



Effect of colloidal oatmeal cream on IL-10 and TGF- β levels in UV-B-exposed male Wistar rats

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ABSTRACT

Background: Chronic ultraviolet B (UV-B) exposure causes photoaging and tissue damage through chronic inflammation. Colloidal oatmeal contains avenanthramides and β -glucan with antioxidant, anti-inflammatory, and wound-healing properties, and may enhance interleukin-10 (IL-10) and transforming growth factor- β (TGF- β), which are important for skin repair. This study evaluated the effect of colloidal oatmeal cream on IL-10 and TGF- β levels in UV-B-exposed Wistar rats.

Methods: A post-test-only control group experiment used 36 male Wistar rats in six groups of six: healthy (K1), UV-B with base cream (K2), UV-B with vitamin E cream (K3), and UV-B with 0.5% (K4), 1% (K5), or 2% (K6) colloidal oatmeal cream. Except for K1, rats were exposed to UV-B (70 mJ/cm², 20 cm, 15 minutes daily) for 14 days, and creams were applied twice daily. Skin tissue was collected 24 hours after the last treatment, and IL-10 and TGF- β were measured by enzyme-linked immunosorbent assay.

Results: IL-10 and TGF- β were highest in the 1% group (207.96 $\pm$ 24.22 pg/mL and 606.78 $\pm$ 50.20 ng/mL). IL-10 in K5 was higher than in K2 ($p = .001$) and K6 ($p = .003$), and TGF- β in K5 was higher than in K2 ($p = .037$), K1 ($p = .041$), and K6 ($p = .045$). Collagen thickness did not differ among groups ($p = .054$).

Conclusion: The 1% colloidal oatmeal cream was associated with the highest IL-10 and TGF- β in UV-B-exposed rats, whereas 0.5% and 2% were not.

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INTRODUCTION

Skin aging is divided into intrinsic aging, which occurs naturally, and extrinsic aging, which is triggered by environmental factors such as ultraviolet (UV) light (Gromkowska-Kępa et al., 2021). One form of extrinsic aging is photoaging, the aging of the skin caused by sun exposure, especially to UV-B. Indonesia, as a tropical country, has a high intensity of UV light throughout the year, which increases the risk of photoaging in the population. UV-B exposure causes cellular and tissue damage through oxidative stress, inflammation, and immunosuppression (Ansary et al., 2021; Panich et al., 2016). Reactive oxygen species trigger expression of inflammatory genes and production of proinflammatory cytokines by keratinocytes, fibroblasts, and leukocytes, which contributes to structural and functional damage of the skin. UV light also damages collagen by increasing collagenase activity and reducing collagen production by fibroblasts, so that skin aging is accelerated and elasticity decreases (Chung et al., 2001; Feng et al., 2024; Fisher et al., 2008). Topical treatments to counter these effects have been developed, but some are limited in effectiveness, skin penetration, or side effects, and attention has turned to natural agents with antioxidant and anti-inflammatory

properties. These mechanisms explain why photoaging is studied through both inflammatory mediators and structural collagen changes.

One such agent is colloidal oatmeal, derived from *Avena sativa*, which has long been used for the care of sensitive skin. Its bioactive constituents, including avenanthramides, β -glucan, and flavonoids, are known to suppress inflammatory pathways and to increase production of anti-inflammatory cytokines; avenanthramides inhibit IL-1 β -induced NF- κ B activation, and oat β -glucans have anti-inflammatory activity (Guo et al., 2008; Żyła et al., 2021). Oat-based moisturizers have been reported to improve dry skin and the skin barrier (Kim et al., 2023; Sacchidanand et al., 2018), and a 1% colloidal oatmeal cream was effective and safe in children with mild to moderate atopic dermatitis (Lisante et al., 2017). The cytokines IL-10 and TGF- β play important roles in the resolution of inflammation and tissue repair. IL-10 suppresses the inflammatory response by inhibiting proinflammatory cytokines, and its increase has been linked to attenuation of UV-B-induced skin barrier dysfunction in mice (Katayama et al., 2023), while TGF- β promotes cell regeneration and the synthesis of extracellular matrix, and its signaling is involved in photoaging (Ke & Wang, 2021). Raising the levels of these two cytokines is therefore a strategic approach to reducing the effects of UV-B-induced aging. Taken together, this literature provides a rationale for testing colloidal oatmeal on these two cytokines in UV-B-exposed skin.

