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Delaying Age-Related Skin Changes: Investigating the Role of Enriched Oat β-Glucan Complex from Avena sativa L. In Telomere Protection and Skin Rejuvenation

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1. Introduction

The intersection of cellular aging and skin health underscores the intricate mechanisms driving age-related changes in dermal appearance and functionality. Throughout the aging process, the skin undergoes a series of structural and functional changes that manifest as a progressive decline in hydration, texture quality, elasticity and radiance [1]. This reduction in radiance, characterized by diminished luminosity and a more uneven complexion, is largely due to the skin's decreasing capacity for effective regeneration and repair. As skin cells age, their renewal rate slows, leading to an accumulation of dead cells on the surface. This buildup contributes to a rougher texture and a dull, lacklustre appearance [2].

A pivotal factor in this process is telomere shortening, a hallmark of cellular aging that plays a critical role in the senescence of dermal fibroblasts and keratinocytes. Telomeres are protective caps at the ends of chromosomes that safeguard genetic material during cell division [3]. With each division, telomeres naturally shorten and when they reach a critically short length, they trigger cellular senescence. This loss of proliferative capacity disrupts the production of essential proteins such as collagen and elastin, undermining the skin's structural integrity and radiance [4].

Moreover, senescent cells often produce elevated levels of reactive oxygen species and pro-inflammatory cytokines, compounding oxidative stress and inflammation. This hostile environment further degrades extracellular matrix components, weakens the skin barrier and accelerates the loss of elasticity and smoothness [5]. Compromised cellular function and the resulting oxidative stress also impair the skin's ability to reflect light evenly, leading to a dull and uneven appearance. Telomere attrition thus emerges as a critical driver of the visible and functional decline associated with skin aging.

β-Glucans (BG) are natural cell wall polysaccharides found in yeast, fungi, seaweeds and cereals. BG possesses many health benefits (3), however, information on the skin benefits of BG derived from cereals is fragmented. Oat β-glucan (OBG), one of the major components of bran soluble fiber, is a polysaccharide made of a linear branched chain of D-glucose monosaccharides bonded by mixed β(1 → 3) and β(1 → 4) linkages. Its molecular weight, found in its natural form, varies from approximately 65 to 3,100×103 g/mol and. This difference affects both viscosity and solubility [6]. Skin penetration of OBG is a query often raised, given its molecular weight. However, fluorometric microscopy studies have been able to demonstrate [7] that despite its high molecular weight, OBG does penetrate the epidermis and dermis, by permeating between cells rather than through them. In this paper, the enriched OBG complex is obtained from oat bran subject to enzymatic treatment and wet milling, followed by centrifugation and ultrafiltration (manufacturing process optimized to preserve the original and natural structure of oat molecules).

This work evaluates the efficacy of an enriched oat β-glucan complex (*Avena sativa* (Oat) Bran Extract) in enhancing skin resilience and supporting healthy skin aging. The investigation explores its potential to provide cellular protection by preventing telomere shortening, inhibiting collagen degradation and thereby supporting mechanisms of cellular longevity. It also examines its ability to protect against environmental aging stress, specifically by inhibiting collagen degradation. Additionally, this work assesses functional skin improvements in clinical conditions, including enhanced skin hydration, texture and brightness, which contribute to a smoother and more rejuvenated skin surface.

2. Materials and Methods

2.1. Chemical Composition

The β-glucan content, of enriched OBG complex, was determined using the lichenase/β-glucosidase streamlined McCleary method and the resultant D-glucose was assayed using a glucose/peroxidase reagent. Its molecular weight was determined using high-performance size exclusion chromatography.

2.2. Cellular Aging and Longevity Markers

An in vitro study was conducted to assess the protective effect of enriched OBG complex on telomeres health using primary adult human fibroblast cells. Cells were cultured with 0.00025% enriched OBG complex diluted in water and telomere health indicators were measured as follows:

Cell growth was monitored with a cell counter (countess™) and population doubling was calculated at each passage.

Telomerase activity was measured using a quantitative telomeric repeat amplification protocol after 3 days of treatment.

