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A Review on Benefits of Lycopene in Formulation of Sunscreen

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Abstract: *Lycopene which is a carotenoid found in tomatoes and other red and orange fruits, has shown benefits in dermatology and photoprotection. It is a powerful antioxidant and has been proposed as a potential ingredient for sunscreen preparations designed to reduce UV-induced skin damage. The review will discuss the available data regarding the activity of lycopene in sunscreen formulations, mainly in relation to mechanism of action, performance.*

The photoprotective properties of lycopene depend on its free radical scavenger activity and capacity for neutralizing ROS, produced upon UV activation. ROS plays a key role in damage to structures within skin through DNA mutations, inflammation, photo-ageing, and enhanced risk for skin cancer. Lycopene has antioxidant properties and the capacity to absorb UV radiation in the UVA and UVB spectrum, making it an interesting ingredient in fortified sunscreens. Several in vitro and in vivo studies have shown that lycopene can significantly reduce erythema, DNA damage, and oxidative stress after UV exposure, making it an interesting potential preventive agent against both acute sunburn and chronic, cumulative damage associated with long-term skin ageing.

Lycopene remains a highly promising natural photoprotective agent; however, additional clinical studies and safety assessments must be undertaken to establish the best use of lycopene as a participant in the composition of sunscreen ingredients.

Keywords: Lycopene, Tomato Extract, herbal sunscreen, sunscreen formulation

I. INTRODUCTION

Carotenoids were first discovered in biological tissues during the nineteenth century, when W.H. Wackenroder isolated carotene for the first time in 1831, from carrot roots. During the period 1873–1927 that lycopene was separated from other carotenoids by Harsten and R. M. Willstatter, who isolated 11 g of lycopene from 75 Kg of tomatoes. lycopene may act as an antioxidant, trapping reactive oxygen species (ROS), increasing the overall antioxidant potential, or reducing the oxidative damage to lipids, proteins, and deoxyribonucleic acid (DNA), thereby lowering oxidative stress, which may lead to a reduced risk for cancer and cardiovascular disease (CVD) with an anticarcinogenic and antiatherogenic effect. Alternatively, the increased lycopene status in the body may regulate gene functions and metabolism, improve intercellular communication, and modulate hormone and immune response, thus lowering the risk for different chronic diseases. These mechanisms may also be interrelated and may act simultaneously to provide health benefits. However, the exact mechanisms of action of lycopene are still not clearly understood.

Tomato

Tomatoes are rich in various phytochemicals and nutrients. These include lycopene, potassium, iron, folate, and vitamin C. Additionally, tomatoes contain other antioxidants such as beta-carotene, and phenolic compounds like flavonoids, hydroxycinnamic acid, chlorogenic acid, homovanillic acid, and ferulic acid.

Biological name: Solanum lycopersicum.[1]

In this review paper the benefits of tomato extract specifically containing lycopene on protection against UV radiation, its anti-oxidant property and more will be included.

Tomatoes, botanically a fruit, are packed with numerous health benefits, making them a versatile addition to a healthy diet. Lycopene, a potent antioxidant found in tomatoes, plays a key role in combating cancerous cell growth and various other health issues. It neutralizes free radicals, which are harmful molecules in the body. The high lycopene content in

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tomatoes, which gives them their deep red color, is unmatched by other fruits and vegetables. Medical studies consistently highlight the extensive health advantages of tomatoes, including reducing risks of cancer, heart disease, and high cholesterol. Consuming tomatoes regularly can help prevent cancers such as prostate, cervical, colon, rectal, stomach, mouth, throat, and esophageal cancers.[2]

Benefits of Tomatoes

1. Lower Cholesterol: Cholesterol-free and rich in niacin (vitamin B3) and fiber, tomatoes help reduce cholesterol levels.
2. Lower Blood Pressure: Regular tomato intake (lycopene complex) significantly lowers blood pressure.
3. Protection from Cell Damage: Antioxidant-rich tomatoes neutralize harmful free radicals, reducing disease risk.
4. Counteract Acidosis: Tomatoes provide essential minerals like calcium, magnesium, and potassium, helping maintain alkaline balance and prevent acidosis.