Whether a topical colloidal oatmeal cream modulates IL-10 and TGF- β in UV-B-exposed skin, and which concentration is most effective, had not been tested in an in vivo photoaging model. The present study therefore evaluated the effect of colloidal oatmeal cream at 0.5%, 1%, and 2% on IL-10 and TGF- β levels in the skin of UV-B-exposed male Wistar rats, with a healthy group, a base-cream group, and a vitamin E cream group as references. Skin collagen was also examined histologically with hematoxylin–eosin and Masson's trichrome staining to describe structural changes. The concentrations were chosen to explore the effect of a low dose (0.5%), the dose that is established clinically (1%), and a higher dose (2%) that could either increase the biological effect or provoke a skin reaction. The study aimed to identify the dose that is both effective and suitable for topical use. The combination of cytokine measurement and histology allows a biochemical outcome to be compared with a structural outcome in the same animals, and it provides a way to judge whether changes in the cytokines are accompanied by changes in the dermal matrix. The results are intended to inform the choice of a concentration for further development of an oatmeal-based topical product for photodamaged skin.

METHODS

Research Design and Animals

This experimental study used a post-test-only control group design and was carried out in July–August 2025 at the Integrated Biomedical Laboratories, Faculty of Medicine, Universitas Islam Sultan Agung, Semarang. The subjects were clinically healthy male Wistar rats aged 2–3 months and weighing 175–200 g; rats that became ill or showed clinical symptoms during the study were excluded, and rats that died during the study were dropped out. The sample size followed the Federer formula, $(n - 1)(t - 1) \geq 15$, and 36 rats were used, divided randomly into six groups of six after 7 days of adaptation under controlled conditions with standard feed and water ad libitum. The groups were: K1, healthy rats without UV-B exposure; K2, negative control exposed to UV-B and given base cream; K3, positive control exposed to UV-B and given vitamin E cream; and K4, K5, and K6, exposed to UV-B and given colloidal oatmeal cream at 0.5%, 1%, and 2%. Ethical clearance for the study was requested from the ethics committee of the Faculty of Medicine, Universitas Islam Sultan Agung, to ensure the ethical integrity of the data produced. Random allocation to groups was used to distribute individual differences among rats evenly across the groups.

Cream Preparation, UV-B Exposure, and Treatment

Colloidal oatmeal was obtained from PT Phytocemindo Reksa and processed to a particle size below 100 microns, ideally 20–30 microns, so that it disperses homogeneously in water and forms a stable colloidal system. The powder was mixed into a base cream gel produced by PT Derma Elok Farma, with an ultrasonic homogenizer used as an additional mixing step to prevent particle agglomeration. For UV-B exposure, rats were anesthetized with ketamine 60 mg/kg and xylazine 20 mg/kg intramuscularly (0.5 mL), the dorsal hair was shaved clean over an area of 3×4 cm², and the rats were exposed to UV-B at a distance of 20 cm with a minimal erythema dose of 70 mJ/cm² for 15 minutes daily for 14 days. The creams were applied topically

twice daily, 20 minutes before and 4 hours after UV-B exposure, for 14 days in each treatment group. The healthy group was not exposed to UV-B. The UV-B lamp emitted in the 290–320 nm range, and the selected concentrations of colloidal oatmeal were based on evidence that a cream containing 1% colloidal oatmeal relieves symptoms of dermatitis and improves skin condition (Lisante et al., 2017). The vitamin E cream served as an active reference, and the base cream was identical to the vehicle of the oatmeal creams.

Sampling, ELISA, Histology, and Data Analysis

Twenty-four hours after the last treatment, the rats were killed by cervical dislocation, and skin tissue was taken from the exposed area with a 6 mm punch biopsy. IL-10 and TGF- β in tissue were measured on day 15 by enzyme-linked immunosorbent assay (ELISA) with commercial kits, reading optical density at 450 nm on a microplate reader. Collagen was examined on paraffin sections stained with hematoxylin–eosin and Masson's trichrome, the latter performed at the CITO laboratory, and the assessment covered collagen quantity, fiber density, fiber organization, and fragmentation. Data were first checked for normality with the Shapiro–Wilk test and for homogeneity of variance with Levene's test. When both assumptions were met, one-way ANOVA with the Tukey post hoc test was used; when variances were not homogeneous, the Tamhane post hoc test was used; and the Kruskal–Wallis test was used for data that were not normally distributed. The significance level was 5%. Values are presented as mean $\pm$ standard deviation, with $n = 6$ per group for IL-10 and TGF- β , as reported in the source study. The punch biopsy sample was divided so that the same exposed area was used for the biochemical and the histological analyses. The same procedure was applied to every animal to limit variation between samples.