Telomere length was evaluated after 42 days of treatment using high-throughput telomere analysis technology® (TAT®). Fluorescent peptide nucleic acid probes were used to measure telomere length, with results quantified with life length's proprietary program

2.3. Protection Against Environmental Aging Stress

Human abdominal skin explants (41-year-old Caucasian female, phototype II/III) were cultured on metal grids in OxiProteomics® medium at 37°C with 5% CO_2. Explants were divided into four groups (n=3; Table 1) and treated with 1% enriched oat-β-glucan (30 µL/cm², twice daily for 24 h) or vehicle (ultra-pure water). UV-A irradiation (365 nm; 6 J/cm²) was applied to stressed groups using the OxiProteomics® system. Control explants received no treatment or irradiation. After UV exposure, explants were cultured for 24 h before being embedded in OCT, snap-frozen in liquid nitrogen, and stored at -80°C.

Table 1. Experimental Groups

Lot	Groups	Treatment
1	Control	Not treated, not stressed
2	Stress (UV-A)	UV-A irradiation (365 nm; 6 J/cm^2)
3	1% enriched oat-β glucan complex + Stress	Treated with product (30 µL/cm^2) for 24h + UV-A irradiation
4	Vehicle control + Stress	

Frozen sections (5 µm) were fixed (95% ethanol/5% acetic acid), blocked (3% BSA in PBS), and incubated with anti-MMP1 primary antibody (Abcam, ab137332), followed by Alexa Fluor 647-conjugated secondary antibody. Nuclei were stained with DAPI. Fluorescent images (16-bit, .TIFF) were captured with an EVOS M5000 microscope and analyzed using ImageJ. MMP1 expression was quantified from three images per explant by integrating signal intensity over the surface area. Results were normalized to untreated controls (100%) and expressed as mean ± SD. Efficacy was calculated relative to the control and UV-stressed groups.

2.4. Functional Skin Improvements in Clinical Conditions

2.4.1. Improvement in Skin Hydration

A blind clinical evaluation was performed to evaluate the efficacy of enriched OBG complex on skin hydration. The study included 3 panels of 20 female participants of Caucasian background (Fitzpatrick skin phototype: II and III), aged 18 to 48, with mixed skin types (very dry, dry or normal). Over 28 days, participants applied one of three face creams: 1% enriched OBG face cream (containing Aqua, Phenoxyethanol, Ethylhexylglycerin, Caprylic/Capric Triglyceride, Polyacrylate-13, Polyisobutene, Polysorbate 20, Glycerin, *Avena sativa* (Oat) Bran Extract), a competitor β-glucan face cream (containing Aqua, Phenoxyethanol, Ethylhexylglycerin, Caprylic/Capric Triglyceride, Polyacrylate-13, Polyisobutene, Polysorbate 20, Glycerin, Sodium Carboxymethyl B-Glucan), or a placebo face cream (containing Aqua, Phenoxyethanol, Ethylhexylglycerin, Caprylic/Capric Triglyceride, Polyacrylate-13, Polyisobutene,

Polysorbate 20, Glycerin). The face creams were applied twice daily, in the morning and evening.
Skin hydration was assessed from the cheek using Corneometer CM 825 (Courage + Khazaka Electronic GmbH). 5 technical replicates per measurement for hydration were conducted in a 3x3 cm square region of interest. The measurements were performed before the start of the treatment (D0), after 7 days (D7) and 28 days (D28).

2.4.2. Reduction in Skin Roughness

A double-blind half-face clinical evaluation was performed to evaluate the efficacy of enriched OBG complex on skin roughness. The study included 20 female participants of Caucasian and Hispanic backgrounds (Fitzpatrick skin phototype: II, III and IV), aged 30 to 54, with mixed skin types (dry, oily or combination) and presenting moderate to very severe signs of aging (rugosity) (Eiben-Nielson's grade 2-4) [*8*]. Over 56 days, participants applied enriched OBG face serum (containing Aqua, Sodium Acrylates Copolymer, Lecithin, Sodium Gluconate, *Avena sativa* (Oat) Bran Extract, Phenoxyethanol, Ethylhexylglycerin, Caprylic/Capric Triglyceride) to one half of their face and a placebo face serum (with the same ingredients minus the *Avena sativa* (Oat) Bran Extract) to the other half, with the treatment areas randomised. The face serums were applied twice daily, in the morning and evening.
The 3D skin topography parameters (rugosity) were recorded from cheekbones area using AEVA-HE V4 system (Eotech SAS, Marcoussis, France). The participants were installed on the VisioTOP-500 bench for accurate and stable positioning and re-positioning between the different measuring times. The measurements were performed before the start of the treatment (D0), after 28 days (D28) and after 56 days (D56).

