conditions contribute to the increase in the burden of tuberculosis, which poses new challenges for the medical community. Tuberculosis is one of the main infectious deaths in the world, in fact, every year 10 million people become ill with tuberculosis and 1.5 million people die from tuberculosis [1-3].

Tuberculosis is a major public health problem: the World Health Organization estimates that there were 9.4 million cases of tuberculosis and 1.8 million deaths from tuberculosis worldwide in 2008. Enhancing the immune response to Mycobacterium tuberculosis has the potential to reduce antimicrobial therapy for drug-susceptible disease or improve outcomes for drug-resistant disease [4].

Multidisciplinary research on post-traumatic stress disorders during war among patients, primarily combatants, has recorded the discovery of tuberculosis as a comorbid disease [5-10].

One of the most vulnerable populations is those at high risk of infection with Mycobacterium tuberculosis, such as immunocompromised individuals, HIV-positive patients, close contacts of tuberculosis patients, and patients with chronic diseases. In these groups, the likelihood of developing active tuberculosis is significantly increased, which requires health professionals to find new approaches to the prevention and treatment of this infectious disease.

In this context, antioxidant vitamins are beginning to attract significant attention from researchers and doctors, as their potential properties in supporting the immune system and combating oxidative stress may play an important role in the prevention and treatment of tuberculosis. Oxidative stress, caused by excessive free radicals in the body, can lead to damage to cells and tissues, as well as suppression of the immune response. Vitamins such as vitamin C, vitamin E and B vitamins are powerful antioxidants that can neutralize free radicals, strengthen the immune system and increase the body's resistance to infections.

Many studies indicate that the additional administration of antioxidant vitamins can improve the general condition of patients suffering from tuberculosis and reduce the likelihood of developing complications. They can also help to increase the effectiveness of traditional antibacterial agents, which opens up new horizons for the development of combined treatment regimens. Thus, the study of the possibilities of using antioxidant vitamins in the treatment and prevention of tuberculosis seems extremely relevant and requires further study.

Vitamins play an important role in vital functions due to their antioxidant, prooxidant, anti-inflammatory and metabolic functions [11].

Vitamins play an important role in the treatment of tuberculosis, contributing to the overall strengthening of the immune system and improving the patient's condition. In addition, they provide effective support for the body during long-term antibiotic treatment, which is usually used for this disease. Vitamins can be divided into two main groups: water-soluble and fat-soluble. Water-soluble vitamins include B vitamins (B1, B2, B3, B5, B6, B8, B9, B12) and ascorbic acid (C). These vitamins must be obtained daily with food, since they are not stored in the body. They are distributed in products of plant and animal origin. Fat-soluble vitamins (A, D, E and K) are absorbed together with fats from food and accumulate in the liver and adipose tissue, with the exception of vitamin K, which is not accumulated and requires a constant supply with food. Vitamins A and E act as antioxidants, helping the body fight harmful free radicals, which is especially important for patients with tuberculosis. Vitamin D, which can be synthesized in the body under the influence of sunlight, also plays an important role in supporting the immune system, which is critically important for the fight against tuberculosis. A lack of this vitamin can negatively affect the body's ability to resist infections, including tuberculosis. Thus, the complex use of vitamins contributes to the overall health of patients, helping their bodies to fight the disease more effectively and recover after treatment [12].

The article continues the author's research on the chosen topic [13-16]. Thus, the author previously conducted a comprehensive review of the results of studies on the use of B vitamins in the pharmacotherapy of tuberculosis. The study is based on a retrospective and marketing analysis covering the period from 1950 to 2024 and using leading scientific databases. The results indicate a significant potential benefit of antioxidant vitamins in the prevention and treatment of tuberculosis, which is explained by their antioxidant properties and beneficial effects on the immune system. The marketing analysis shows the wide availability and popularity of B vitamins on the Ukrainian market, which increases the availability and economic feasibility of these products. The study offers important conclusions for medical practice and lays the foundation for future research aimed at improving the prevention and treatment of tuberculosis, especially in conditions of increased risk of infection. Furthermore, the article highlights the importance of integrating these vitamins into therapeutic protocols, which could lead to more effective strategies for managing tuberculosis and possibly other infectious diseases. By identifying gaps in current treatment approaches and highlighting the cost-effectiveness of B vitamins, the study also paves the way for public health initiatives to incorporate these findings into broader health policies. Such a comprehensive approach provides information to both the medical community and policymakers, facilitating a coordinated response to tuberculosis at multiple levels [17].