RESULTS

Collagen Histology

Hematoxylin–eosin staining was used to evaluate histopathological changes in the skin due to UV-B and the protective effect of the cream. The measured thickness of collagen connective tissue was highest in the negative control K2 (43.40 ± 17.91) and lowest in the positive control K3 (24.00 ± 7.07); the 0.5% group (26.00 ± 6.63) was almost the same as the healthy group (26.20 ± 6.72), and the 1% and 2% groups had the same value (30.60 ± 9.55 and 30.60 ± 5.03 ; Table 1). K2 was not normally distributed (Shapiro–Wilk $p = .010$), variances were homogeneous (Levene $p = .222$), and the Kruskal–Wallis test showed no significant difference among groups ($p = .054$). With Masson's trichrome staining, collagen in the healthy group appeared dense and orderly, the negative control showed higher collagen density than the healthy group with the most contrasting blue color, the positive control and 0.5% groups showed looser and less organized collagen, and the 1% and 2% groups showed more regular and denser collagen than the healthy group. The trichrome assessment was qualitative and, according to the source study, was done on one sample per group, so it is descriptive only. The H&E images were used to evaluate the architecture of the tissue in each group.

Table 1. Collagen thickness, IL-10, and TGF- β by group (mean $\pm$ SD)

Variable	K1 Healthy	K2 UV-B + base	K3 UV-B + vitamin E	K4 UV-B + 0.5%	K5 UV-B + 1%	K6 UV-B + 2%
Collagen thickness (H&E)	26.20 ± 6.72	43.40 ± 17.91	24.00 ± 7.07	26.00 ± 6.63	30.60 ± 9.55	30.60 ± 5.03
IL-10 (pg/mL)	150.47 ± 50.03	123.37 ± 14.24	166.46 ± 28.50	147.60 ± 35.50	207.96 ± 24.22	134.84 ± 16.91
TGF- β (ng/mL)	428.72 ± 125.46	426.19 ± 157.95	556.80 ± 57.83	489.59 ± 98.99	606.78 ± 50.20	431.02 ± 44.24

Note. Collagen thickness: Levene $p = .222$, Kruskal–Wallis $p = .054$. IL-10: Shapiro–Wilk $p = .178$ –.912, Levene $p = .019$, one-way ANOVA $p < .001$. TGF- β : Shapiro–Wilk $p = .115$ –.492, Levene $p = .167$, one-way ANOVA $p = .011$. The source text gave 207.96 for K6 IL-10; its table (134.84) is used. Collagen thickness is given in the units of the source study.

IL-10 Levels

The lowest mean IL-10 was in the negative control K2 (123.37 ± 14.24 pg/mL), and the positive control K3 had a higher level (166.46 ± 28.50). The 0.5% group had 147.60 ± 35.50 , the 1% group had the highest level

(207.96 ± 24.22), and the 2% group was lower (134.84 ± 16.91 ; Table 1). All groups were normally distributed (Shapiro–Wilk $p = .178-.912$), but variances were not homogeneous (Levene $p = .019$), so the Tamhane post hoc test was used after a significant one-way ANOVA ($p < .001$). Tamhane's test showed that the 1% group had a significantly higher IL-10 than the negative control ($p = .001$) and than the 2% group ($p = .003$). No other pair differed significantly: K1–K2 $p = .987$, K1–K3 $p = 1.000$, K1–K4 $p = 1.000$, K1–K5 $p = .441$, K1–K6 $p = 1.000$, K2–K3 $p = .166$, K2–K4 $p = .936$, K2–K6 $p = .981$, K3–K4 $p = .998$, K3–K5 $p = .285$, K3–K6 $p = .515$, K4–K5 $p = .108$, and K4–K6 $p = 1.000$. The effect of colloidal oatmeal on IL-10 was therefore limited to the 1% concentration. The standard deviations of the 1% and 2% groups were small relative to the difference between them.

