ENVIRONMENTAL AND ECONOMIC RATIONALE FOR EXTRACTING BIOACTIVE COMPOUNDS FROM TOMATO PROCESSING WASTE AND THEIR DEMAND IN THE COSMETIC INDUSTRY

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Annotatsiya. Ushbu maqola pomidorni qayta ishlash sanoatida hosil bo‘ladigan chiqindilardan- po‘stloq, urug‘ va pulpadan- biologik faol birikmalar (BFM)-karotenoidlar, polifenollar, tolalar va yog‘lar ajratib olishning sanoatdagi ahamiyatiga, ekologik va iqtisodiy zaruriyatiga bag‘ishlangan. Ularni qayta ishlash orqali ekologik muhitga bo‘ladigan salbiy ta’sirni kamaytirish va iqtisodiy foyda olish mumkinligi asoslangan. Jumladan, ajratib olingan BFMning kosmetologiya sanoatida (ultrabinafsha nurlardan himoya va qarishga qarshi xususiyatlari tufayli) qo‘llanilishi, unga bo‘lgan talabning yuqori ekanligini isbotlaydi. Maqolada xalqaro va respublika miqyosida olib borilgan tadqiqotlar tahlil qilingan hamda O‘zbekistondagi me’yoriy hujjatlarning bu yo‘nalishdagi ahamiyati yoritilgan.

Kalit so‘zlari: pomidor chiqindilari, biologik faol moddalar, likopen, kosmetologiya sanaoati.

Аннотация. В данной статье рассмотрено промышленное значение, а также экологическая и экономическая необходимость извлечения биологически активных соединений (БАС) — каротиноидов, полифенолов, пищевых волокон и липидов — из отходов томатоперерабатывающей промышленности, включающих кожуру, семена и мякоть. Обосновано, что переработка этих отходов позволяет снизить негативное влияние на окружающую среду и получить дополнительную экономическую выгоду. В частности, показано, что извлечённые БАС обладают высоким потенциалом применения в косметологической промышленности благодаря своим защитным (УФ-фильтрация) и антивозрастным свойствам, что определяет высокий спрос на них. В статье проанализированы международные и республиканские исследования, а также освещено значение нормативных документов Республики Узбекистан в данном направлении.

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Ключевые слова: отходы томата, биологически активные вещества, ликопин, косметологическая промышленность.

Abstract. This article examines the industrial relevance, as well as the environmental and economic necessity, of extracting bioactive compounds (BACs)—carotenoids, polyphenols, dietary fibers, and lipids—from tomato processing waste, including peel, seeds, and pulp. It is substantiated that the valorization of such waste reduces negative environmental impact and provides additional economic benefits. In particular, the study demonstrates that the extracted BACs have high potential for use in the cosmetic industry due to their UV-protective and anti-aging properties, which explains the growing demand for these compounds. The article analyzes international and national research studies and highlights the importance of regulatory documents of Uzbekistan in this field.

Keywords: tomato waste, bioactive compounds, lycopene, cosmetic industry.

Introduction.

Tomato (Solanum lycopersicum) is one of the most widely cultivated and consumed vegetables worldwide, and its processing industry (purée, ketchup, tomato paste, juice, etc.) is highly developed. However, a significant amount of waste—peels, seeds, and pulp—is generated during processing, with approximately 5–10% of the raw material ending up as waste [1]. These wastes contain valuable bioactive compounds (BACs), such as lycopene, β-carotene, and tocopherols. The disposal or improper utilization of large volumes of tomato waste leads to environmental problems (contamination of groundwater, air pollution during burning) [2]. At the same time, not utilizing these valuable BACs results in economic losses.