Antioxidants may protect against oxidative stress, which is associated with tuberculosis disease. However, direct evidence of a protective association between dietary antioxidants and tuberculosis incidence in humans is lacking. The association between intake of antioxidant vitamins (vitamins A, C, D, and E) and selected carotenoids ( $\alpha$ -carotene,  $\beta$ -carotene,  $\beta$ -cryptoxanthin, lycopene, and lutein) and tuberculosis incidence was investigated in the Singapore Chinese Health Study. The researchers found that the lower risk of tuberculosis was observed among vitamin C consumers only among smokers. Other vitamins and carotenoids were not associated with the risk of tuberculosis. These results suggest that vitamin C may reduce the risk of tuberculosis in current smokers by attenuating oxidative stress, while vitamin A and  $\beta$ -carotene may have additional antimycobacterial properties [18].

Certain antioxidant vitamins may be prescribed to maintain general health and enhance the effectiveness of tuberculosis treatment. They help strengthen the immune system and promote overall recovery. Key antioxidant vitamins that may be helpful in the treatment of tuberculosis include:

- Vitamin A: Supports the immune system and the health of the mucous membranes, which help protect the body from infections.
- B vitamins: Important for energy metabolism and the nervous system. Vitamin B6 (pyridoxine) is particularly useful when taking isoniazid, as it helps prevent peripheral neuropathy.
- Vitamin C: A powerful antioxidant that supports the immune system and may enhance the effects of anti-tuberculosis drugs.
- Vitamin D: Important for the immune system, helps fight infections, and improves the outcome of tuberculosis treatment.
- Vitamin E: An antioxidant that protects cells from damage and supports the immune system.
- These vitamins are not the mainstay of tuberculosis treatment, but they can help improve the patient's overall health and support the mainstay of therapy. Vitamins should be prescribed by a doctor based on the patient's individual needs.

**The purpose of the study** was to discuss and summarize the available evidence and still open questions regarding the use of antioxidant vitamins in the pharmacotherapy of tuberculosis as a preventive measure for individuals at high risk of infection and development of active tuberculosis. To achieve this goal, a retrospective and marketing analysis of antioxidant vitamins A, C and E, which may be useful in the pharmacotherapy of this disease, was conducted. This approach allows for a comprehensive assessment of the potential benefits and challenges of using antioxidant vitamins in the fight against tuberculosis, as well as their availability and cost-effectiveness on the Ukrainian market.

**Materials and methods.** The study lasted from June 2024 to July 2024. A retrospective documentary search was conducted on the topic of the article on the websites PubMed, Scopus, Google Scholar, EMBASE, Cochrane Library, WHO, Crossref, Copernicus. The search covered the period from 1950 to 2024. Articles discussing the role of vitamins A, C and E in the treatment of tuberculosis were identified. In addition, the State Formulary of Medicines of Ukraine, 16th edition [19] and the State Register of Medicines of Ukraine [20] were studied to conduct a marketing analysis of the antioxidant vitamin market in Ukraine.

The research of the article is a fragment of research works of Private Scientific Institution "Scientific and Research University of Medical and Pharmaceutical Law" on the topic "Multidisciplinary research of post-traumatic stress disorders during war among patients (primarily combatants)" (state registration number 0124U002540, implementation period 2024-2028); Lviv Medical Institute LLC on the topic of "Improving the system of circulation of drugs during pharmacotherapy on the basis of evidentiary and forensic pharmacy, organization, technology, biopharmacy and pharmaceutical law" (state registration number 0120U105348, implementation period 2021-2026) and "Pharmaceutical and medical law: integrated approaches to the system of drug circulation from the standpoint of forensic pharmacy and organization of pharmaceutical business" (state registration number 0121U000031, terms 2021-2026); Luhansk State Medical University "Conceptual interdisciplinary approaches to pharmaceutical provision and availability of drugs, taking into account organizational and legal, technological, analytical, pharmacognostic, forensic and pharmaceutical, clinical and pharmacological, pharmacoeconomic, marketing, social and economic competencies" (state registration number 0123U101632, terms 2023-2027); Petro Mohyla Black Sea National University on the topic "Conceptual interdisciplinary approaches to the drug circulation system, taking into account organizational and legal, technological, biopharmaceutical, analytical, pharmacognostic, forensic and pharmaceutical, clinical and pharmacological, pharmacoeconomic, pharmacotherapeutic aspects" (state registration number 0123U100468, implementation period 2023-2028).