2.4.3. Enhancement of Skin Radiance

A double-blind half-face clinical evaluation was performed to evaluate the efficacy of enriched OBG complex on skin radiance compared to a placebo. The study included 20 female participants of Caucasian and Hispanic backgrounds (Fitzpatrick skin phototype: II, III and IV), aged 25 to 51, with mixed skin types (dry or combination) and stressful lifestyles, including stress and lack of sleep. Over 28 days, participants applied enriched OBG face serum (containing Aqua, Phenoxyethanol, Ethylhexylglycerin, Sodium Phytate, Sodium Acrylates Copolymer, Lecithin, Caprylic/Capric Triglyceride, *Avena sativa* (Oat) Bran Extract) to one half of their face and a placebo face serum (with the same ingredients minus the *Avena sativa* (Oat) Bran Extract) to the other half, with the treatment areas randomised. The face serums were applied twice daily, in the morning and evening.
Diffuse brightness parameter was recorded from the Region of Interest (area around the cheek, left and right) using Nikon D5600 installed in the HeadScan Bench Light Face for accurate and stable positioning and re-positioning between the different time pointsand FrameScan software (Orion Concept) for 2D image analysis.
Instrumental measurements were performed before the start of the treatment (D0), after 1 day (D1) and after 28 days (D28).

3. Results

3.1. Chemical Composition

The molecular weight of the enriched OBG complex was determined to be in the region of 600 to 700 kDa. B-glucan content (β (1 → 3)-β (1 → 4) linked) was approximately 30%; total lipids 8%; starch 30%; and tryptophan 130 ppm.

3.2. Cellular Aging and Longevity Markers

Telomerase is an enzyme that adds repeated DNA sequences (telomeric repeats) to the ends of chromosomes. By maintaining telomere length, telomerase extends the replicative lifespan of cells [9]. After 3 days, 0.00025% of enriched OBG complex significantly increased telomerase activity by 112% ($p<0.05$), compared to the control. This suggests enriched OBG complex enhances telomerase activity and helps to preserve telomere length, promoting cellular viability.

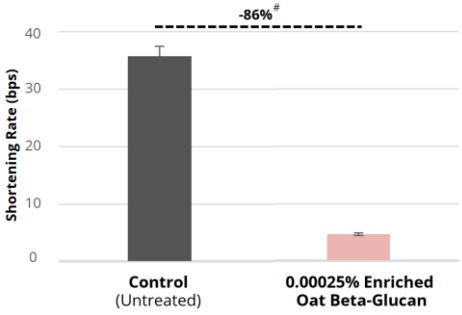

Figure 1. Telomere shortening rate (in base pairs (bps)) after 42 days with enriched OBG complex treatment. T-test, Significant: *=$p<0.05$ (95%)

The telomere length measurements were normalized based on the population doubling values (cell replication). The telomere shortening rates were calculated by measuring the median telomere length change (initial-final) per population doubling. As shown in Figure 2, after 42 days of treatment, 0.00025% of enriched OBG complex significantly reduced the telomere shortening rate, compared to the control. This suggests that enriched OBG complex exerts beneficial effects by decreasing telomere shortening rate and preserving telomere length, which supports cellular longevity [10].

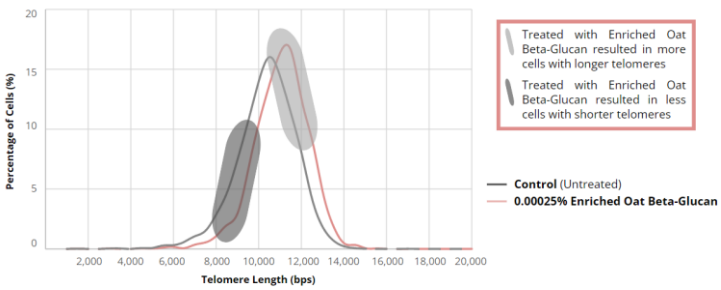

Figure 2. Telomere length distribution after 42 days with enriched OBG complex treatment.

The assessment of cells with short telomeres involved measuring the percentage of cells with specific average telomere length, which reflected the telomeric profile at the cellular level. This metric accounts for the effects of senescence and apoptosis. A higher percentage of cells with shorter telomeres indicates closer proximity to senescence. As shown in Figure 2, the control displays a telomere length peak at 10,500 bp, whereas the cells treated with 0.00025% enriched OBG complex exhibited a peak at 11,500 bp. After 42 days of treatment, enriched OBG complex results in a lower percentage of cells with short telomeres and a higher percentage of cells with longer telomeres, compared to the control. These findings suggest that enriched OBG complex helps delay aging by preventing telomere shortening.