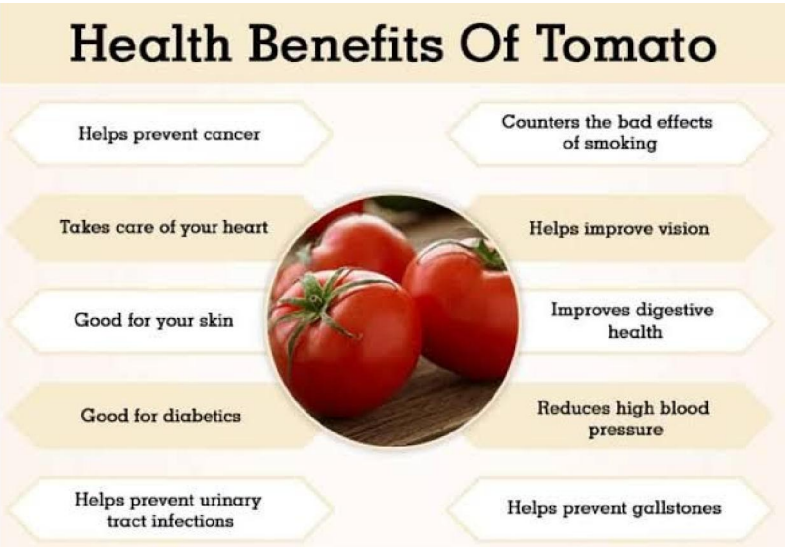

Figure 1 Benefits of tomato

5. Treatment of Vasodilation: Vitamin C in tomatoes aids blood vessel dilation, improving cardiovascular health.
6. Lead Toxicity: High in vitamin C, tomatoes help reduce lead toxicity, particularly in children.
7. Eye Disorder: Vitamin C in tomatoes improves blood flow to the eyes, reducing cataract risk.
8. Cancer: Increased consumption of tomatoes lowers the risk of various cancers due to their high vitamin C content.
9. Combating Stroke: Vitamin C in tomatoes helps maintain blood pressure levels and reduces stroke risk. [3]

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Nutritional Values:

Tomato fruit, classified as a fleshy berry, exhibits a diversity of sizes and colors. It is predominantly composed of water (>90%), with minimal protein and fat content, and approximately 3% carbohydrates (primarily glucose and fructose). The nutrient composition of a typical round tomato, in relation to recommended daily intakes, is illustrated in the accompanying figure.

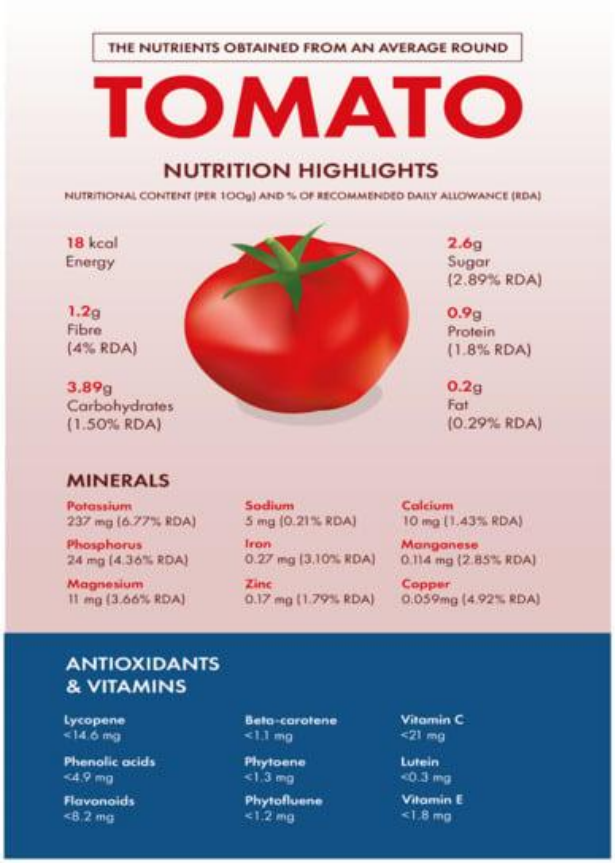

Figure 2 Nutritional values of tomato

Anatomical Structure

- Pericarp: The tomato pericarp consists of an outer exocarp, inner mesocarp, and endocarp.
- Exocarp (Epidermis): Characterized by a thin cuticle devoid of stomata, with an increasing phenolic content during growth. The cuticle primarily comprises a lipid polymer (cutin) and waxes, exhibiting complexity and variability.
- Mesocarp: Contains fruit vascular tissue connected to the pedicel vascular tissue, facilitating water and mineral transport.
- Endocarp: Within the unicellular boundary are locules, seed-containing cavities derived from carpels. The number of locules can vary, affecting the fruit's size and shape. These locules are divided by a septum, with seeds attached to an elongated axial placenta.[4]

Phytochemical Content

Tomato seeds contain steroidal saponins, known as lycoperoside H, which are attributed with anti-inflammatory properties.