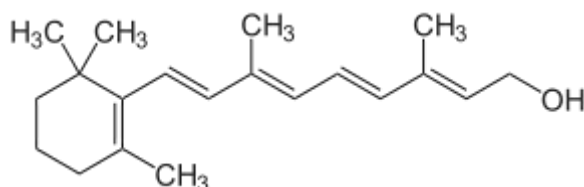
**Research and discussion.** Vitamins are key participants in metabolic processes in the body, including the skin and other organs and systems. For proper metabolism in the skin, vitamins such as

pyridoxine, pantothenic and ascorbic acids, riboflavin, thiamine, retinol, tocopherol (vitamin E), and vitamin F are necessary. The deficiency of some of these vitamins can cause serious skin problems, such as atrophy of the epidermis, hair follicles and sebaceous glands (pyridoxine, pantothenic and nicotinic acids), hyperkeratosis (retinol) [21-28].

Tuberculosis is a serious disease that requires a comprehensive approach to treatment. Antioxidant vitamins can play an important role in maintaining overall health and the effectiveness of primary tuberculosis treatment [1].

The author further examines each antioxidant vitamin separately.

### Retinol (Vitamin A)



Retinol, also known as vitamin A, is a vital substance that plays a key role in maintaining healthy skin, vision, and the immune system. It is found mainly in animal fats such as liver, butter, cheese, milk, and egg yolk. Plant foods (carrots, apricots, tomatoes, green peas) contain provitamin A or carotene, which the body converts to retinol.

#### *Biological role of retinol and carotene*

Retinol and carotene play an important role in the preventive processes of the skin, and also act in redox reactions. Due to their structure with double bonds, these vitamins can carry oxygen and hydrogen in tissues. Retinol is involved in the metabolism of sulfur-containing amino acids and affects the functional state of the endocrine glands.

With a deficiency of retinol, hyperkeratosis develops, dry skin is observed, loss of elasticity, sweating and sebum secretion are reduced. It regulates the function of the sebaceous and sweat glands, stimulates metabolic processes in the skin, helps to eliminate dandruff, restores damaged tissues, makes the skin elastic and elastic, protects the skin and hair from dryness, harmful meteorological and toxic effects.

#### *The benefits of retinol in the treatment of tuberculosis*

Tuberculosis is a serious infectious disease that most often affects the lungs, but can also spread to other organs [29-31].

Treatment of tuberculosis requires an integrated approach, including the use of antibacterial drugs and supportive therapy. One of the important components of supportive therapy are antioxidant vitamins, among which retinol occupies a special place.

#### *Retinol and the immune system*

Retinol plays an important role in maintaining immune function, which is critical for patients with tuberculosis. It helps increase the activity of immune cells, such as T-lymphocytes and macrophages, which are essential for fighting tuberculosis bacteria. Studies have shown that vitamin A deficiency can weaken the immune response, making it more difficult to treat TB.

#### *Antioxidant action*

As an antioxidant, retinol helps protect cells from damage caused by free radicals. In tuberculosis, inflammatory processes can lead to increased production of free radicals, which damage tissues and can increase the severity of the disease. Retinol neutralizes free radicals, reducing oxidative stress and promoting the repair of damaged tissues.

#### *Retinol and tissue repair*

During the treatment of tuberculosis, retinol promotes the regeneration and repair of damaged lung tissue. This is especially important because TB often leads to the destruction of lung tissue, the formation of cavities and fibrosis. Retinol stimulates the synthesis of collagen and other structural proteins that promote healing and restoration of normal tissue structure.

