Abstract

**Purpose:** The hair losing population is increasing due to stress, environmental pollution, and various cosmetic procedures, and the market for functional cosmetics for scalp and hair care is further growing due to the lower aging population. Recently, however, many studies have been conducted where many are found to seek cosmetic raw materials from natural substances or apply fermentation techniques to cosmetic manufacturing processes. Hence, after fermenting with Sasa Borealis, which is edible and has been used for various pharmacological functions in the private sector for a long time and has secured clinical safety, the effectiveness (in vitro) has been investigated, and the fermented mixture of natural products is used as a sample for damaged hair, and the recovery effect has been examined and understood.

**Method:** Examined in this study were the antibacterial activity, anti-inflammatory activity, and dermal papilla cell proliferation rate of Sasa Borealis leaf fermented product, which were mixed with the green coffee bean and Smilax china L. leaf fermented product, and after selecting the fermented mixed sample, the added scalp hair care product was treated with heat perm and dyeing to measure tensile strength and glossiness, where the recovery effect of damaged hair was investigated by imaging with SEM.

**Results:** Sasa Borealis leaf ferment was superior to M. canis, anti-inflammatory activity and dermal papilla cell proliferation. The product to which the fermentation mixture sample was added increased both the tensile strength and glossiness of the hair damaged by heat perm and dyeing, and as a result of confirming such via the SEM, it was found that there is an effect of restoring the damaged hair.

**Conclusion:** Sasa Borealis leaf fermented product has excellent M. canis, anti-inflammatory ability, and dermal papilla cell proliferation rate, and hence, it was confirmed that it may be applied as a raw material for various cosmetics. The cosmetics containing natural fermentation mixtures increased tensile strength and glossiness of damaged hair. Future research is expected to articulate the pharmacological mechanism of the fermentation mixture through the physiological studies related to the fermentation process and the growth rate of dermal papilla cells.

**Keywords:** Sasa Borealis, Fermentation Mixture, Hair Loss, Tensile Strength, Glossiness

1. Introduction

1.1. Need and purpose of the study

In the 21st century, in the Korean society, the quality of life has significantly improved due to the rapid industrialization and economic growth, and the average life expectancy has increased, thereby raising the interest as to whether it is possible to maintain a healthy body and beauty even in old age, and at the same time, industries such as health supplements, exercise, and pharmaceuticals are showing high growth[1]. Furthermore, as the social life of the elderly has
continued, various beauty devices have been released, and many beauty devices that have a positive effect on hair care by managing scalp are sold[2].

This trend is also prevalent in the cosmetic industry, and the organic, eco-friendly, well-being, and natural cosmetics are preferred[3]. In particular, among the modern people, not only natural hair loss due to genetic factors, aging, etc., yet also external factors such as pollutants, ultraviolet rays, stress, western eating habits, and cosmetic procedures threaten the health of scalp and hair.

Scalp is a skin tissue which protects the head among the skin tissues of the human body, and it is a place where the brain is protected from external shocks, and the function of discharging harmful heavy metals to the outside of the body and generating hair. Furthermore, it is very sensitive and reacts sensitively to internal abnormalities such as perm, dyeing, and chemical procedures such as bleaching, stress, and anxiety[4]. Hair is generated from the hair root of scalp, and is not always attached to scalp, yet goes through the process of growth and exfoliation. When over 200 hairs fall out per day, it is called abnormal hair loss and requires management. Abnormal hair loss occurs is known that it progresses due to various reasons such as stress, nutritional status, imbalance of male hormones, and genetic factors[5].

Accordingly, the interest in the health of scalp and hair has increased, and many studies have been conducted on scalp and hair care products that can maintain and restore the health of scalp and hair. However, many products have caused side effects that damage scalp or cause hair loss, such as irritating scalp or causing allergies due to toxic residues[6]. In order to overcome these shortcomings, in recently, a lot of research has been conducted to search for substances useful for scalp and hair care using natural products[7][8][9].