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UV-radiation protection property:

Tomatoes possess significant anti-UV radiation properties primarily due to their high content of lycopene, a potent antioxidant.

- UV Absorption: Lycopene can absorb UV radiation, reducing the penetration of harmful rays into the skin.
- Antioxidant Activity: It neutralizes free radicals generated by UV exposure, preventing oxidative stress and cellular damage.
- Anti-Inflammatory Effects: Lycopene helps reduce inflammation caused by UV radiation, soothing the skin.[5]

Lycopene is a key component in tomatoes that provides significant protection against UV radiation. This powerful antioxidant absorbs UV rays, preventing them from penetrating the skin and causing damage. Lycopene also neutralizes free radicals generated by UV exposure, reducing oxidative stress and preventing cellular damage. Additionally, it has anti-inflammatory properties that soothe the skin after sun exposure.

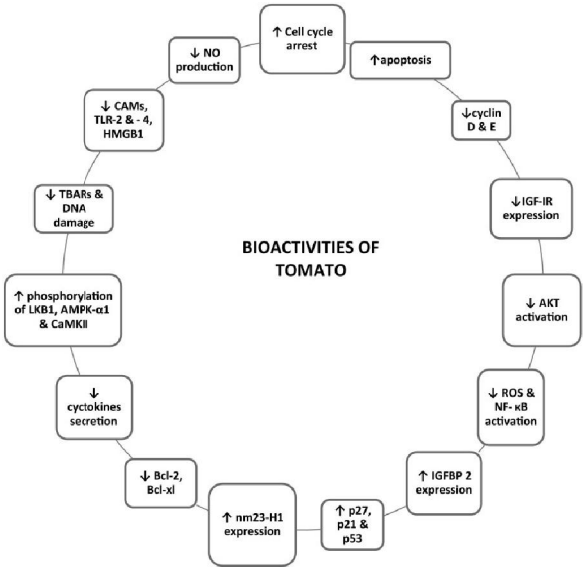

Figure 3 Bioactivities of tomato

Lycopene

Chemistry:

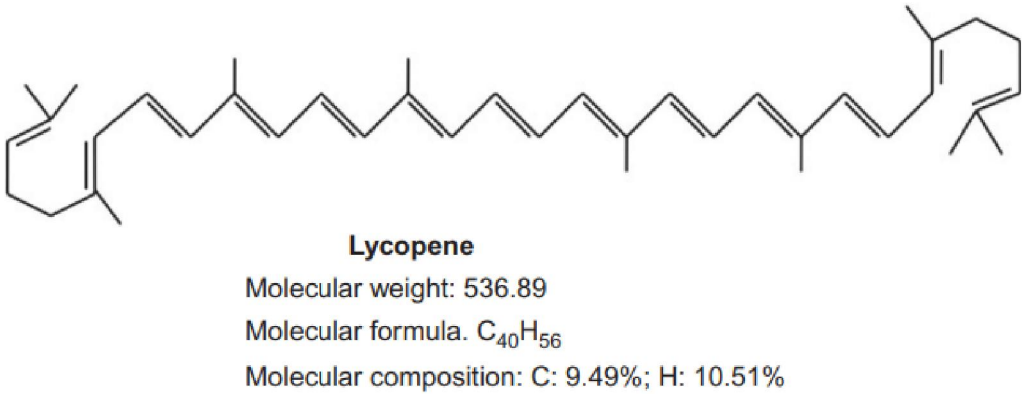

Figure 4 Lycopene

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Lycopene is a lipophilic red carotenoid pigment in nature. It is composed of eight isoprene units (octaprene) joined by regular head-to-tail bonds, except in the middle where the bond is tail-to-tail which results in a symmetric structure. It works as the prototype for other carotenoids formed through cyclizations, oxidations, or reductions. Lycopene's ability to absorb light in UV-visible spectrum is due to its 11 conjugated double bond system.