3.3. Protection Against Environmental Aging Stress

In situ detection of MMP1 levels was performed by epifluorescence microscopy. The analysis of MMP1 levels (% normalized to the control) are reported in the following bar graph as mean values +/- SD (Figure 3). The exposure to the stress (UV-A) significantly increased MMP1 levels when compared to the control. The vehicle control (H_20), upon stress, did not show significant difference on MMP1 levels when compared to the stress. The presence of 1% enriched oat-β glucan complex significantly preserved the skin from the UV-A-induced increase in MMP1 levels.

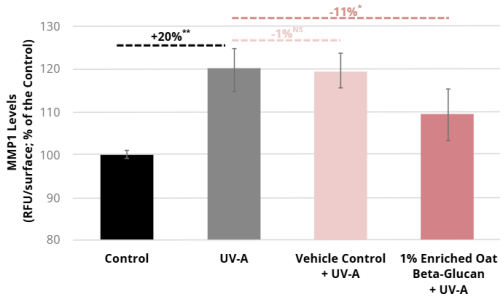

Figure 3. Quantification of MMP1 Levels (Protection). The levels of MMP1 of each experimental group are expressed as relative values (% vs Control) and shown as mean +/- S.D. **, p<0.001; * p<0.05; ns=not significant– One-way ANOVA and Dunnett's post-hoc test for multi-comparisons vs Stress group (alpha=0.05).

Taking together, these results indicate the positive effects and benefits of 1% enriched OBG complex against stress (UV-A)-induced MMP1 levels, a biomarker associated to associated with the degradation of key dermal components and skin aging [11].

3.4. Functional Skin Improvements in Clinical Conditions

3.4.1. Improvement in Skin Hydration

Skin hydration is fundamental to overall skin quality, directly influencing smoothness and radiance [12]. Adequate hydration plumps the skin's surface, reducing roughness and

improving texture, while also enhancing light reflection for a more luminous, even-toned appearance (X). Maintaining optimal moisture levels supports skin barrier integrity and helps prevent dullness and visible signs of fatigue [13].

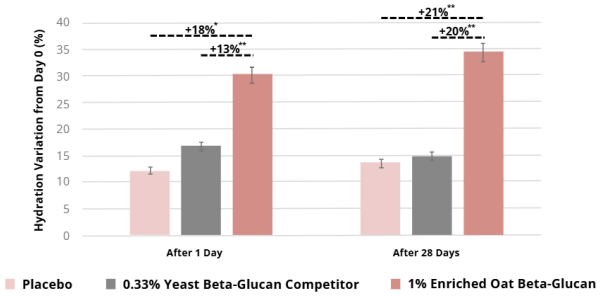

Figure 4. Variation of skin hydration (Increase). The mean values of hydration of each product are normalized to individual baseline values (Day 0) and results were expressed as percentage change from baseline and shown as mean ± SEM. **p<0.01, *p<0.05 – Two-way ANOVA.

1% enriched OBG complex significantly increased skin hydration after both 1 and 28 days of treatment compared to baseline (Figure 4). After just 1 day, hydration improved by 18% and 13% more compared to the placebo and 0.33% yeast β-glucan competitor, respectively. After 28 days, the 1% enriched OBG complex showed a 21% and 20% greater improvement than placebo and 0.33% yeast β-glucan competitor groups, respectively. In contrast, the placebo and yeast β-glucan competitor treatments showed only minimal hydration benefits over time. Enhanced skin hydration is crucial for refining skin texture and youthful appearance. These results confirm that enriched OBG complex provides superior moisturizing benefits, supporting healthier, more resilient skin.

3.4.2. Reduction in Skin Roughness

Skin smoothness and texture refer to the skin's surface, which can be enhanced by reducing roughness, unevenness and imperfections. Achieving smoother skin often improves light reflection, contributing to a more radiant, youthful appearance [14].