TGF- β Levels

The mean TGF- β was 428.72 ± 125.46 ng/mL in the healthy group and 426.19 ± 157.95 in the negative control; K3 had 556.80 ± 57.83 , K4 had 489.59 ± 98.99 , K5 (1%) had the highest level (606.78 ± 50.20), and K6 (2%) had 431.02 ± 44.24 , slightly lower than K5 and close to K1 and K2 (Table 1). All groups were normally distributed (Shapiro–Wilk $p = .115-.492$) with homogeneous variances (Levene $p = .167$), and one-way ANOVA showed a significant difference among groups ($p = .011$). Tukey's test showed that the 1% group had a higher TGF- β than the negative control ($p = .037$), the healthy group ($p = .041$), and the 2% group ($p = .045$). The other comparisons were not significant (K1–K2 $p = 1.000$, K1–K3 $p = .246$, K1–K4 $p = .890$, K1–K6 $p = 1.000$, K2–K3 $p = .227$, K2–K4 $p = .872$, K2–K6 $p = 1.000$, K3–K4 $p = .842$, K3–K5 $p = .949$, K3–K6 $p = .263$, K4–K5 $p = .335$, and K4–K6 $p = .904$). As for IL-10, the 1% concentration was the only one whose effect on TGF- β was distinguishable from the controls. Figure 1 shows the group means and standard deviations of IL-10 and TGF- β .

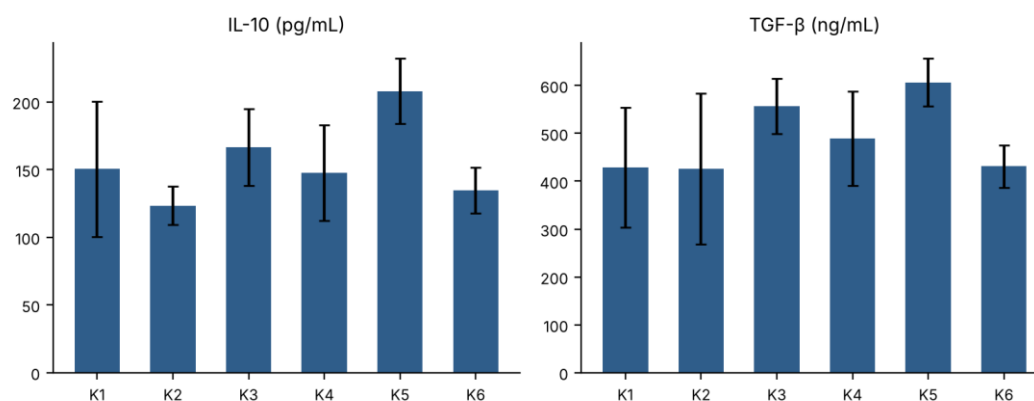


Figure 1. IL-10 and TGF- β levels by group (mean $\pm$ SD)

DISCUSSION

IL-10 and TGF- β

UV-B exposure affects the levels of IL-10 and TGF- β in the skin, which are important in regulating inflammation and healing, and excessive UV-B can reduce IL-10 production and lead to an imbalance between inflammatory and anti-inflammatory responses (Omer et al., 2019; Ansary et al., 2021). Low TGF- β is associated with greater tissue damage and a risk of fibrosis (Ke & Wang, 2021). In this study the 1% colloidal oatmeal cream gave the highest IL-10, higher than in the negative control and the 2% group. The source study attributed this to an optimal concentration of bioactive compounds such as avenanthramides and β -glucan, which reduce inflammation by increasing anti-inflammatory activity (Guo et al., 2008; Żyła et al., 2021), and suggested that 1% is enough to stimulate a good response while limiting further damage. The low IL-10 in the negative control is consistent with a limited capacity of untreated skin to control inflammation (Katayama et al., 2023). The 1% group also had the highest TGF- β , significantly higher than the negative control, the healthy group, and the 2% group. Although this suggests a stronger regenerative response at 1%, the TGF- β levels of the 0.5% and 2% groups did not differ from the negative control, and the 2% group showed no increase in either cytokine, which indicates that a higher dose does not necessarily give a better result.