*Use of retinol in tuberculosis*

Given its important functions, retinol can be prescribed as part of complex therapy for tuberculosis. It is used to maintain the general health of patients, strengthen the immune system, reduce oxidative stress and promote the restoration of damaged tissues.

*Conclusion*

Retinol is a vital vitamin that plays a key role in maintaining the health of the skin, vision and immune system. Its use in the treatment of tuberculosis helps to strengthen immunity, protect cells from oxidative stress and promote the regeneration of damaged tissues. Thus, retinol is an important component of complex therapy for tuberculosis, which contributes to the effectiveness of treatment and improvement of the general condition of patients.

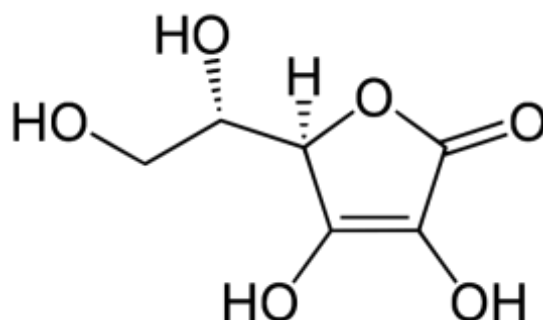
**Table 1.** Marketing analysis of Retinol (Vitamin A).

Trade name/dosage form	Composition of active substances	Manufacturer/ Country	No registration certificate	Validity from/to
Retinole acetate Solution	1 ml contains 34.4 mg	"VITAMINY" JSC, Ukraine	UA/5428/01/01	unlimited since 24.11.2016
Retinol acetate (Vitamin A) Solution	1 ml contains 34.4 mg	Technolog PJSC, Ukraine	UA/6646/01/01	unlimited since 25.07.2017
VITAMIN A ACETATE 1.5 MILLION IU/G Solution oleosum	1 ml contains from 1.50 million IU/g to 1.65 million IU/g	BASF CE, Federal Republic of Germany	UA/10727/01/01	unlimited since 14.11.2019

Table 1 presents a marketing analysis of retinol (vitamin A) preparations available on the Ukrainian market. The table provides information on various trade names and forms of release of the preparations, the composition of their active substances, manufacturers and countries of origin, as well as registration certificate numbers and their validity periods.

- The preparations are presented by three different manufacturers: "VITAMINS" JSC (Ukraine), PJSC "Technolog" (Ukraine) and BASF CE (Federal Republic of Germany).
- All preparations have different forms of release, but contain the active substance retinol (vitamin A) in the form of acetate.
- Each preparation has a unique registration certificate number and is indefinitely registered from the corresponding dates: 11/24/2016, 07/25/2017 and 11/14/2019.

This analysis allows us to assess the availability and regulatory status of various forms of retinol on the Ukrainian market, and also provides an idea of the main manufacturers of these preparations.

**Ascorbic acid (Vitamin C)**

Ascorbic acid, also known as vitamin C, is a water-soluble vitamin that performs numerous important functions in the body. It is a powerful antioxidant that helps strengthen the immune system, improve wound healing, and maintain healthy skin, cartilage, teeth, and bones.

*Biological Role of Ascorbic Acid*

**Antioxidant Protection.** Ascorbic acid is one of the most powerful antioxidants, protecting cells from damage caused by free radicals. This helps reduce the risk of chronic diseases and maintain overall health.

**Collagen Synthesis.** Vitamin C is necessary for the synthesis of collagen, a protein that is the basis of connective tissue. Collagen is important for wound healing, maintaining skin elasticity, and joint health.

*Immune System Support*

Ascorbic acid helps activate immune cells such as phagocytes and T-lymphocytes, which increases the body's ability to fight infections. It also promotes the synthesis of interferons, which play a key role in protecting against viruses.

**Improving iron absorption.** Vitamin C improves the absorption of non-heme iron from plant foods, which helps prevent anemia, especially in people with iron deficiency.

**Anti-inflammatory properties.** Ascorbic acid has anti-inflammatory properties, which helps reduce inflammation and maintain vascular health.