In this study, an attempt was made to find a cosmetic raw material that can reduce environmental pollution and is clinically safe by fermenting natural products that have been used for various pharmacological functions in the private sector for a long time and have secured clinical safety. In addition, most scalp and hair care products were developed for the purpose of preventing hair damage. In this study, the effectiveness of natural fermented mixture as a functional cosmetic ingredient for scalp hair was investigated by focusing on the recovery of damaged hair.

1.2. Theoretical background

1.2.1. Natural fermented cosmetics

Flavonoids, celluloses, carotenoids, and phenyl compounds contained in natural plants have excellent antioxidant, anti-cancer and antibacterial properties, and are therefore used as materials to improve health and beauty, and are widely used in the fields of food, pharmaceuticals, and cosmetics[10][11][12]. Furthermore, as the physiological activity of plants that have been traditionally used as medicines in the private sector for a long time has been scientifically proven, many studies have been reported[13][14][15].

Fermentation refers to the action of microorganisms using organic matters to produce substances beneficial to humans[16][17], and through the fermentation process, the nutrients contained in it are activated to facilitate absorption, and harmful bacteria and toxins are neutralized, etc., operating beneficially for humans. For this reason, fermentation is widely used throughout industries such as food, cosmetics, feed, and pharmaceuticals[18][19].

1.2.2. Coffee

Coffee tree is affiliated with Coffea and with Rubiaceae family, there is a study that caffeine in coffee has a function to promote hair growth[20]. Furthermore, Bussoletti et al. reported that caffeine shampoo and lotion were effective for the androgenic hair loss syndrome(AGA)[21]. There is also a study report that the proliferation rate of dermal papilla cells increased when green coffee beans were double fermented using EM and malt[22]. There were also studies
which claimed that caffeine, which is an alkaloid, offers a very strong antioxidant action and is helpful for hair growth by inhibiting the activities of 5α-Reductase[23].

1.2.3. Smilax china L.

Smilax china L. is a deciduous broad-leaved vine shrub affiliated with the Liliaceae family. Various pharmacological actions such as antioxidant and antibacterial action of the leaves of Smilax china are known, and is also used for packaging food such as rice cake, and it has been proven to have the effect of not only inhibiting the growth of microorganisms, but also providing a good flavor. The young shoots and fruits of Smilax china are edible, and the roots and wood are known to be effective in antipyretic, detoxification, alleviation of diuresis, physical strength, cystitis, dermatitis, nephritis, arthritis, antibacterial action, and breast cancer, furthermore, it has been reported that bioactive ingredients are effective in preventing aging-related diseases caused by reactive oxygen species and hair loss[24].

1.2.4. Sasa Borealis

Sasa Borealis is edible, and hence, both the leaves, stems and roots have been used favorably in private sector since ancient times. The fruit of Sasa Borealis contains a lot of starch, and hence, has been used as a crop by the producers, and the dried leaves were used to brew tea or use as a bathing agent. It is widely known that it has antibacterial and anti-inflammatory effects, and hence, it has been widely used in folk remedies, and in particular, it is known to have excellent antipyretic, blood pressure lowering, blood sugar lowering, and anti-inflammatory effects, and is known to help strengthen heart and brain functions by improving blood circulation[25]. As it has been clinically proven for a long time as such, the studies to use it have been actively conducted[26][27].

1.2.5. Malt

Malt is also called 'gilgeum powder', a material used to make 'Shikhye', a traditional drink. It contains a lot of enzymes and minerals such as saccharification enzymes α-Amylase, Glucoamylase, and β-Amylase, and is rich in calcium[28].

2. Research Method

2.1. Preparation of sample

2.1.1. Fermentation of leaf of Sasa Borealis

250g of Sasa Borealis leaves and 2L of distilled water were placed in SMART OCOO(Oku, Korea), sealed, and extracted by convection for 6 hours. After the extraction was finished, it was cooled to room temperature and then used for fermentation. 2L of Sasa Borealis leaf extract was mixed with 300 ml of malt liquid, and the fermentation was carried out under two conditions. First, it was made to leave stationary fermentation at 25℃ for 2 weeks. As another condition, fermentation was carried out in a sealed convection method for 6 hours at 60℃ in SMART OCOO(Oku, Korea). After fermentation, it was filtered with sterile gauze and stored in a refrigerator for use in the experiment.