Lycopene is insoluble in water, nearly insoluble in methanol and ethanol, but soluble in organic solvents such as carbon disulfide, ethyl ether, petroleum ether, chloroform, and benzene. Over 72 lycopene isomers have been identified, including all-trans-lycopene, neolycopene A (6-cis-lycopene), 5-cis-lycopene, and various cis-lycopene forms. Naturally, lycopene is predominantly found in the all-trans form, which can isomerize to mono-cis or poly-cis forms when exposed to heat, light, oxygen, acids, catalysts, and metal ions. The cis form is less thermostable. Studies indicate that lycopene from natural sources like tomatoes is more stable than isolated lycopene.[6]

Metabolism and Bioavailability

After ingestion, lycopene is rapidly absorbed in the intestine at a rate of 7-10% along with dietary fats and is distributed throughout various tissues in the body. This process is facilitated by protein-mediated transport mechanisms, which become saturated at low doses of lycopene (less than 30 mg). Human intervention studies have shown that plasma concentrations of 4-11 mg/dL are reached within 15-32 hours after consuming 10-30 mg/day. Higher intakes, up to 120 mg/day, do not further increase plasma lycopene levels.[6]

In food, all-trans-lycopene is the dominant form, but cis-lycopene isomers exhibit higher bioavailability. This is attributed to their shorter molecular length, reduced precipitation in the gastrointestinal tract, and higher solubility in bile micelles, which facilitates their incorporation into chylomicrons. Significant isomerization to cis-lycopene occurs during or after absorption, explaining the higher plasma levels of these isomers.

The food matrix, processing methods, and presence of other dietary substances can influence lycopene bioavailability. Studies have demonstrated comparable bioavailability from various tomato-based products, including lycopene-rich juice, tomato oleoresin, supplements, and synthetic sources. Mild heating and particle size reduction enhance lycopene absorption by releasing it from the cellular matrix and promoting isomerization to more bioavailable cis-forms. The presence of fats in tomato products and concurrent consumption of beta-carotene also enhance lycopene absorption, whereas factors that inhibit fat absorption reduce lycopene uptake.

Lycopene is efficiently absorbed in the intestine alongside dietary fats, facilitated by protein-mediated transport mechanisms which saturate at low doses. After ingestion, plasma levels peak around 6 hours and have a half-life of 12-20 hours. Factors like alcohol consumption and smoking can influence these levels.

Primarily stored in the liver, lycopene also accumulates in lipid-rich tissues such as adipose tissue, adrenal glands, prostate, kidneys, and ovaries. Despite being ingested mainly in the all-trans form, lycopene isomerizes to the more bioavailable cis-forms during metabolism, producing various epoxides.

Lycopene is excreted mainly through feces, with smaller amounts found in urine and via sebaceous glands. Its lipid solubility allows efficient transfer through breast milk, benefiting breastfed infants.

Generally well-tolerated, excessive lycopene intake may cause lycopenemia, a reversible condition resulting in yellowish-orange skin pigmentation without health risks. No adverse effects have been observed during pregnancy according to animal studies. The no-observed-adverse-effect level (NOAEL) for lycopene is 3 g/kg/day, significantly higher than typical intake levels. Lycopene from natural and synthetic sources is recognized as safe (GRAS) for use in foods at concentrations of 0.5-7%.[6]

Mechanism of Action:

The various physiological mechanisms of action documented for lycopene in scientific research, the most extensively studied includes its protective effects against oxidative damage, its benefits for cardiovascular health, and its antineoplastic (anti-cancer) properties.

Antioxidant Activity:

Oxidation processes involve electron transfer reactions, typically occurring enzymatically, such as in the mitochondria during respiration. These reactions are crucial for producing adenosine triphosphate (ATP), the energy currency of the

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cell, along with carbon dioxide and water. However, this process is not entirely efficient and also generates reactive oxygen species (ROS), which are highly reactive molecules capable of damaging various biological structures.

During cellular respiration, oxygen is consumed, and while most of it is used efficiently, a small percentage (between 1% and 3%) is converted into ROS. These free radicals, which have unpaired electrons, can cause significant damage to proteins, lipids, and DNA. The body has developed antioxidant systems to counteract these harmful effects. These systems are divided into two main categories: enzymatic antioxidants, such as catalase and superoxide dismutase, and nonenzymatic antioxidants, including vitamins and other dietary compounds.

