



Prebiotic *Chlorella vulgaris*: A novel ingredient for skincare products targeting hyperpigmentation and acne

Dr. Reshma Mirajkar¹, Ms. Ankita Ingale², Mrunmayee Vanne³, Sanket Mane⁴, Janhavi Shinde⁵, Pravin Gade⁶, Pruthvirani Sakhare⁷

* Corresponding author :

reshma_m@aissmscop.com

ankita_ingale@aissmscop.com

mrunmayee13vanne@gmail.com

janhavis071@gmail.com

sanketmane2143@gmail.com

pravingade1771@gmail.com

pruthviranisakhare034@gmail.com

AISSMS College of Pharmacy, Near RTO, Kennedy Road, Pune, Maharashtra, India- 411001

ABSTRACT :

Dysbiosis of the skin microbiome contributes hyperpigmentation and acne, necessitating novel therapeutic approaches. This imbalance can be due to number of external, internal and medical factors. This review explores the potential of *Chlorella vulgaris* as a natural, prebiotic solution for hyperpigmentation and acne management, highlighting the importance of skin microbiome balance in maintaining healthy skin. (Zheung, Y., & Otto, M. 2022, March)(Byrd, A.L & Searge, J. A, 2018, January 15)

Keywords: *Chlorella vulgaris*, Human skin, Microbes, Anti – oxidant, Anti-inflammatory, Prebiotic and Probiotic

1. Introduction

The skin is the largest organ of the human body providing a protective barrier against external factors such as pathogens, UV radiations and environmental pollutants. It also controls loss of valuable fluids, prevents penetration of noxious foreign material and radiations, cushions against mechanical shock, regulates heat loss and transduces internal stimuli. The skin has 3 distinct layers 1) Epidermis 2) Dermis 3) Sub dermis from out to inwards. These layers contains more sub layers. (Cosmetic Science Technology Vol-3 & ; Grice, E.A, & Serge, J.A, 2011, March 6)

2. Discussion

Skin contains its own microbiome which helps regulate these functions. It consists of bacteria which by their diverse mechanism helps to regulate skin functions and keeps it healthy. These microbes kills the harmful microbes and maintains its balance. Providing prebiotics to these essential microbes helps to maintain skin health naturally. After the age of 20 the skin ageing is characterized by three ways:

- Decrease in Thickness
- Decrease in Firmness
- Decrease in Elasticity

Human skin is home to many microorganisms, known as skin flora or skin microbiota. There are about 1,000 different types of bacteria living on our skin, which come from 19 different groups. Most of these tiny living things live on the surface of our skin or in the roots of our hair.

Most of the bacteria on our skin are harmless and actually help us regulate skin function. They just live on our skin without doing any harm, they help us by keeping bad bacteria from growing. They can even help our skin fight off infections.

Previous studies have found that chlorellin, a mixture of fatty acids from the algae *Chlorella vulgaris*, can stop the growth of many types of bacteria. This includes both Gram-positive and Gram-negative bacteria.

In particular, linolenic acid, a type of fatty acid found in *Chlorella vulgaris*, has been shown to kill *Staphylococcus aureus*, a common cause of skin infections, and *Salmonella typhi*, and the bacteria that causes typhoid fever.

This makes *Chlorella vulgaris* a promising natural alternative to traditional antibiotics, with the potential to fight a wide range of infections. (Zheung, Y & Otto, M. 2022, March)(Grice, E. A. & Serge J.a. 2009, May29)(Boxberger, M & La Scola, B 2021, May 30)(Byrd A & Serge, J. A. 2018, January 15)(agricultural and biological sciences)(Ru, T.K, wahid 2020, February 24)

Fig 1 . Microbiome of skin

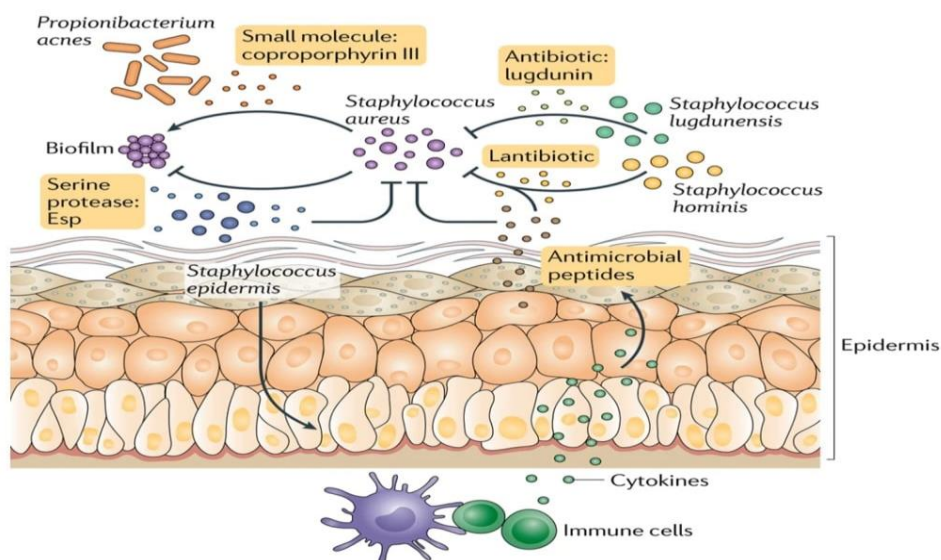


Table 1. Microbes and their mechanism of action. (Grice, E. A. & Serge J.a. 2009, May29)(Boxberger, M & La Scola, B 2021, May 30)(Grice, E. A, & Serge J. A, 2011, March16)