2.1.2. Selection of fermentation mixture

For the human hair experiment, the composition of fermentation mixture for hair treatment and hair essence production was selected. Coffee Green Bean, Sasa Borealis leaf and Smilax china L. leaf fermented products were tested for antioxidant, antibacterial, anti-inflammatory and dermal papilla cell proliferation rates, then, the fermented product demonstrating were used as a sample by mixing 1:1:1 <Table 1>. 

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Table 1. Selection of fermentation mixture.

<table>
<thead>
<tr>
<th>Test</th>
<th>Sample</th>
<th>CEFE 25</th>
<th>CEFE 60</th>
<th>JEE 25</th>
<th>JEE 60</th>
<th>MEE 25</th>
<th>MEE 60</th>
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<tr>
<td>Anti-microbial activity</td>
<td>B. subtilis</td>
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<td>-</td>
<td>○</td>
<td>○</td>
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<tr>
<td></td>
<td>M. canis</td>
<td>-</td>
<td>-</td>
<td>◎</td>
<td>○</td>
<td>◎</td>
<td>○</td>
</tr>
<tr>
<td></td>
<td>T. mentagrophytes</td>
<td>-</td>
<td>-</td>
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<td>-</td>
<td>◎</td>
<td>-</td>
</tr>
<tr>
<td>Anti-oxidant activity</td>
<td></td>
<td>○</td>
<td>○</td>
<td>◎</td>
<td>○</td>
<td>◎</td>
<td>-</td>
</tr>
<tr>
<td>Anti-inflammatory activity</td>
<td></td>
<td>○</td>
<td>○</td>
<td>◎</td>
<td>◎</td>
<td>○</td>
<td>○</td>
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<tr>
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<td></td>
<td>○</td>
<td>○</td>
<td>-</td>
<td>-</td>
<td>○</td>
<td>-</td>
</tr>
<tr>
<td>ERK / akt phosphorylation</td>
<td></td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
<td>○</td>
</tr>
</tbody>
</table>

Note: * CEFE25: Coffee extract fermentation by EM and enzyme at 25°C.
* CEFE60: Coffee extract fermentation by EM and enzyme at 60°C.
* JEE 25: Sasa borealis fermentation by enzyme at 25°C.
* JEE 60: Sasa borealis fermentation by enzyme at 60°C.
* MEE25: Smilax china fermentation by enzyme at 25°C.
* MEE60: Smilax china fermentation by enzyme at 60°C.

2.2. Manufacturing of laboratory products

2.2.1. Manufacturing of hair treatment

For this experiment, a base hair treatment to be used as a control group and a test group in which 10% of the fermentation mixture was added to the base hair treatment were prepared. First, the base hair treatment was prepared as a hair treatment that did not contain other extracts or nutrients in order to examine the efficacy of the selected samples. Distilled water was used for the negative control.

2.2.2. Manufacturing of hair essence

For this experiment, a test group in which 10% of the fermentation mixture was added to the base hair essence and the base hair essence to be used as a control group was prepared. First, the base hair essence was prepared as a hair essence that did not contain other extracts or nutrients in order to examine the efficacy of the selected samples. Distilled water was used for the negative control.

2.2.3. Hair sample

The hair used for this study was virgin hair in the fifth grade of elementary school that had not been exposed to chemical treatment for over 3 years. To remove contaminants from the hair sample, it was washed with lukewarm water using a weak acid shampoo, rinsed thoroughly with lukewarm water, and then dried naturally for use in the experiment. Furthermore, it was used with the consent of the subject that the researcher could use it for academic research and experiments.

