Introduction

Skin aging shows structural, and functional changes that are either intrinsic or extrinsic. Intrinsic aging is defined as the decreased skin structure and physiological activity over time, while extrinsic aging, or photodamage, is caused by external stresses such as ultraviolet and reactive oxygens (Helfrich et al., 2008).

The keratinocytes from the basal layer of the skin move toward the surface of the stratum corneum. These are removed through desquamation, as the skin regenerates over time, a period called skin turnover. The life span of keratinocytes in the human skin is approximately 20–28 days (Ho & Dreesen, 2021). Skin renewal by the keratinocytes slows down as the skin becomes older (Choi et al., 2017). Lifestyle habits such as insufficient sleep, alcohol drinking, and smoking retard skin cell regeneration. Skin-related problems such as wrinkles and freckles occur due to the delay of skin turnover.

Abstract

Purpose: To verify the biological effects including anti-aging and anti-inflammatory effects, of fermented plant root extract mixtures that were measured in vitro.

Method: To select the most effective plant root extract, the effects of DPPH free radical scavenging were measured. The mixture (MC) of selected plant roots was fermented with Saccharomyces cerevisiae (S. cerevisiae) (MF). Reverse transcription (RT)-PCR was performed on human dermal fibroblast to measure the effects of MC and MF on the mRNA expression of COL1A1 and hyaluronic acid synthase 2 (HAS2) and on the anti-inflammatory-related gene expressions such as cyclooxygenase-2 (COX-2), interleukin-6 (IL-6), and tumor-necrosis factor (TNF)-α. Additionally, we also tested the cell renewal and proliferation for skin cell migration. Student’s t-test was performed for statistical analysis, and results were expressed as mean ± standard deviation.

Results: Among 15 root extracts, those of Taraxacum officinale (T. officinale) rhizome, Arctium lappa (A. lappa), Anemarrhena asphodeloides (A. asphodeloides), Pueraria lobata (P. lobata), and Nelumbo nucifera (N. nucifera) were selected based on the effect of DPPH free radical scavenging. The mRNA expression levels of COL1A1 and HAS2 were increased by MC and MF in a concentration-dependent manner. MC and MF showed cell renewal and proliferation. Inflammation-related genes were inhibited by MC or MF in a concentration-dependent manner (TNF-α, IL-6, and COX-2). MF showed significantly better efficacy than MC.

Conclusion: Mixed root extracts of T. officinale rhizome/root, A. lappa, A. asphodeloides, P. lobata, and N. nucifera fermented with S. cerevisiae enable cell renewal, have anti-aging and anti-inflammatory effects, and can be used as an active cosmetic raw materials.

Keywords: Plant root extracts, Fermentation, Anti-inflammation, Anti-aging, Cosmetic raw material
Biological Effect of Yeast-fermented Plant Root Extract

Studies on herbs and its benefit for skincare have recently increased, particularly due to the interest of cosmetic consumers in natural products (Shim, 2021; Zhang et al., 2018; Moon et al., 2017; Di Napoli & Zucchetti, 2021; Sivamaruthi et al., 2018). The benefits of mixed plant extracts and the mixed extracts have been reported to be better than those of individual extracts (Choi, 2022; Kim et al., 2019; Lee et al., 2021).

By fermentation, certain common substrate components are degraded or transformed into compatible components. This process can generally increase the physiological and biochemical activities of biological substrates by modifying naturally occurring molecules and can be used to develop new pharmaceutical and cosmetic formulations (Kim, 2011; Chiba, 2007; Um et al., 2017; Hussain et al., 2016). The cytotoxicity of certain herbal extracts can be reduced or eliminated after treatment using various microbial species. Some probiotics, such as Bifidobacterium bifidum and Saccharomyces cerevisiae, can produce new components by fermentation or reduce the cytotoxicity of herbal extracts (Shim et al., 2019; Hussain et al., 2016; Wang et al., 2016).

In the present study, the effects of plant roots extracts of Taraxacum officinale, Arctium lappa, Anemorrhena asphodeloides, Pueraria lobata, and Nelumbo nucifera fermented with S. cerevisiae on the expression of anti-aging and inflammatory-related genes were evaluated using human keratinocytes and fibroblasts to evaluate their potential as a cosmetic raw material.