Despite the efficiency of the endogenous antioxidant system, it is not sufficient on its own. Therefore, the human body relies on antioxidants obtained from the diet to maintain a balance and prevent oxidative stress. Some of the most important dietary antioxidants include carotenoids (like lycopene), phenolic compounds, vitamin C (ascorbic acid), and vitamin E (alpha-tocopherol).

Lycopene, a powerful antioxidant found in tomatoes and other red fruits, is particularly effective in neutralizing ROS. It is twice as efficient as beta-carotene in quenching singlet oxygen, a type of ROS. Lycopene's chemical structure, characterized by conjugated double bonds, allows it to capture and neutralize ROS, thereby protecting cells from oxidative damage. This antioxidant action is crucial in preventing and mitigating various diseases that originate from oxidative stress, such as cardiovascular diseases and certain types of cancer.

Antineoplastic Activity:

Most of lycopene's antineoplastic activity may beattributed to its antioxidant properties. However, other mechanisms underlying the inhibitory effects of lycopene on carcinogenesis have been described,such as upregulation of detoxification systems, interference with cell proliferation, induction of gap junctional communication (GJC), inhibition of cellcycle progression, and modulation of signal transduction pathways. The antineoplastic activity of lycopene may be due to its inhibition ofDNA synthesis. Lycopene strongly inhibited proliferation of endometrial(Ishikawa), mammary (MCF-7), and lung (NCI-H226) human cancer cellswith the half-maximal inhibitory concentration of 1–2 mM; lycopene also suppressed insulin-like growth factor-I-stimulated growth. Inhibition of cell proliferation by lycopene may involve a modulation of protein kinase C (PKC)activity, which is important in the signal transduction pathway leading to cell proliferation. Thus, inhibition of proliferation might also be linked tolycopene's antioxidant effect.Modulation of intercellular communication, which has been demonstratedin cell cultures, may be another mechanism for the antiproliferative effect oflycopene. The scientific findings show that lycopene differentially modulatesgap-junctional intercellular communication (GJIC) depending on the dose,with beneficial effects on cell communication. Lycopene may stimulate GJC through stabilization of connexin43 mRNA.Another postulated mechanism for the antiproliferative effect of lycopeneis inducing differentiation of cancer cells. This induction of differentiation hasbeen observed in leukemic cell cultures exposed to a combination of bothlycopene and 1,25 dihydroxyvitamin D3.In breast and endometrial cancer, lycopene's mechanism of action is based onthe inhibition of cell cycle progression associated with reduction in cyclin D levelsand retention of p27Kip1 in the cyclin E binds to G1 phase—cyclin-dependentkinase 2 (E-cdk2) complexes. In prostate cancer, different mechanisms are proposed for the inhibition of cancerous cell proliferation at the G0–G1 cell cycletransition and protection of DNA.[6]

Efficacy of Lycopene in Sunscreen:

1. UV Protection: Lycopene has been shown to absorb UV radiation, particularly UVB rays, which are responsible for sunburn and skin damage. This absorption helps reduce the penetration of harmful rays into the skin.[7]
2. Enhanced Sun Protection Factor (SPF): Studies have demonstrated that incorporating lycopene into sunscreen formulations can enhance the overall SPF4. This means thatsunscreens containing lycopene provide better protection against UV-induced skin damage.[7]
3. Synergistic Effects: Lycopene works well with other sun-protective ingredients, such as zinc oxide and titanium dioxide, to provide a more comprehensive defense against UV radiation.[8]

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Benefits of Lycopene in Sunscreen:

1. Antioxidant Properties: Lycopene is a potent antioxidant that helps neutralize free radicals generated by UV exposure. This reduces oxidative stress and cellular damage, preventing premature aging and maintaining skin health.[9]
2. Anti-Inflammatory Effects: Lycopene has anti-inflammatory properties that help soothe the skin and reduce redness and irritation caused by sun exposure. This makes it beneficial for individuals with sensitive or acne-prone skin.[9]
3. Improved Skin Health: Regular use of lycopene-enriched sunscreens can improve skin texture, elasticity, and hydration. It supports collagen production, which is essential for maintaining youthful and firm skin.[8]
4. Natural and Safe: Lycopene is a natural ingredient, making it an attractive option for those seeking cleaner and more organic skincare products. It is generally well-tolerated and recognized as safe (GRAS) for use in various food and cosmetic products.[8]
5. Enhanced Bioavailability: The presence of fats in sunscreen formulations can improve the absorption of lycopene, enhancing its efficacy1. This is similar to how dietary fats enhance lycopene absorption in the body.[8]

Synergistic Effect:

Enhanced UV Protection

Lycopene, a potent antioxidant, works alongside traditional UV filters like zinc oxide and titanium dioxide to provide a broader spectrum of UV protection. While these physical sunscreens block UV rays, lycopene absorbs and neutralizes UV-induced free radicals, reducing oxidative stress and cellular damage.