*Benefits of ascorbic acid in the treatment of tuberculosis*

Ascorbic acid can be a useful addition to tuberculosis therapy due to its numerous biological functions.

*Strengthening the immune response in tuberculosis*

Vitamin C strengthens the immune system by increasing the activity of white blood cells that fight infections. This is especially important for patients with tuberculosis, as a strong immune system helps fight mycobacteria tuberculosis more effectively.

**Protection against oxidative stress.** Tuberculosis can cause oxidative stress, which contributes to cell and tissue damage. Ascorbic acid, as a powerful antioxidant, helps neutralize free radicals and protect cells from damage.

**Improves healing.** Vitamin C promotes collagen synthesis, which improves the healing of wounds and damaged tissues, which may be beneficial for patients with tuberculosis, who may have complications related to tissue healing.

*Supports overall health in tuberculosis*

Through its numerous biological roles, ascorbic acid contributes to overall health by increasing energy levels, supporting cardiovascular health, and ensuring proper DNA synthesis.

*Conclusion*

Ascorbic acid (vitamin C) is an important component of supportive therapy in the treatment of tuberculosis. Its role in enhancing the immune response, protecting against oxidative stress, improving healing, and supporting overall health makes it indispensable for patients with tuberculosis. Incorporating ascorbic acid into a comprehensive tuberculosis treatment regimen can help reduce symptoms, improve quality of life, and speed up recovery for patients.

**Table 2.** Marketing analysis of ascorbic acid (Vitamin C).

Trade name/dosage form	Composition of active substances	Manufacturer/ Country	No registration certificate	Validity from/to
ASKOCIN® MAX tablets	1 tableta contains: vitamin C 1000 mg; zinc 10 mg	KUSUM HEALTHCARE PVT LTD, India	UA/18993/01/01	13.10.2021 13.10.2026
REVIT pills	1 dragee contains: retinol acetate	Technolog PJSC, Ukraine	UA/3354/01/01	unlimited with 15.06.2020

	(vitamin A) – 0.86 mg (2500 IU), thiamine hydrochloride (vitamin B1) – 1 mg, riboflavin (vitamin B2) – 1 mg, ascorbic acid (vitamin C) – 35 mg			
HEXAVITE dragee	1 dragee contains: retinol acetate (vitamin A) – 1.72 mg (5000 IU); thiamine hydrochloride (vitamin B1) – 2 mg; riboflavin (vitamin B2) – 2 mg; pyridoxine hydrochloride (vitamin B6) – 2 mg; nicotinamide (vitamin PP) – 15 mg; ascorbic acid (vitamin C) - 70 mg	Technolog PJSC, Ukraine	UA/3286/01/01	unlimited with 25.03.2020
REVIT pills	1 dragee contains: retinol acetate (vitamin A) – 0.86 mg (2500 IU), thiamine hydrochloride (vitamin B1) – 1 mg, riboflavin (vitamin B2) – 1 mg, ascorbic acid (vitamin C) – 35 mg	Technolog PJSC, Ukraine	UA/3353/01/01	unlimited with 15.06.2020
OPTIKS film-coated tablets, 10 tablets in a blister, 3 or 6 blisters in a pack	1 tablet contains: $\beta$ -carotene 1.5 mg; lutein 2.5 mg; zeaxanthin 0.5 mg; vitamin E 36 mg; vitamin C 225 mg; zinc 5 mg; copper 1 mg	"KYIV VITAMINY ZAVOD" JSC, Ukraine	UA/6929/01/01	unlimited with 04.07.2017
UNDEVIT dragee	1 dragee contains: retinol - 1.135 mg; tocopherol - 10 mg; thiamine – 2	Technolog PJSC, Ukraine	UA/2986/01/01	unlimited with 02.04.2020