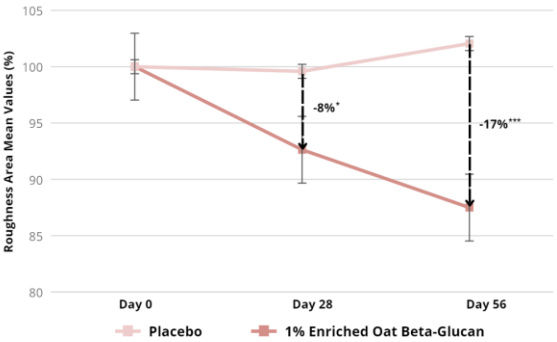

Figure 5. Quantification of roughness area mean values (Reduction). The mean values of roughness area of each product are normalized to individual baseline values (Day 0) and results were expressed

as percentage change from baseline and shown as mean ± SEM. ***p<0.001, *p<0.05 – Two-way ANOVA.

1% enriched OBG complex significantly reduced roughness area after 28 and 56 days of treatment compared to the baseline (Figure 5). In contrast, the placebo showed no relevant effects on skin roughness. Rough skin texture can trap and scatter light, making the skin appear dull and tired. These findings validate that enriched OBG complex smooths the skin, enhancing skin reflectivity.

3.4.3. Enhancement of Skin Radiance

Skin brightness results from a radiant and luminous appearance, free from dullness, allowing light to reflect evenly. An even skin tone means a uniform complexion that enhances overall brightness and creates a smooth, balanced look.

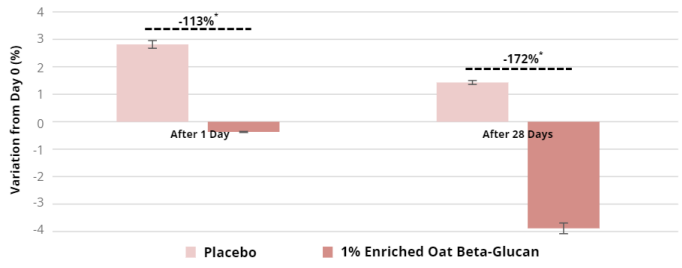

Figure 6. Variation of skin diffuse brightness (Reduction). The mean values of Skin diffuse brightness of each product are normalized to individual baseline values (Day 0) and results were expressed as percentage change from baseline and shown as mean ± SEM. *p<0.05 – Two-way ANOVA.

As shown in Figure 6, 1% enriched OBG complex significantly reduced skin diffuse brightness after 1 and 28 days of treatment, compared to the placebo. This indicates that enriched OBG complex minimizes light scattering on the skin's surface, leading to a smoother and more uniform complexion.

4. Discussion

These studies demonstrate that treatment with enriched oat β-glucan complex exerts multifaceted anti-aging and skin rejuvenation effects by addressing key biological and functional markers of skin health. The findings support the hypothesis that enriched OBG complex contributes to cellular longevity and visible skin improvements through a combination of molecular and clinical effects.

One of the most notable outcomes was the enhancement of telomerase activity and the reduction in telomere shortening rate. Telomeres are critical biomarkers of cellular aging and their progressive shortening is linked to decreased replicative potential and increased cellular senescence. The ability of enriched OBG complex to significantly increase telomerase activity and preserve telomere length suggests it may help maintain dermal cell viability over

time. These findings are consistent with growing evidence that certain bioactive compounds can influence telomere dynamics and support skin longevity [15].
The inhibition of MMP1 expression under UV-A stress conditions further reinforces the protective potential of enriched OBG complex. MMP1 plays a central role in collagen degradation and the breakdown of extracellular matrix components (ECM), which are hallmark features of photoaged skin. The reduction in MMP1 levels observed here suggests enriched OBG complex may mitigate UV-induced structural damage, aligning with previous reports of beta-glucans modulating inflammatory and stress-related pathways [12,16].
Clinical assessments complement these molecular findings. Enriched OBG complex significantly improved skin hydration, reduced surface roughness and enhanced radiance, confirming its relevance for improving skin's functional and aesthetic properties. The hydration benefits likely support barrier integrity, which is critical for maintaining smoothness and reflectivity. The reduction in roughness and increased brightness observed in vivo mirror the improvements in dermal structure and cellular activity observed in vitro and ex vivo, suggesting a coherent mechanism of action from cell to skin surface.
Future studies should further explore the specific molecular pathways modulated by enriched OBG complex, including its impact on oxidative stress responses and ECM remodeling in human skin models. Longitudinal studies on broader populations and skin types would also be valuable to assess its generalizability and effectiveness under real-world conditions.