Microbe	Anti-bacterial molecule	Targeted microbe	Mechanism of action
<i>Cutibacterium acnes</i>	-Propionic acid	- <i>Candida albicans</i> , <i>MRSA</i> , <i>E.coli</i>	- Lowers local pH limiting the growth of several pathogens .Inhibits bacterial biofilm formation.
<i>Corynebacterium sp.</i>	Unidentified protein	<i>Staphylococcus aureus</i>	Inhibits the arg quorum sensing system and prevents agr-dependent virulence factor expression.
<i>Staphylococcus capitis</i>	Capidermicin	- <i>Lactococcus lactis</i> - <i>S. aureus</i> - <i>S. intermedius</i> - <i>S. pseudointermediis</i>	Forms pores in membranes Induces cell lysis
- <i>Staphylococcus epidermidis</i> - <i>S. hominis</i>	-Esp (Serine protease)	<i>S. aureus</i>	Inhibits biofilm formation
- <i>Staphylococcus lugdunensis</i> - <i>S. simulans</i> - <i>S. warneri</i>	Lugdunin (thiazolide containing cyclic peptide, AMP)	<i>S. aureus</i>	Direct killing and amplification of innate immune responses

Many synthetic drugs like antibiotics and natural sources containing essential oils are used to maintain this microbial balance. *Chlorella vulgaris* has been recorded as a new promising aspirant in this field. (Managing GSH elevation and hypoxia using nanocarriers)

Chlorella vulgaris, a microalga, is rich in various bioactive compounds, including:

Nutritional Components:

1. Proteins (50-70%): Essential amino acids, peptides, and polypeptides.
2. Carbohydrates (10-20%): Starch, glucose, and other polysaccharides.
3. Fiber (5-10%): Cellulose, hemicellulose, and lignin.
4. Fats (5-10%): Polyunsaturated fatty acids (PUFAs), omega-3, and omega-6.

5. Vitamins: B1, B2, B6, B12, C, D, E, and K.
6. Minerals: Calcium, iron, magnesium, phosphorus, potassium, and zinc. (Naggar NEA, Dalal SR. Production, Scientific reports 2020 Feb 20)

Bioactive Compounds:

1. Chlorophyll: Antioxidant, anti-inflammatory, and anti-cancer properties.
2. Phycocyanin: Antioxidant, anti-inflammatory, and anti-cancer properties.
3. Carotenoids (lutein, zeaxanthin, and beta-carotene): Antioxidant and anti-inflammatory effects.
4. Tocopherols (Vitamin E): Antioxidant and anti-inflammatory properties.
5. Polyphenols: Antioxidant, anti-inflammatory, and anti-cancer effects.
6. Polysaccharides: Immunomodulatory and anti-inflammatory properties.
7. Ubiquinone (Managing GSH elevation and hypoxia using nanocarriers)

Prebiotic and Probiotic Components:

1. Fructooligosaccharides (FOS): Prebiotic fiber.
2. Mannan: Prebiotic polysaccharide.
3. Galactomannan: Prebiotic polysaccharide.
4. Chlorella-derived probiotics (e.g., Chlorella-derived Lactobacillus). (Managing GSH elevation and hypoxia using nanocarriers)

Other Bioactive Compounds

1. Chlorellin: Antimicrobial peptide.
2. Chlorella-derived peptides: Antioxidant, anti-inflammatory, and anti-cancer properties.
3. Algal lectins: Immunomodulatory and anti-inflammatory effects.
4. Sulfated polysaccharides: Antiviral and anti-inflammatory properties. (Managing GSH elevation and hypoxia using nanocarriers)

Mechanisms of Chlorella vulgaris

1. Radical scavenging: Chlorella vulgaris's antioxidants neutralize free radicals by increasing thioredoxin expression in keratinocytes, protecting beneficial bacteria from oxidative stress. (Effect of chlorella vulgaris extract on skin)
2. Inhibition of melanogenesis: Chlorella vulgaris inhibits tyrosinase, a key enzyme used in melanin synthesis.
3. Protection against UV radiation: Chlorella vulgaris's extract absorbs UV radiation, preventing skin damage and hyperpigmentation. (Effect of chlorella vulgaris extract on skin)
4. Anti-inflammatory effect: It reduces inflammation which contributes to hyperpigmentation.
5. Increased collagen synthesis: It reduces MMP-1 expression in human skin cell fibroblasts which are responsible for breaking down collagen. Hence, by this mechanism Chlorella vulgaris helps maintain skin collagen thereby shows anti-wrinkle, anti-aging, anti-stretch mark properties. (Ferreira, M.S. & Almeida, I. F, 2021, August 17) (Effect of chlorella vulgaris extract on skin)