	mg; riboflavin – 2 mg; pyridoxine – 3 mg; cyanocobalamin - 0.002 mg; ascorbic acid - 75 mg; nicotinamide - 20 mg; folic acid - 0.07 mg; rutoside - 10 mg; calcium pantothenate - 3 mg			
HEXAVIT dragees, 50 dragees in containers	1 dragee contains: retinol acetate (vitamin A) – 1.72 mg (5000 IU); thiamine hydrochloride (vitamin B1) – 2 mg; riboflavin (vitamin B2) – 2 mg; pyridoxine hydrochloride (vitamin B6) - 2 mg; nicotinamide (vitamin PP) – 15 mg; ascorbic acid (vitamin C) - 70 mg	Technolog PJSC, Ukraine	UA/3285/01/01	unlimited with 25.03.2020
VAZAVITAL® capsules	dry extract of ginkgo biloba (ginkgo biloba L.), bee pollen (pollen), rutin (vitamin P), ascorbic acid (vitamin C), nicotinic acid (vitamin PP), thiamine hydrochloride (vitamin B1), riboflavin (vitamin B2), pyridoxine hydrochloride (vitamin B6); 1 capsule contains dry extract of ginkgo biloba (ginkgo biloba L.) (ratio of the starting material to	LLC "ASTRAPHARM", Ukraine PJSC "Biolik", Ukraine	UA/6628/01/01	unlimited with 14.07.2017



	the obtained extract 50:1; extractant ethanol 60%) 40 mg, bee pollen (pollen) 60 mg, rutin (vitamin P) 20 mg, ascorbic acid (vitamin C) 30 mg, nicotinic acid (vitamin PP) 17 mg, thiamine hydrochloride (vitamin B1) 1 mg, riboflavin (vitamin B2) 1 mg, pyridoxine hydrochloride (vitamin B6) 1 mg			
UNDEVIT dragee	1 dragee contains: retinol – 1.135 mg; tocopherol – 10 mg; thiamine – 2 mg; riboflavin – 2 mg; pyridoxine – 3 mg; cyanocobalamin – 0.002 mg; ascorbic acid – 75 mg; nicotinamide – 20 mg; folic acid - 0.07 mg; rutoside - 10 mg; calcium pantothenate - 3 mg	Technolog PJSC, Ukraine	UA/2985/01/01	unlimited with 02.04.2020
ELEVIT® PRONATAL tablettas	1 tablettas contains: vitamin A - 3600 IU, vitamin B1 -1.6 mg, vitamin B2 - 1.8 mg, vitamin B6 - 2.6 mg, vitamin B12 - 4 µg, vitamin C - 100 mg, vitamin D3 - 500 MO, vitamin E - 15 mg, calcium pantothenate - 10 mg, biotin - 0.2 mg, nicotinamide - 19 mg, folic acid - 0.8 mg, calcium -	Drazenopharm Apotheke Püschel GmbH, Germany	UA/9996/01/01	unlimited with 05.07.2019

	125 mg, - 100 mg, phosphorus - 125 mg, iron - 60 mg, zinc - 7.5 mg, manganese - 1 mg, copper - 1 mg			
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Table 2 provides an overview of the marketing analysis of a number of vitamin preparations on the market. Table 2 lists the trade names of the preparations, their dosage forms, active ingredient composition, manufacturers and countries of origin, as well as the registration certificate numbers and their expiry dates.

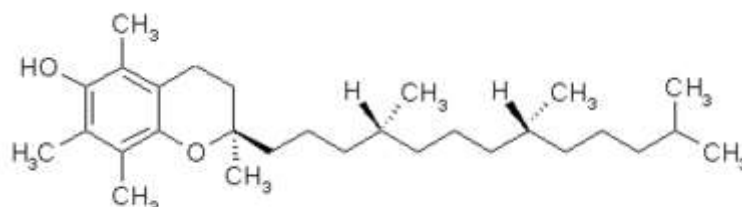
The preparations include various combinations of vitamins and minerals, such as vitamin C, vitamin A, vitamin E, B vitamins, as well as other active ingredients, such as  $\beta$ -carotene, lutein and zeaxanthin. The manufacturers of these preparations come from different countries, including Ukraine, India and Germany.

The registration certificates of the above preparations have different expiry dates: some preparations have an indefinite registration, others have a fixed period, ranging from several years to an indefinite status from the date of registration.

Table 2 helps in assessing the availability, regulatory status and composition of various vitamin products on the market, providing useful information for healthcare professionals and consumers.