Materials and Method

1. Plant roots and extraction

Each plant root was acquired from Shenzhen Mannay Cosmetics Co. Ltd., and was dried and ground before extraction (Table 1). The resulting powder was extracted in 20 volumes of 70% alcohol at room temperature for 3 h and filtered using a filter paper (No. 2 qualitative filter papers, Whatman, England). The resulting filtrates were concentrated under a vacuum using a rotary evaporator (N-1110; EYELA, USA) until alcohol was eliminated. The concentrated extracts were stored at -20°C until further use.

The select root powders were mixed at equal amounts and extracted as described above. To prepare the fermented root mixture extracts, pre-cultured S. cerevisiae (1×10^6/mL) was inoculated on the root mixture extracts and fermented at 28°C with 30 rpm for 3 days. To terminate the fermentation, the cultures were boiled at 100°C for 30 min and filtered using a 0.45 μm filter.

The international nomenclature cosmetic ingredient (INCI) of each plant root extract used in this study is described in Table 1.

2. DPPH free radical-scavenging activity assay

The free radical-scavenging activity of plant root extracts was determined using a 2,2-diphenyl-1-picrylhydrazyl (DPPH; Sigma Aldrich, USA) assay. 50 μL of the diluted extracts were mixed with 100 μL of 0.1 mM DPPH solution. The DPPH solution without the test sample was used as a control. The mixture was incubated for 30 min at room temperature and subsequently measured for its absorbance at 515 nm. The antioxidative activity was calculated using the formula below and expressed as the percentage of DPPH radical elimination:

\[\left(\frac{A_{\text{blank}} - A_{\text{sample}}}{A_{\text{blank}}}\right) \times 100\%\]

where \(A_{\text{blank}}\) is the absorbance of the blank DPPH solution and \(A_{\text{sample}}\) is the absorbance of the DPPH solution after the addition of test sample.

3. Cell lines

Human dermal fibroblasts (HDF: Thermo Fisher Scientific, USA) were cultured in Fibroblast Basal Medium (FBM 106; Gibco, USA) supplemented with low serum growth supplement (LSGS; Gibco), 100 IU/mL penicillin, and 100 μg/mL streptomycin. Human epidermal keratinocytes (HEKa; Invitrogen, USA) were cultured in Dulbecco’s modified Eagle’s medium (DMEM; Gibco, Thermo Fisher Scientific, USA) supplemented with antibiotics (100 IU/mL penicillin and 100 μg/mL streptomycin) and 10% fetal bovine serum (FBS; Gibco BRL, USA). The cells were maintained at 5% CO₂ at 37°C. Confluent monolayer cultures of HDF and HEKas were trypsinized with 0.25% trypsin–EDTA.

4. Cell viability

Cell viability was determined by measuring the conversion of 3-(4,5-dimethyl-2-thiazolyl)-2,5-diphenyl-2H-tetrazolium bromide (MTT) into formazan via mitochondrial oxidation according to a modified Mosmann’s method (Mosmann, 1983). HEKas and HDF were seeded at 1×10^4 cells/well in a 96-well plate and cultured for 18 h. The prepared sample was added in 0, 1, 2, and 5% concentrations. After incubating for 24 h, the medium was gently removed, the cells were washed twice in phosphate-buffered saline (PBS), and then the wells were
filled with 5 mg/mL of solution MTT (Sigma Aldrich) as the new medium. Afterward, formazan crystals produced from MTT were solubilized in 150 μL dimethyl sulfoxide (DMSO: Sigma Aldrich). The absorbance of each well was then measured at 570 nm using a microplate reader (Epoch2, USA). The optical density of formazan formed in control cells without sample was considered as 100% viability.

5. Wound-healing (cell renewal) test

To examine cell renewal, HEKa was subjected to a wound-healing assay. The cells were inserted on a 12-well plate and then incubated for 4 h under cell culture conditions. On the removal of the culture medium, a "wound gap" in a cell monolayer was created by scratching, and then 2% of test samples along with a new culture medium were added to the cells; the plate was incubated again for 18 h. Four hours after incubation, cell migration was analyzed to measure the cell renewal effect.