2.3. Efficacy experiment of Sasa Borealis' leaf fermentation

2.3.1. Antimicrobial activity

2.3.1.1. Antimicrobial test method - paper disc method
The strain used in the antibacterial experiment was purchased from the Korean Collection for Type Cultures (KCTC). The paper disc method was used as the antibacterial test method [29].

2.3.1.2. Anti-fungal test method - liquid mixing test method

After the treatment by putting the fungal activity solution and each sample in a sterilized test tube, 100 μl of each strain was dispensed and loaded into an appropriate growth plate medium for inoculation, and growth inhibition was observed.

2.3.2. Anti-inflammatory

Proteins in cultured cells were quantified using BCA reagent, and after electrophoresis on 10% SDS polyacrylamide gel, each band was photographed.

2.3.3. TNF-α, IL-6 and iNOS expression using the HaCaT cells

The HaCaT cells cultured for 24 hours were treated with the fermented product and LPS (lipopolysaccharide) at the same time, and the expression levels of the factors causing hair follicle destruction and cell death were compared by relative quantification.

2.3.4. Effect on the dermal papilla cell proliferation and Akt phosphorylation

The HHDPCs cells were aliquoted in a 96-well plate, the samples were processed, and then analyzed by the CCK-8 method, and the cell viability relative to the control was expressed as a percentage. The measurement of ERK and Akt phosphorylation was confirmed by absorbance and Western-blot after culturing HHDPCs cells, fermented product and standard (minoxidil) treatment.

2.4. Experiment of damaged hair recovery efficacy

Damaged hair recovery efficacy experiment of the natural product fermentation mixture was conducted as follows. Hair treatment was applied for the hair damaged by heat perm and dyeing, immersed for 5 minutes, wrapped in aluminum foil, and heat treated at 50°C for 5 minutes. Thereafter, it was left at room temperature for 10 minutes and then rinsed with warm water. The experimental group (PTB, PTS, CTB, CTS) treated only with hair treatment after removing moisture with a towel was dried naturally, and the experiment was conducted with the rest of the hair. Hair essence was applied for the hair treated with the hair treatment and dried naturally (repeated twice) <Figure 1>.

Figure 1. Configuration of the experiment for the recovery of efficacy of damaged hair.
2.5. Measurement of the effect of recovery of damaged hair

2.5.1. Tensile strength

To evaluate the extent of damage to the hair, it was measured using a tensile strength meter, Digital Force Gauge, HF-20(Tripod, China). For the reliability of the tensile strength measurements, the average value was obtained after 5 measurements and statistical analysis was performed.

2.5.2. Glossiness

To examine the change in the gloss of the hair, it was measured using a gloss meter(Gloss Meter NH268, Shenzhen Threenh Technology, China). The measurement was taken based on the 7 cm position from the hair root of the sample bundle. To increase the reliability of the measured value, the average value was obtained after 10 measurements and statistical analysis was performed.

2.5.3. Statistical analysis

The two-tailed test was performed with t-tests(Independent Sample t-test) using jamovi 1.2.27 solid, a statistical program, as a post-test after obtaining the mean and standard deviation(SD), and the significance level was verified at the p<0.05 level. The null hypothesis was “There is no difference between before and after the application” and the research hypothesis was “There is a difference between before and after the application”.

2.5.4. Hair observation using a scanning electron microscope(SEM)

To observe the extent of damage to the hair, using a scanning microscope(SEM, Scanning Electron Microscope, Electron Gun) was enlarged at a constant ratio(×1000, X3000) and then observed.