Literature review. Numerous international studies have been conducted on tomato by-products. For instance, the article Valorization of Tomato By-Products: Advanced Extraction Methods and Bioprocessing of Bioactive Compounds and Functional Products analyzes the extraction of lycopene, β-carotene, polyphenols, and fibers from tomato peels, as well as their potential applications in food, pharmaceuticals, and cosmetics. Another study—Bioactive Compounds Extracted from Tomato Processing By-Products as a Source of Valuable Nutrients—reports that tomato industry waste contains lycopene, β-carotene, amino acids, fibers, and oils, and considers them as potential sources of functional foods or dietary supplements. Researchers identified carotenoids and phenolic compounds in peel extracts of more than 10 tomato varieties and emphasized their antioxidant and antimicrobial activity (e.g., Screening of Ten Tomato Varieties Processing Waste for Bioactive Components and Their Related Antioxidant and Antimicrobial Activities). In another study, Green Extraction of Carotenoids from Tomato By-products Using Sodium Dodecyl Sulphate, β-carotene and lycopene were

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successfully extracted from tomato peels. Lycopene is the major carotenoid in tomatoes and exhibits strong antioxidant activity [3]. Its health benefits—including the prevention of cardiovascular diseases and certain types of cancer—have been scientifically proven. Up to 80% of total lycopene in tomatoes is located in the peel [4]. Several researchers have also studied the SPF (sun protection factor) properties of lycopene extracted from tomato by-products and demonstrated its effectiveness when incorporated into cosmetic creams [5]. Another study showed that tomato seeds are rich in gluten (plant protein), making them suitable raw materials for functional food or cosmetic formulations [6].

In Uzbekistan, studies on the processing of agricultural waste and the extraction of BACs are also being conducted. Local researchers have investigated the prospects of using tomato by-products in food and pharmaceutical industries [7]. Their focus has primarily been on optimizing extraction methods and introducing technologies for obtaining BACs from local raw materials. These studies contribute to establishing a scientific basis for processing waste under local conditions.

Research Methodology. This scientific study is based on analytical and synthesis methods.

The research is a meta-analysis conducted through a systematic review of scientific literature. The following stages were performed:

1. Searching databases (ScienceDirect, PubMed, Web of Science, Google Scholar) using keywords such as “tomato by-products,” “waste valorization,” “tomato peel extract,” “lycopene extraction,” “cosmetics,” “bioactive compounds,” etc.

2. Giving priority to studies published between 2015 and 2025, as the last decade has seen significant advancements in “green extraction” methods.

3. Summarizing the selected articles based on raw material type (peel, seed, pulp), extraction method, extracted compounds, their quantity, and functional properties (antioxidant, pigments, fibers, oils).

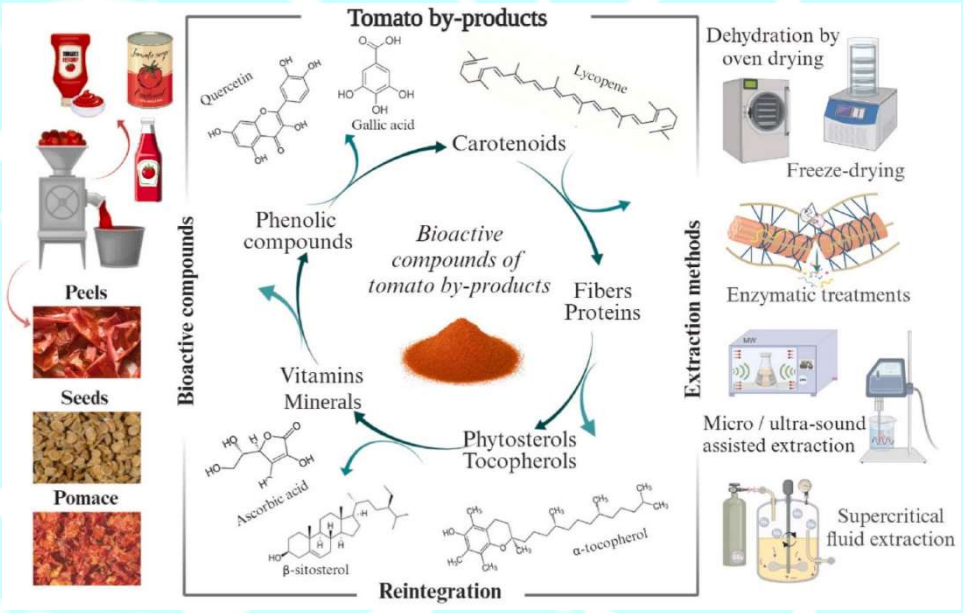
Analysis and results. The evaluated theoretical and experimental data confirm that extracts obtained from tomato peels exhibit antioxidant activity of approximately 201 ± 44 μmol Trolox/100 g DW [10].