6. Cell proliferation

To examine the cell proliferation of the test sample, CytoSelect™ BrdU Cell Proliferation ELISA Kit (Cell Biolabs Inc., USA) was used. The cells were inserted on a 96-well plate and then incubated for 18 h under cell culture conditions. Upon removal of the culture medium, the cells were washed with PBS, and then test samples along with a new culture medium were added to the cells; the plate was again incubated for 24 h. Afterward, a BrdU Solution was added to the wells, and the plate was again incubated at 37°C and 5% CO₂ in a humidified incubator for 4 h. In each tested well, 100 μL of diluted anti-BrdU antibody and secondary antibody HRP conjugate were added. After incubation for 30 min, absorbance was measured according to the manufacturer’s instructions. The cell proliferation rate of each sample treated was calculated based on the blank.

7. RNA isolation and reverse transcription (RT)–PCR

To determine the mRNA expression of COL1A1, hyaluronic acid synthase2 (HAS2), tumor–necrosis factor–α (TNF–α), interleukin–6 (IL–6), and cyclooxygenase–2 (COX–2), cells were cultured in Medium 106 supplemented with 1× LSGS, 100 IU/mL penicillin, and 100 μg/mL streptomycin at 5% CO₂ at 37°C for 24 h. The medium was gently removed, and the cells were treated with 0.1%, 0.5%, 1%, and 2% concentrations of the sample and then cultured for 48 h. Total RNAs from each well were isolated using the TransZol reagent and obtained to generate the cDNA using the PrimeScript 1st cDNA synthesis kit, as recommended by the manufacturer’s instructions. Amplifications were performed in a thermal cycler. The experiment consisted of 35 cycles: denaturation at 95°C for 1 min, annealing at 50–60°C for 30 s, and extension at 72°C for 1 min. The sequences of primer pairs, and further details of PCR, are given in Table 1.

| INCI | Korean name | Chinese name | Abbreviations |
|------|-------------|--------------|---------------|
| Althaea rosea root extract | 접시꽃뿌리추출물 | 蜀葵花提取物 | AR |
| Anemarrhena asphodeloides root extract | 지모뿌리추출물 | 知母根提取物 | AA |
| Arctium lappa root extract | 우엉뿌리추출물 | 牛蒡根提取物 | AL |
| Lepidium meyenii root extract | 마카뿌리추출물 | 迈因睾根提取物 | LM |
| Nelumbo nucifera root extract | 연꽃뿌리추출물 | 莲根提取物 | NN |
| Oenothera biennis (Evening Primrose) root extract | 달맞이꽃뿌리추출물 | 月见草根提取物 | OB |
| Pachyrhizus erosus root extract | 암빈뿌리추출물 | 豆薯根提取物 | PE |
| Paeonia suffruticosa root extract | 모란뿌리추출물 | 牡丹根提取物 | PS |
| Panax notoginseng root extract | 삼질뿌리추출물 | 三七根提取物 | PN |
| Polygonum cuspidatum root extract | 호창근뿌리추출물 | 虎杖根提取物 | PC |
| Polygonum multiflorum root extract | 하수오뿌리추출물 | 何首乌根提取物 | PM |
| Pueraria lobata root extract | 칠부리추출물 | 野葛根提取物 | PL |
| Sciadopitys verticillata root extract | 금송뿌리추출물 | 金松根提取物 | SV |
| Sedum rosea root extract | 돌 mainScreen/뿌리추출물 | 玫瑰红酒根提取物 | SR |
| Taraxacum officinale rhizome/root extract | 서양민들레뿌리줄기/뿌리추출물 | 欧葆公英根茎/根提取物 | TO |
2. Glyceraldehyde 3-phosphate dehydrogenase (GAPDH) was used as a control gene. PCR products were electrophoresed on a 1% agarose gel and stained with ethidium bromide to analyze the relative ratio of changes in the target gene in comparison to those of the control.

8. Statistical analysis

The results obtained were expressed as mean±standard deviation (SD) from at least three independent experiments. The student’s *t*-test with Microsoft Excel (Microsoft, USA) was used to analyze the data, *p*<0.05 was considered to indicate statistical significance.

**Results and discussion**

In the cosmetic industry, natural ingredients have been increasingly a point of concern. In this study, we focused on plant roots due to their medicinal use in Asian cultures (Bark et al., 2010). We prepared 15 plant root extracts (Table 1) and evaluated the antioxidant effect using DPPH free radical scavenging assay. The tested plant root extracts show an antioxidant effect at 10% treatment (Figure 1). Among them, only five show more than 80% of DPPH free radical-scavenging activity: *Taraxacum officinale*, *Arctium lappa*, *Anemarrhena asphodeloides*, *Pueraria lobata*, and *Nelumbo nucifera*.