It should be noted that tuberculosis, caused by the bacterium *M. tuberculosis*, is one of the deadliest infectious diseases of our time, along with HIV and malaria. Chemotherapy, the cornerstone of the fight against tuberculosis, is under threat from the emergence of strains of *M. tuberculosis* that are resistant to many, if not all, of the existing drugs. Isoniazid, rifampicin, pyrazinamide, and ethambutol are used to treat drug-susceptible tuberculosis for two months, followed by four months of isoniazid and rifampicin, but chemotherapy with potentially harmful side effects is sometimes required to treat multidrug-resistant tuberculosis for two years. Chemotherapy can be significantly reduced with drugs that kill *M. tuberculosis* more quickly while limiting the emergence of drug resistance. Regardless of the target action, bactericidal drugs usually kill pathogenic bacteria (Gram-negative and Gram-positive) by producing hydroxyl radicals through the Fenton reaction. Researchers have focused on vitamins with bactericidal properties to address this growing problem worldwide and have found that these vitamins are effective when used in conjunction with first-line drugs. The presence of high iron content, generation of reactive oxygen species, and DNA damage contributed to the sterilizing effect of vitamin C on *M. tb* in vitro. In addition, it has pleiotropic effects on a variety of biological processes such as detoxification, protein folding – chaperones, cell wall processes, signaling pathways, regulation, virulence, metabolism, etc. [32].

### Tocopheryl Acetate (Vitamin E)



Tocopherol acetate, also known as vitamin E, is a powerful antioxidant that has several important functions in the body, including protecting cells from damage, promoting blood circulation, and strengthening the immune system.

#### *Biological role of Tocopherol Acetate*

**Antioxidant Properties.** Tocopherol acetate acts as an antioxidant, protecting cells from damage caused by free radicals. This is especially important for patients with tuberculosis, as the disease can lead to oxidative stress, which can increase inflammation and contribute to tissue damage.

*Benefits of Tocopherol Acetate in the treatment of tuberculosis*

**Protection from Oxidative Stress.** Tocopherol acetate helps protect the body's cells from damage caused by oxidative stress, which can occur as a result of tuberculosis. This can improve the effectiveness of treatment and prevent complications of the disease. Tocopherol acetate helps improve blood circulation, which can be beneficial for TB patients because it helps deliver oxygen and nutrients to damaged tissues, helping them heal faster.

*Supporting the immune response*

Tocopherol acetate strengthens the immune system, which helps the body fight infection and prevent complications. This is especially important for TB patients because the disease can weaken their immune system. Tocopherol acetate supports the functioning of the immune system by strengthening the body's defenses. This can help TB patients fight the pathogen and prevent complications from the disease.

*Improving overall health*

Tocopherol acetate helps improve overall health, which can help TB patients recover faster and improve their quality of life.

*Conclusion*

Tocopherol acetate (vitamin E) is an important component of supportive TB treatment. Its antioxidant properties, immune system support, and overall health benefits can help patients manage this condition and improve treatment effectiveness.

**Table 3.** Tocopheryl Acetate (Vitamin E) Marketing Analysis.

<b>Trade name/dosage form</b>	<b>Composition of active substances</b>	<b>Manufacturer/ Country</b>	<b>No registration certificate</b>	<b>Validity from/to</b>
VITAMIN E capsules	1 capsule contains 100 mg	"KYIV VITAMINY ZAVOD" JSC, Ukraine	UA/0717/01/01	unlimited with 16.08.2018
VITAMIN E capsules	1 capsule contains 200 mg	"KYIV VITAMINY ZAVOD" JSC, Ukraine	UA/0717/01/02	unlimited with 16.08.2018
VITAMIN E capsules	1 capsule contains 400 mg	"KYIV VITAMINY ZAVOD" JSC, Ukraine	UA/0717/01/03	unlimited with 16.08.2018
VITAMIN E OIL solution oleosum	not less than 96.5% and not more than 102.0%	Zhejiang NHU Company Ltd., China	UA/13966/01/01	unlimited with 30.05.2019
VITAMIN E-HEALTH capsules	1 capsule contains 100 mg	Limited liability company "Pharmaceutical company "Zdorovya", Ukraine	UA/16044/01/01	unlimited with 09.11.2021