3. Results

3.1. Abbreviation

- PNC : Damaged hair by heat perm
- PBT: Only base treatment on damaged hair with heat perm
- PBTE: Base treatment and base essence treatment for damaged hair with heat perm
- PST: Only treatment with sample addition treatment for damaged hair
- PSTE: Sample addition treatment and sample addition essence treatment for damaged hair
- PPC: Normal hair
- CNC : Dyeing damaged hair
- CBT: Only base treatment on dyed damaged hair
- CBTE: Base treatment and base essence treatment on dyed damaged hair
- CST: Only treatment with sample addition to dyed damaged hair
- CSTE: Sample addition treatment and sample addition essence treatment for dyed damaged hair
- CPC: Normal hair

3.2. Effectiveness of fermented product of leaf of Sasa Borealis

3.2.1. Antibacterial activation

3.2.1.1. Antibacterial test method

The fermentation broth at 25° C. demonstrated an inhibitory ring(18 mm) against Bacillus subtilis.
3.2.1.2. Anti-fungal test method

The growth of *Microsporum canis* was inhibited in the order of 60°C fermentation broth and 25°C fermentation broth. In the growth-inhibited *Microsporum canis*, not only the number of colonies yet also the size were small, and it was confirmed that the growth was inhibited because the formation of white filaments was significantly reduced <Table 2>.

**Figure 2.** Antifungal test results of fermented *Sasa Borealis* leaves.

<table>
<thead>
<tr>
<th>temperature</th>
<th>25°C</th>
<th>60°C</th>
</tr>
</thead>
<tbody>
<tr>
<td>control</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Microsporum canis</em></td>
<td>++++</td>
<td>++</td>
</tr>
</tbody>
</table>

3.2.2. Anti-inflammatory

It was confirmed that the inflammatory cytokines TNF-α and IL-6 were increased when treated with LPS(400ng/ml), as for the sample-treated group, it was confirmed that TNF-α and IL-6 were inhibited compared to the LPS-treated control group.

3.2.3. TNF-α, IL-6 and iNOS expression using the HaCaT Cells

As for the sample-treated cells, it was significantly reduced compared to the LPS-treated group, and in particular, the iNOS gene was hardly found in the fermentation broth at 25°C. The expression level of IL-6 gene was significantly decreased at the 25°C and 60°C fermentation broth. TNF-α gene expression was significantly decreased in the enzyme fermentation broth at 25°C and 60°C <Figure 2>.

**Figure 3.** Inhibitory effects of extract on iNOS, IL-6, and TNF-a expression.

Note: (A) iNOS, IL-6, and TNF-a were evaluated by western blot and (B) Representative protein expression to β-actin. Values are relative to the control. *p < 0.05, **p < 0.01 indicate a significant difference from the LPS-treated control.
3.2.4. Effect on the dermal papilla cell proliferation and Akt phosphorylation

Cell proliferation has increased compared to Minoxidil in the cells treated with Sasa Borealis leaf extract and 25°C enzyme fermentation broth of Smilax china L. leaf extract. Akt phosphorylation decreased in the positive control group treated with Minoxidil compared to the control group, and significantly increased in the sample-treated group. In particular, the expression level of Akt phosphorylation gene increased about 4 times compared to Control in the 60°C enzyme fermentation broth. Based on such results, it was confirmed that the Sasa Borealis leaf fermented product promoted the proliferation of dermal papilla cells by promoting Akt phosphorylation <Figure 3>.

Figure 4. Inhibitory effects of extract on p-Akt, Akt, p-ERK1/2 and ERK1/2 expression.

3.3. Tensile strength

In this experiment, as for the tensile strength, based on the hair damaged by dyeing and heat perm, the tensile strength of the base hair treatment without the addition of the fermentation mixture sample, the base hair essence, the hair treatment with 10% of the fermentation mixture sample, and the hair essence treatment group were compared to the normal hair for analysis.

For the hair damaged by heat perm, the group treated with the hair treatment with the fermentation mixture sample and the hair essence demonstrated an increase rate of about 37% compared to the damaged hair, and it is believed that there will be some preventable effect. It was also found that the tensile strength of damaged hair is lower than that of healthy hair because the extent of damage to hair is increased by chemical treatment. This is supportive of the research result that the cysteine bond cleaved by the perm agent is not completely sealed and the reduced cysteine remains and the tensile strength is lowered <Figure 4>[30].