The synergic effect of a mixture of plant extract and the fermented mixture of plant extract have been reported (Kim et al., 2019; Um et al., 2017). Five roots were selected to be mixed and extracted (MC). In addition, MC was fermented using *S. cerevisiae* (MF). Fermentation is a strategy to improve efficacy and reduced toxicity product and is frequently used to manufacture cosmetic raw materials.

The results showed that MC and MF treated on HDF and HEKα had more than 80% of cell viability at 2% concentration and following works were carried out in this range (Figure 2).

The effects of each root extract, MC, and MF on cell renewal were measured in HEKα cells: 34–63% by each root extract and 67% of cell renewal activity by MC-treated HEKα cells, which is similar to that by positive controls. MF-treated HEKα cells recovered the wound gap by approximately 77%, which was approximately 20% higher than that of MC. Thus, MF promotes skin cell regeneration and activates the proliferation of the skin

**Table 2. Primer sequences**

| Primer | Forward sequence | Reverse sequences |
|--------|------------------|------------------|
| GAPDH*1 | ATT GTT GCC ATC AAT GAC CC | AGT AGA GGC AGG GAT GAT GT |
| GAPDH*2 | CTG GCA CCC AGC ACA ATG AAG | ACC GAC TGC TGT CAC CTT CA |
| HAS2 | GCT ACC AGT TTA TCC AAA CG | GTG ACT CAT CTG TCT CAC CG |
| COL1A1 | GGC CCA GAA GAA CTG GTA CA | GCC TGT TGC AGT GGT AG |
| IL6 | ATG AAC TCC TTC TCC ACA AGG GC | GAA GAG CCC TCA GGG TGG ACT G |
| COX2 | GAA GAG CCC TCA GGG TGG ACT GT | AGA TCA TCT CTG CCT GAG TAT CTT |
| TNF-α | CAT TCT GGG AGG GGT CTT CC | GGT TGA GGG TGT CTG AAG GA |
| AQP3 | TGC AAT CTG GCA CTT CGC | GCC AGC ACA CAC ACG ATA A |

*1* for HDF; *2* for HEKα; GAPDH, glyceraldehyde-3-phosphate dehydrogenase; HAS2, hyaluronic acid synthase 2; COL1A1, collagen type 1 alpha 1 chain; IL6, interleukin 6; COX2, cyclooxygenase 2; TNF-α, tumor-necrosis factor-α.
cells (Figure 3).

Our results also confirmed that MC and MF affect cell proliferation in HEKa cells. Figure 4 shows that MC and MF have cell renewal and cell proliferation in a dose–dependent manner. Results indicated that cell proliferation was significantly increased by MF–treated cells compared to that by MC–treated cells (p<0.05). Cell proliferation in HDF cells treated with 2% MF and 2% MC was significantly higher than that in untreated cells (234.06% and 195.38%, respectively); MF treatment results in approximately 38.68% higher than that of MC treatment at 2% treatments. In terms of efficacy, our result was similar with that of Hsu and Chiang when they compared the effect of fermented Radix astragali with Bacillus subtilis natto and non–fermented R. astragali, which is well–known for its medicinal effect. The fermented R. astragali has a better anti–aging effect despite the reduction in concentration of main isoflavonoids such as galeyosin, formononetin, and ononin (Hsu & Chiang, 2009).

Collagen is composed of three polypeptide α–chains that form a triple helical structure. COL1A1 is a gene–encoding type I collagen that is one of fibril–forming collagen (Yue, 2014; Ricard–Blum, 2011). The effects of MC and MF on COL1A1 mRNA expression were evaluated in HDF cells using RT–PCR.
The mRNA expression levels of COL1A1 in MC- and MF-treated HDF cells increased in a dose-dependent manner (Figure 2). Similar to the cell proliferation test result, the effect of MF on COL1A1 mRNA expression was higher than that of MC with a significantly different (p<0.05). The mRNA expression levels of COL1A1 in HDF cells treated with 2% MC and MF were 157.37% and 195.11%, respectively, while that of a positive control (50 μM retinyl palmitate treatment) was 220.57% (Figure 5A). COL1A1 mRNA expression in MF-treated cells was approximately 24% higher than that of MC-treated cells at 2% (p<0.05).