VITAMIN E- HEALTH capsules	1 capsule contains 200 mg	Limited liability company "Pharmaceutical company "Zdorovya", Ukraine	UA/16044/01/02	unlimited with 09.11.2021
VITAMIN E- HEALTH capsules	1 capsule contains 400 mg	Limited liability company "Pharmaceutical company "Zdorovya", Ukraine	UA/16044/01/03	unlimited with 09.11.2021
DL- $\alpha$ - TOCOPHEROL ACETATE solution oleosum	from 96.5% to 102.0%	DSM Nutritional Products Ltd., Switzerland	UA/19518/01/01	07.07.2022 07.07.2027
DL- $\alpha$ - TOCOPHEROL ACETATE solution	from 96.5% to 102.0%	BASF CE, Germany	UA/19538/01/01	18.07.2022 18.07.2027
VITAMIN E OIL solution oleosum	not less than 96.5% and not more than 102.0%	Zhejiang Medicine Co. LTD., Xinchang Pharmaceutical Factory, China	UA/3747/01/01	unlimited with 29.05.2019
VITAMIN E ACETATE	not less than 96.5% and not more than 102.0%	BASF CE, Germany	UA/6069/01/01	unlimited with 28.04.2017
solution oleosum	1 g contains 500 mg	DSM Nutritional Products Ltd., Switzerland	UA/6373/01/01	unlimited with 04.07.2017
DRY VITAMIN E 50%, pulveris	1 ml contains 50 mg	Technolog PJSC, Ukraine	UA/6656/01/01	unlimited with 04.09.2017
ALPHA- TOCOPHEROL ACETATE (VITAMIN E) solution oleosum	1 ml contains 100 mg	Technolog PJSC, Ukraine	UA/6656/01/02	unlimited with 04.09.2017
ALPHA- TOCOPHEROL ACETATE (VITAMIN E) solution oleosum	1 ml contains 300 mg	Technolog PJSC, Ukraine	UA/6656/01/03	unlimited with 04.09.2017
ALPHA- TOCOPHEROL ACETATE (VITAMIN E) solution oleosa	1 capsule contains 400 IU	Mega Lifesciences Public Company Limited, Thailand	UA/9439/01/01	unlimited with 12.08.2019

ENAT 400 capsules	1 capsule contains 200 IU	Mega Lifesciences Public Company Limited, Thailand	UA/9439/01/03	09.04.2020 09.04.2025
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This table contains data on various trade names and forms of vitamin E, their active ingredient composition, manufacturers and countries of origin, registration certificates and their validity periods.

- Forms of release: capsules and oil solutions.
- Composition: capsules contain 100 mg, 200 mg or 400 mg of vitamin E; oil solutions have a concentration of 96.5% to 102.0%.
- Manufacturers: companies from Ukraine, China, Switzerland, Germany and Thailand.
- Countries of origin: Ukraine, China, Switzerland, Germany, Thailand.
- Registration certificates: all products have certificates with different validity periods, some of which are indefinite, others have specific start and end dates of action.

**Conclusions.** In this paper, the author considers the role of antioxidant vitamins in the prevention and pharmacotherapy of tuberculosis. Summarizes the available evidence and open questions regarding their use. The aim of the study is to discuss the potential benefits and opportunities for the use of antioxidant vitamins A, C and E in the pharmacotherapy of tuberculosis, especially among individuals at high risk of Mycobacterium tuberculosis infection and active tuberculosis. To achieve this goal, the author conducted a retrospective and marketing analysis using leading scientific databases, such as PubMed, Scopus, Google Scholar, EMBASE, as well as resources from the Cochrane Library and WHO. The literature search covered the period from 1950 to 2024. The results of the analysis indicate the potential benefits of antioxidant vitamins in the prevention and treatment of tuberculosis. Vitamins A, C and E are known for their antioxidant properties and ability to support the immune system, which makes them important for combating tuberculosis infection. Marketing analysis of the antioxidant vitamin market in Ukraine allowed us to determine their availability and popularity among the population and medical institutions. The study provides valuable conclusions for medical practice and may become the basis for further research in this area to improve the prevention, diagnosis, and pharmacotherapy of tuberculosis.

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