Seed oil contains ~37.4 mg/100 mL lycopene and a high percentage of linoleic acid [11].

Extraction methods and efficiency: Green extraction methods—ultrasound, microwave, supercritical CO_2—are more efficient and environmentally friendly compared to conventional solvents [12]. For example, lycopene and other carotenoids were effectively extracted from peels using eco-friendly techniques [13]. Other studies reported that oleoresins derived from tomato peels can be

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microencapsulated, ensuring long-term stability and improved performance in formulations [14].



Picture 1. Nutrient and bioactive compound composition of tomato waste and various extraction methods [15]

Environmental and economic analysis: Failure to properly utilize wastes leads to environmental burden, increased waste volume, and the formation of unnecessary waste disposal sites [16]. In contrast, extracting bioactive compounds from wastes reduces their volume, converts waste into valuable products, creates new industrial sectors, increases employment, and generates additional income. The demand for natural pigments, antioxidants, and fiber-based ingredients is increasing in the cosmetics industry, expanding the market for bioactive extracts.

Importance in the cosmetics industry: Extracted lycopene, β-carotene, and polyphenols serve as potent antioxidants, slow skin aging, and are suitable for pigment-based and anti-aging cosmetic products. Fibers can be used in scrubs, peels, or skin-softening formulations. Oil extracts provide moisturizing and nourishing properties for creams and lotions. Furthermore, microencapsulation enhances the stability of extracts, ensures their long-term functionality in formulations, and improves their compatibility—an essential aspect in cosmetic production [17].

Conclusion and Recommendations. Based on the analysis of theoretical and practical data, the following conclusions were drawn: Tomato-processing waste is a valuable source of biologically active compounds. Specifically, tomato peel, seeds, and pulp are biologically rich resources, containing lycopene, β-carotene, polyphenols, fibers, and oils in concentrations suitable for cosmetic applications, as well as valuable raw materials for other industries. Green extraction methods enable the efficient and environmentally friendly recovery of bioactive

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compounds. This approach helps reduce waste, protect the environment, create economic benefits, and introduce new industrial opportunities.

The use of tomato waste for producing cosmetic products is economically and ecologically advantageous. The demand for natural, eco-friendly, and anti-aging products is rising in the cosmetics industry. Lycopene is an ideal bioactive compound satisfying these requirements. Its main cosmetic applications include:

1. Antioxidant: Protects the skin from stress by neutralizing free radicals [8].

2. UV protection: Acts as a natural photoprotective agent (as an additional component in sunscreens).

3. Collagen synthesis stimulation: Increases skin elasticity and slows wrinkle formation [9].

These findings show that each component of tomato waste can yield valuable products for cosmetic use. Given the strong antioxidant and anti-aging properties of lycopene, tomato wastes represent an excellent natural raw material for the cosmetics industry—especially in sunny regions such as Uzbekistan. Therefore, for practical implementation, we selected the tomato cultivars commonly processed in Uzbekistan as the research focus.

Recommendations: Promote investment projects for implementing a "zero-waste" concept in Uzbekistan's fruit and vegetable processing enterprises.

Develop state programs for introducing efficient and eco-friendly technologies (such as supercritical fluid extraction, SFE) for industrial-scale production of lycopene and other BACs from tomato waste.

Provide incentives to local cosmetic manufacturers to encourage the production of BAC-based products derived from tomato waste.

Strengthen collaboration between research institutions and educational organizations in training specialists in agricultural waste processing.

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