Reduced Oxidative Stress

Combining lycopene with sunscreen ingredients has been shown to reduce oxidative stress on the skin. Studies indicate that formulations containing lycopene and other carotenoids can lower the levels of reactive oxygen species (ROS) generated by UV exposure. This dual action helps in preventing premature aging and maintaining skin health.[10]

Improved Skin Health:

The anti-inflammatory properties of lycopene complement the protective effects of sunscreens. By reducing inflammation and redness caused by sun exposure, lycopene enhances the overall soothing effect of sunscreen, making it more comfortable for daily use.

Better Absorption and Stability:

Lycopene's lipid-soluble nature improves the absorption of sunscreen ingredients into the skin. This enhanced absorption ensures that the active ingredients are more effectively delivered to the skin, providing better protection. Additionally, lycopene's stability in formulations helps maintain the efficacy of the sunscreen over time.

Natural and Safe

As a natural ingredient, lycopene is well-tolerated and recognized as safe (GRAS) for use in cosmetic products. Its inclusion in sunscreens appeals to consumers seeking cleaner and more organic skincare options.[10]

Safety and Suitability:

Safety of Lycopene in Sunscreen

Natural and Non-Toxic: Lycopene is a natural compound found in tomatoes and other red fruits. It is non-toxic and well-tolerated by most people.[11][12]

No Adverse Effects: Studies have shown that lycopene does not

cause adverse effects when used in topical applications. It is recognized as safe (GRAS) by regulatory authorities for use in food and cosmetic products.[13]

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Low Risk of Allergic Reactions: Lycopene has a low risk of causing allergic reactions, making it suitable for sensitive skin types.[12]

No Hormonal Disruption: Research indicates that lycopene does not disrupt hormonal balance, which is an important consideration for sunscreen ingredients.[13]

Suitability of Lycopene in Sunscreen:

1. Enhanced UV Protection: Lycopene provides additional UV protection by absorbing UV rays and neutralizing free radicals generated by UV exposure. This makes it a valuable addition to sunscreen formulations.[11]
2. Antioxidant Properties: As a potent antioxidant, lycopene helps reduce oxidative stress and cellular damage caused by UV radiation. This contributes to healthier skin and prevents premature aging.[11]
3. Improved Skin Health: Regular use of lycopene-enriched sunscreens can improve skin texture, elasticity, and hydration. It supports collagen production, which is essential for maintaining youthful and firm skin.[12]
4. Natural Appeal: Consumers seeking cleaner and more organic skincare options appreciate lycopene's natural origin and its inclusion in sunscreens.[11]

Market Potential for sunscreens containing lycopene:

1. Market Growth:

- Rising Demand: The global lycopene market is expected to grow at a compound annual growth rate (CAGR) of around 5% from 2023 to 2032[14]. This growth is fueled by the surging demand for natural ingredients in personal care products.[15]
- Health Consciousness: Consumers are becoming more health-conscious and are seeking products with added health benefits, such as antioxidants and anti-aging properties.[14]

2. Market Value:

- Current Value: The global lycopene market was valued at approximately USD 154 million in 2023 and is projected to reach USD 241.78 million by 2032.[14]
- Product Applications: Lycopene is used in various applications, including food and beverages, dietary supplements, pharmaceuticals, and personal care products.[15]

3. Consumer Trends:

- Preference for Natural Ingredients: There is a growing trend towards natural and organic skincare products.[14] Lycopene, being a natural compound, fits well into this trend.
- Antioxidant Benefits: The antioxidant properties of lycopene make it an attractive ingredient for sunscreens, as it helps protect the skin from oxidative stress and UV damage.