Skin Benefits:

The prebiotic and bioactive components of Chlorella vulgaris contribute to various skin benefits, including:

1. Improved skin barrier function
2. Reduced hyperpigmentation
3. Enhanced skin hydration
4. Reduced inflammation and acne
6. Improved skin elasticity and firmness. (Ferreira, M.S. & Almeida, I. F, 2021, August 17) (Effect of chlorella vulgaris extract on skin). (Managing GSH elevation and hypoxia using nanocarriers)

3. Conclusion

Chlorella vulgaris by its multifaceted mechanism offers a natural, sustainable solution for maintaining healthy skin. Its prebiotic properties promote a balanced skin microbiome, addressing dysbiosis-related issues like hyperpigmentation, acne, and skin hydration.

Acknowledgement

Research inspiration and motivation have always played a key role in the success of any venture. It gives us immense pleasure to acknowledge everyone who has supported and helped us during our research for short communication.

We express our deepest sense of gratitude to the guide Dr. Reshma Mirajkar, AISSMS College of Pharmacy, Pune. We are wholeheartedly thankful to Dr. Ashwini Madgulkar, Principal of AISSMS College of Pharmacy, Pune for constant source of inspiration.

Special mention to Ms. Ankita Ingale for guidance, support and encouragement.

REFERENCES

1. Retrieved from <https://www.amazon.com/Cosmetics-Science-Technology-Vol-3/dp/0471046493>

2. Ferreira, M. S., Resende, D. I. S. P., Lobo, J. M. S., Sousa, E., & Almeida, I. F. (2021, August 17). Marine Ingredients for Sensitive Skin: Market Overview. *Marine Drugs*. MDPI AG. <http://doi.org/10.3390/md19080464>
3. ResearchGate - Temporarily Unavailable. Retrieved from https://www.researchgate.net/publication/350910414_Effect_of_Chlorella_extract_on_skin
4. Zheng, Y., Hunt, R. L., Villaruz, A. E., Fisher, E. L., Liu, R., Liu, Q., ... Otto, M. (2022, March). Commensal *Staphylococcus epidermidis* contributes to skin barrier homeostasis by generating protective ceramides. *Cell Host & Microbe*. Elsevier BV. <http://doi.org/10.1016/j.chom.2022.01.004>
5. Byrd, A. L., Belkaid, Y., & Segre, J. A. (2018, January 15). The human skin microbiome. *Nature Reviews Microbiology*. Springer Science and Business Media LLC. <http://doi.org/10.1038/nrmicro.2017.157>
6. Grice, E. A., Kong, H. H., Conlan, S., Deming, C. B., Davis, J., Young, A. C., ... Segre, J. A. (2009, May 29). Topographical and Temporal Diversity of the Human Skin Microbiome. *Science*. American Association for the Advancement of Science (AAAS). <http://doi.org/10.1126/science.1171700>
7. Boxberger, M., Cenizo, V., Cassir, N., & La Scola, B. (2021, May 30). Challenges in exploring and manipulating the human skin microbiome. *Microbiome*. Springer Science and Business Media LLC. <http://doi.org/10.1186/s40168-021-01062-5>
8. Byrd, A. L., Belkaid, Y., & Segre, J. A. (2018, January 15). The human skin microbiome. *Nature Reviews Microbiology*. Springer Science and Business Media LLC. <http://doi.org/10.1038/nrmicro.2017.157>
9. Grice, E. A., & Segre, J. A. (2011, March 16). The skin microbiome. *Nature Reviews Microbiology*. Springer Science and Business Media LLC. <http://doi.org/10.1038/nrmicro2537>
10. Retrieved from http://doi.org/10.1007/978-94-007-5444-4_10. El-Naggar NEA, Hussein MH, Shaaban-Dessuuki SA, Dalal SR. Production, extraction and characterization of *Chlorella vulgaris* soluble polysaccharides and their applications in AgNPs biosynthesis and biostimulation of plant growth. *Scientific Reports*. 2020 Feb 20;10(1).
11. https://www.researchgate.net/publication/361659544_Managing_GSH_elevation_and_hypoxia_to_overcome_resistance_of_cancer_therapies_using_functionalized_nanocarriers
12. (n.d.). ScienceDirect. Retrieved from <https://www.sciencedirect.com/topics/agricultural-and-biological-sciences/skin-whitening>
13. Ru, I. T. K., Sung, Y. Y., Jusoh, M., Wahid, M. E. A., & Nagappan, T. (2020, February 24). *Chlorella vulgaris*: a perspective on its potential for combining high biomass with high value bioproducts. *Applied Phycology*. Informa UK Limited. <http://doi.org/10.1080/26388081.2020.1715256>