The dose-dependence seen here is not linear: the highest concentration was no better than the base cream, and the 1% concentration gave the best result. Dose optimization is therefore more important than raising the concentration of the active ingredient, and a 1% concentration has been well tolerated and clinically effective in mild to moderate atopic dermatitis (Lisante et al., 2017). Topical colloidal oatmeal has also been reported to increase expression of genes related to keratinocyte differentiation, lipid production, and tight-junction formation (Zeng et al., 2025), which the source study related to the increase of IL-10 and TGF- β . In the negative control, TGF- β was also not increased, which the source study read as a limited capacity of the skin to control inflammation and repair damage (Elkoshi, 2024). These explanations are plausible but were not tested in this study: no inflammatory or oxidative marker other than IL-10 and TGF- β was measured, and the positive control (vitamin E) did not differ significantly from other groups, so the study cannot rank colloidal oatmeal against a vitamin E reference. They support a cautious interpretation in which the concentration, not simply the amount of active ingredient, determines the response. Studies with intermediate concentrations between 0.5% and 2% would show where the optimum lies.

Collagen

UV-B can damage collagen by increasing collagenase activity and decreasing production of collagen by fibroblasts, so collagen density was assessed to estimate the damage and the effect of treatment (Chung et al., 2001; Fisher et al., 2008). Unexpectedly, the negative control showed the highest collagen thickness with hematoxylin–eosin and the highest density with Masson's trichrome. The source study explained that the base cream maintains skin moisture and helps the protective function of UV-B-exposed skin, which might preserve collagen, without the inflammatory reaction that active ingredients could provoke (Wang et al., 2023). The 1% and 2% groups showed better collagen density than the positive control, which the source study linked to the moisturizing and barrier-supporting effect of colloidal oatmeal and its stimulation of fibroblasts (Kim et al., 2023; Sacchidanand et al., 2018). However, the difference in collagen thickness among groups was not significant ($p = .054$), and the trichrome observations were qualitative, so the collagen results cannot be taken as evidence that colloidal oatmeal restored collagen. They show that the histological outcomes were inconclusive in this experiment. The collagen results therefore do not add support to the cytokine findings. Future studies should quantify collagen in all animals with a fixed method.

CONCLUSION AND IMPLICATIONS

Colloidal oatmeal cream at 1% was associated with the highest IL-10 and TGF- β levels in UV-B-exposed rats. IL-10 in the 1% group was significantly higher than in the negative control and the 2% group, and TGF- β was significantly higher than in the negative control, the healthy group, and the 2% group. The 0.5% and 2% concentrations did not differ significantly from the negative control, and the collagen thickness did not differ significantly among groups. The findings suggest that 1% is the most effective of the three concentrations tested for raising these two cytokines in this model, and that a higher concentration does not give a better result. They are preclinical results from a small experiment and need confirmation, including a clearer assessment of whether the higher cytokine levels correspond to better inflammation resolution and skin repair. Further studies are needed to establish the meaning of the cytokine changes for skin repair. The conclusions are limited to the cytokines measured in skin tissue, to the three concentrations tested, and to the 14-day treatment period, and they do not establish a clinical benefit. In practical terms, they provide a basis for selecting the 1% concentration as the reference dose in further preclinical and clinical testing of oatmeal-based photoprotective products.

Limitations and Future Research

The number of samples was limited, with six rats per group, which may affect generalization, and the observation period was relatively short, so long-term effects and the persistence of effects after treatment stopped could not be assessed. Individual variability in response is also a limitation. Masson's trichrome was evaluated on one sample per group, and the source study recommends that all samples be examined. Only a few inflammatory parameters were measured, and other molecular mechanisms and systemic effects were not examined. Future studies should use more animals, longer observation, collagen assessment on all samples with quantitative methods, and additional markers of inflammation and oxidative stress, and should account for individual variability. The ELISA measurements were taken at one time point, 24 hours after the last

treatment, and so describe the cytokine levels only at the end of the 14-day period and cannot show how they changed during treatment. Only male Wistar rats of one age range were used, which limits the extension of the results to females, older animals, or humans. The tissue was analyzed as a whole homogenate, so the cell types responsible for the cytokines could not be identified. These constraints should be considered when the results are interpreted.

DECLARATIONS

Ethics approval: Ethical clearance for the animal experiment was requested from the ethics committee of the Faculty of Medicine, Universitas Islam Sultan Agung, Semarang.

Author contributions: Chairun Nisa' Nur'aini: conceptualization, methodology, investigation, data curation, formal analysis, writing – original draft. Prasetyowati Subchan: supervision, methodology, writing – review and editing. Sri Priyatini Mulyani: supervision, methodology, writing – review and editing. All authors have read and approved the final manuscript.

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