5. Conclusion

Understanding the complexity of cellular aging and the biological changes that occur throughout life is crucial for effective prevention of premature aging. Aging begins early and manifests as a gradual decline in cellular function, influenced by environmental and lifestyle factors that can accelerate this process. Modern lifestyles, with their sustained stress levels, often lead to visibly aged skin [17]. Rough or uneven skin texture further contributes to a dull complexion, exacerbating the appearance of aging. Extensive evidence indicates that a reduction in telomere length is linked to impaired cell division and cellular senescence, with oxidative stress playing a significant role in accelerating telomere attrition [18].
By addressing telomere attrition, enriched oat β-glucan complex supports cellular resilience and dermal vitality. By directly targeting cellular aging, it provides critical telomere support to help maintain a youthful and radiant appearance. These findings establish enriched oat β-glucan as a clinically validated active ingredient for anti-aging formulations, promoting smoother, brighter and more even-toned skin.

6. References

1. Farage MA, Miller KW, Elsner P, Maibach HI. Intrinsic and extrinsic factors in skin ageing: a review. *International Journal of Cosmetic Science*. 2008; 30(2), 87-95.
2. Gilchrest BA, Krutmann J. Skin Aging. *Springer*. 2006.
3. Vaiserman A, Krasnienkov D. Telomere Length as a Marker of Biological Age: State-of-the-Art, Open Issues, and Future Perspectives. *Frontiers in Genetics.* 2021; 11: 630186.
4. Buckingham EM, Klingelhutz AJ. The role of telomeres in the ageing of human skin. *Experimental Dermatology.* 2011; 20(4): 297-302.

5. Victorelli S, Passos JF. Telomeres and Cell Senescence - Size Matters Not. *eBioMedicine*. 2017; 21, 14-20.
6. Du B, Meenu M, et al. A Concise Review on the Molecular Structure and Function Relationship of β-Glucan. Int. J. Mol. Sci. (2019), 20: 4032.
7. Pillai R, Redmond M, Röding J. Anti-wrinkle therapy: Significant new findings in the non-invasive cosmetic treatment of skin wrinkles with beta-glucan. International J. Cosmet. Sci. (2005), 27: 92 - 292.
8. Eiben-Nielson C, Kerscher M. Development and validation of a global photonumeric scale for evaluating skin quality of aged female facial skin. J Cosmet Dermatol. 2021;20(12):4032-4039.
9. Razgonova MP, et al A. Telomerase and telomeres in aging theory and chronographic aging theory (Review). Mol Med Rep. 2020 Sep;22(3):1679-1694.
10. Schellnegger M, Hofmann E, Carnieletto M, Kamolz LP. Unlocking longevity: the role of telomeres and its targeting interventions. Front Aging. 2024 Jan 25;5:1339317.
11. Pittayapruek P, Meephansan J, Prapapan O, Komine M, Ohtsuki M. Role of Matrix Metalloproteinases in Photoaging and Photocarcinogenesis. Int J Mol Sci. 2016 Jun 2;17(6):868.
12. Palma L, Marques LT, Bujan J, Rodrigues LM. Dietary water affects human skin hydration and biomechanics. Clin Cosmet Investig Dermatol. 2015 Aug 3;8:413-21.
13. Batt MD, Fairhurst E. Hydration of the stratum corneum. Int J Cosmet Sci. 1986;8(6):253-64.
14. Humphrey S, Manson Brown S, Cross SJ, Mehta R. Defining Skin Quality: Clinical Relevance, Terminology, and Assessment. Dermatol Surg. 2021 Jul 1;47(7):974-981.
15. Victorelli S, Passos JF. Telomeres and Cell Senescence - Size Matters Not. EBioMedicine. 2017 Jul;21:14-20.
16. Kim JW, Ahn JM, Kwon OJ, Kim SH. β-Glucan contents and anti-wrinkling effects of brown rice Phellinus linteus mycelium extracts fermented with Lactobacillus plantarum. Asian J Beauty Cosmetol 2016; 14: 127-137.
17. Dunn JH, Koo J. Psychological Stress and skin aging: a review of possible mechanisms and potential therapies. *Dermatology Online Journal*. 2013; 19(6): 18561.
18. Lin J, Epel E. Stress and telomere shortening: Insights from cellular mechanisms. *Ageing Research Reviews*. 2022; 73: 101507.