In the skin, gene expression of HAS2 is stimulated by keratinocyte migration and stimulates wound healing (Papakonstantinou et al., 2012). We measured the effect of MC and MF on HAS2 mRNA expression. HAS2 mRNA expression was increased in a dose-dependent manner, with MF-treated cells having significantly higher results than those of MC-treated cells (p<0.05). HAS2 expression levels of HDF cells treated with 2% MC and MF were 221.71% and 256.64%, respectively, and that of 50 μg/mL hyaluronic acid was 267.39% (Figure 5B).

Inflammation of the skin was caused by TNF-α, ILs, and other cytokines that could be upregulated by environmental or physiological stresses, thereby restricting the growth of skin cells while inhibiting skin inflammation and aging. Inflammation is one of the intrinsic reasons for aging, and to maintain a healthy skin, inflammation control is important (Baylis et al., 2013). The effect of MC and MF on inflammation-related gene expressions such as TNF-α, IL6, and COX2 was measured in HEKa cells (Figure 6). TNF-α mRNA expression in HDF cells after treatment of 2% of MC was measured as 157.37% of UV-irradiated control, whereas the same concentration of MF treatment was measured as 195.11%. A positive control treatment with 50 μM retinyl palmitate resulted in a TNF-α expression level of 220.57% (Figure 6A).

At 2% treatment of MC, IL6 mRNA expression in HDF cells was measured as 157.37% of UVB-irradiated control, whereas the same concentration of MF treatment was measured as 195.11%. A positive control treatment with 50 μM retinyl palmitate resulted in an IL6 expression level of 220.57% (Figure 6B).

The effect of MC and MF on COX2 mRNA expression in HDF cells also similar with other inflammatory-related biomarkers (157.37% and 195.11%, respectively, of UVB-irradiated control). A positive control treatment with 50 μM retinyl palmitate resulted in a COX2 expression level of 220.57% (Figure 6C). The expression of TNF-α, IL6, and COX2 mRNA in MC- or MF-treated HEKa cells was inhibited in a concentration-dependent manner.

NN root contains betulinic acid, rutin, isoquercetin, and other flavonoids that have antioxidant, anti-inflammatory, and cytoprotective activities (Sruthi et al., 2019). Petkova et al. reported the phytochemical composition of AL root extracts and their antioxidant effects. AL roots contain phenolic compounds such as chlorogenic acid, caffeic acid, and p-coumaric acid (Petkova et al., 2022), and these compounds are well-known antioxidants (Predes et al., 2011; Rosalia et al., 2010). Phytochemicals such as carotenoids, flavonoids, and phenolic compounds have a number of medicinal properties such as

![Figure 5. Effect of MC and MF on COL1A1 and HAS-2 mRNA expression in HDF cells.](http://dx.doi.org/10.20402/ajbc.2022.0045)
antioxidant, antiviral, antifungal, and antibacterial effects (Di Napoli & Zucchetti, 2021). Wang et al. isolated saponins from AA roots and investigated the isolated compounds that inhibit LPS-induced NO production (Wang et al., 2018). PL root, known as Kuzu, has been used as a traditional medicine for treating cardiovascular diseases and type 2 diabetes mellitus in China (Luo et al., 2007). PL root contains antioxidants, isoflavones, triterpene, and their glycosides and have anti-inflammatory and anti-apoptosis properties (Zhang et al., 2018; Wong et al., 2011). Each root contains various active compounds that possess biological activities.

In this study, we prepared a mixture of extracts using five roots selected from 15 roots based on DPPH radical scavenging activity, and the effect of MC and MF were compared on the mRNA expression of COLA1A1 and HAS2 and cell proliferation, as well as their effect of MC and MF on the expression of inflammation-related mRNA such as TNF-α, IL-6, and COX-2. Based on our results, the treatment of MC and MF could enhance anti-aging properties by promoting COL1A1 and HAS2 mRNA expression and inducing a positive effect on cell migration. Fermentation of the mixture of the selected roots extracts significantly contributed to the increased anti-aging capabilities.

**Conclusion**

Of 15 plant root extracts, only five root extracts were selected based on the result of DPPH free radical scavenging activity: T. officinale, A. lappa, A. asphodeloides, P. lobata, and N. nucifera. The mixture of selected root extracts (MC) and their fermented products (MF) with S. cerevisiae improved COL1A1 and HAS2 mRNA expressions and cell proliferation efficacy in HDF. MC and MF also showed anti-inflammatory effects in human keratinocytes and inhibited the mRNA expression of TNF-α, IL6, and COX2. Furthermore, MF had better efficacies for anti-aging and anti-inflammation than MC. Based on these results, MF has better efficacy than MC and can be used as an active material for cosmetics with anti-aging and anti-inflammation effects.