4. Competitive Advantage:

- Synergistic Effects: Sunscreens containing lycopene offer enhanced UV protection and additional health benefits, giving them a competitive edge in the market.
- Innovative Formulations: Companies are developing innovative formulations that combine lycopene with other protective ingredients, appealing to consumers looking for comprehensive sun protection.

II. CONCLUSION

Lycopene present in tomato which is a carotenoid in nature shows prominent effect against UV radiation due its antioxidant property. It can be used as an active ingredient in formulation of sunscreen in the current growing market where consumers are concern about their health and wishes to use herbal products.

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REFERENCES

[1]. Lal B. A review study on tomato and its health benefits. Asian Journal of Research in Social Sciences and Humanities. 2021;11(12):197–202. DOI: 10.5958/2249-7315.2021.00337.3 https://aijsh.com/wp-content/uploads/2022/01/12.-35-Bajrang-Lal-FULL.pdf

[2]. Collins EJ, Bowyer C, Tsouza A, Chopra M. Tomatoes: An Extensive Review of the Associated Health Impacts of Tomatoes and Factors That Can Affect Their Cultivation. Biology. 2022 Feb 4;11(2):239. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8869745/

[3]. https://www.lybrate.com/topic/benefits-of-tomato-and-its-side-effects

[4]. D.Rančić, Quarrie SP, Ilinka Pecinar. Anatomy of tomato fruit and fruit pedicel during fruit development. 2010 Oct 1;2. Available from: https://www.researchgate.net/publication/262523007_Anatomy_of_tomato_fruit_and_fruit_pedicel_during_fruit_development

[5]. Kurzawa M, Wilczyńska E, Brudzyńska P, Sionkowska A. Total Phenolic Content, Antioxidant Capacity and UV Radiation Protection Properties of Marigold (Calendula officinalis), Carrot (Daucus carota), Tomato (Solanum lycopersicum) and Hop (Humulus lupulus) Extracts. Cosmetics. 2022 Dec 5;9(6):134. https://www.mdpi.com/2079-9284/9/6/134?form=MG0AV3

[6]. Cámara M, de Cortes Sánchez-Mata M, Fernández-Ruiz V, Cámara RM, Manzoor S, Caceres JO. Lycopene. Studies in Natural Products Chemistry. 2013;40:383–426. Available from :https://www.researchgate.net/publication/253802934

[7]. Sopyan I, Gozali D, Tiassetiana S. Formulation of tomato extracts (Solanum lycopersicum L.) as a sunscreen lotion. National Journal of Physiology, Pharmacy and Pharmacology [Internet]. 2017;1. Available from: https://www.ejmanager.com/mnstemps/28/28-1507541267.pdf?t=1670314890

[8]. https://www.dermatoljournal.com/articles/skin-health-properties-of-lycopene-and-melatonin.pdf?form=MG0AV3

[9]. Doctor's Desk. Lycopene: The Game Changer in Skincare Available from: https://www.clinikally.com/blogs/news/lycopene-the-game-changer-in-skincare?form=MG0AV3

[10]. Synergy between Carotenoids and sunscreen. Lycored research | Lycored. Lycored - Nutrients, Colors & Taste. 2022. Available from: https://www.lycored.com/synergy-between-carotenoids-and-sunscreen-lycored-research/?form=MG0AV3

[11]. Lycopene: antioxidant and sunscreen in one. Smartskincare.com. 2017. Available from:http://www.smartskincare.com/treatments/topical/lycopene.html?form=MG0AV3

[12]. WebMD Editorial Contributor. Health Benefits of Lycopene. WebMD. 2020.Available from: https://www.webmd.com/diet/health-benefits-lycopene?form=MG0AV3

[13]. An Article Review - Natural Sun Protection - Byte of Nutrition. Byte of Nutrition. 2020. Available from: https://byteofnutrition.com/article-review-lycopene/?form=MG0AV3

[14]. Straitsresearch.com. Available from: https://straitsresearch.com/report/lycopene-market/?form=MG0AV3

[15]. .Kiran Pulidindi, Ahuja K. Lycopene Market Size By Source (Natural, Synthetic), By Property (Health Ingredient, Coloring agent), By Application (Food & beverages, Personal care products, Dietary supplements, Pharmaceuticals), By Formulation & Global Forecast, 2022-2032. Global Market Insights Inc. 1970. Available from: https://www.gminsights.com/industry-analysis/lycopene-market?form=MG0AV3