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**Author’s contribution**

HL, YJK designed the study, HL, YJK carried out the extraction and biochemical assays, HL and WHC oversaw the project, HL wrote the manuscript with assistance from YJK, All authors read and approved the final manuscript.

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Figure 6. Effect of MC and MF on inflammatory-related mRNA expression in HEKa cells.

The expression levels of TNF-α (A) IL6 (B) COX-2 (C) were measured by RT-PCR in HEKa treated with indicated increasing concentrations of MC or MF. Each value represents the mean±SD of three individual experiments. Allantoin (0.01 μg/mL) was used as a positive control (PC).
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국문초록

효모 발효 식물 뿌리 혼합 추출물의 피부세포에 대한 생물학적 활성

이현성을1,2*, 김윤정1, 청와이호3
1배나이아이템디센터, 경기도 안양시, 한국
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3선천매니화장품, 선천, 중국

목적: 혼합 식물 뿌리 추출물 및 발효 혼합 식물뿌리 추출물의 생물학적 활성을 확인하기 위하여 체외 실험을 통하여 항노화 및 항염효과를 확인하였다.

방법: DPPH 라디칼 소거 활성을 통해 항산화 활성이 우수한 식물 뿌리추출물을 선별하였으며, 선별된 식물뿌리의 혼합 추출물 (MC) 및 S. cerevisia을 이용하여 식물 뿌리 혼합추출물의 발효물을 (MF) 제조하였다. 인체 피부 세포에서의 MC 및 MF의 COLLA1 및 HAS2 mRNA 발현에 대한 영향을 확인하였으며, 세포 증식 실험을 통하여 세포 이동을 평가하였다. MC 및 MF의 항염증 효과를 확인하기 위하여 인체 각질세포의 시험용활성을 보았다. 실험 결과는 평균치와 표준편차를 나타내었고, 결과는 t-test를 사용하여 분석하였다. 결론: DPPH 라디칼 소거 활성성 평가를 통하여 15종의 추출물 중 5 종을 선별하였다. MC 및 MF는 COLLA1 및 HAS2의 발현을 농도의존적으로 증가시켰으며, 세포 증식효과를 보여주었다. 또한 MC 및 MF는 염증 관련 유전자인 TNF-α, IL6, COX2의 발현을 농도의존적으로 저해하였다. 모든 실험에서 MF는 MC와 비교하여 더 좋은 효과를 보여주었다. 본 연구는 식물뿌리추출물의 항노화 및 항염효과를 확인함으로써, 기능성 화장품 원료로 적용 가능하다.

핵심어: 식물뿌리추출물, 발효, 항염, 항노화, 화장품원료

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中文摘要
酵母发酵植物根提取物混合物对皮肤细胞的生物学作用

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目的：为了确认混合植物根提取物和发酵混合植物根提取物的生物活性，通过体外实验证实了抗衰老和抗炎作用。方法：通过对DPPH自由基清除活性的评价，筛选出具有优异抗氧化活性的植物根提取物，并利用所选择的植物根混合提取物(MC)和酿酒酵母制备了混合植物根提取物(MF)的发酵产物。确认MC和MF对人皮肤成纤维细胞COL1A1和HAS2 mRNA表达的影响，并通过细胞增殖实验评价了细胞迁移能力。为了证实MC和MF的抗炎作用，通过RT-PCR证实了COX2、TNF-α、IL6在人角质形成细胞中的表达。实验结果用平均值和标准差表示，结果采用t检验分析。结果：通过对DPPH自由基清除活性的评价，选择了15种根提取物中的5种。MC和MF在浓度依赖性方式增加COL1A1和HAS2的表达，并表现出细胞增殖作用。此外，MC和MF以剂量依赖性方式抑制炎症相关基因TNF-α、IL6、COX2的表达。在所有实验中，与MC相比，MF显示出更好的效果。结论：蒲公英根茎/根提取物、牛蒡根提取物、知母根提取物、野葛根提取物和莲根提取物的混合发酵产物具有抗衰老和抗炎作用，可作为功能性化妆品原料应用。

关键词：植物根提取物，发酵，抗炎，抗衰老，化妆品原料