For the hair damaged by dyeing, the group treated with a hair treatment with a fermented mixture sample and hair essence demonstrated a 30% increase in tensile strength compared to damaged hair, and it is expected to have some preventive effect against the results of steeply falling tensile strength to some extent. This is consistent with the research results that the tensile strength decreases when hair damage occurs due to bleaching or dyeing[31].

Consequently, it is considered that the simultaneous treatment of hair treatment with fermented mixture sample and hair essence will increase the tensile strength of damaged hair, restoring hair breakage and giving it. There is also a study result that the tensile strength is lowered due to damage to the hair due to cosmetic treatment[32], and it is reported that treatment with Googicha extract or Mokdanpi microcapsules to the hair shows higher tensile strength than untreated hair[33][34].
Hence, it is considered that the fermented mixtures in the sample restore the damages to the hair with antioxidant action and hair coating effect, thereby resulting in the increased tensile strength.

3.4. Glossiness

As for the glossiness of this experiment, the glossiness of the base hair treatment without the addition of the fermentation mixture sample, the base hair essence, the hair treatment with 10% of the fermentation mixture sample, and the hair essence treatment group were compared and analyzed based on hair damaged by dyeing and heat perm. Overall, regardless of the cause of hair damage, the group treated with the fermented mixture sample and the hair essence at the same time demonstrated the highest glossiness and higher glossiness than that of undamaged normal hair <Figure 4>.

As a result of the heat perm test, the glossiness of the group treated with the hair treatment and hair essence containing the fermented mixture sample increased by about 28% compared to the glossiness of the damaged hair, and turned out to be higher than that of the normal hair. As a result of the dyeing experiment, the glossiness of the group treated with the hair treatment and the hair essence containing the fermented mixture sample increased by about 60% compared to the glossiness of the damaged hair, and was higher than that of the normal hair <Figure 4>.

Consequently, it was confirmed that the group treated with both the base hair treatment and the base hair essence without the addition of the fermentation mixture did not increase the glossiness of the hair damaged by heat perm or dyeing, and it is considered that it can make hair shiny by increasing glossiness of damaged hair when the hair treatment with the fermented mixture sample is added and hair essence are concurrently treated.

Figure 5. Restorative effect on hair damaged by heat perm or dyeing – tensile strength and glossiness.

3.5. Analysis of hair surface via SEM(SEM, scanning electron microscope)

The surface of the hair was observed using the SEM with a view to examine the effect of restoring damaged hair of a hair cosmetic prepared by adding 10% of a fermentation mixture to hair damaged by dyeing and heat perming.

As for the hair damaged by heat perm, it was determined that there would be a recovery effect of damaged hair because cosmetics were adhered to the cuticle damaged area when only hair treatment with fermented mixture was treated alone. Furthermore, when the hair essence added with the fermentation mixture was treated concurrently, the adhesion effect on the cuticle surface was very good, and it was found that the recovery effect of damaged hair was excellent <Figure 5>. In this connection, there is a research report that natural ingredients coat the epidermis to protect hair by reducing porosity during the chemical cosmetic procedures[35].

As for the hair damaged by dyeing, when only the hair treatment with the addition of the fermentation mixture was treated alone, it was determined that there would be an effect of
restoring the damaged hair because the cosmetics were adhered to the cuticle damaged area. Furthermore, when the hair essence containing the fermentation mixture was treated concurrently, the adhesion effect on the cuticle surface was very good, and the shape of the cuticle was not seen because it was covered (Figure 5). As a result of the experiment, it was apparent that the recovery effect of damaged hair was the best when the hair treatment with the addition of the fermentation mixture and the hair essence were concurrently treated.

As a result of the experiment, regardless of the cause of hair damage, when the hair treatment with fermented mixture and hair essence were treated concurrently, the cosmetics filled the damaged and floating parts of the cuticle, pressed the floating cuticle, and the surface of the cuticle, and it was determined that the recovery effect of damaged hair was excellent by being thickly coated due to its excellent ability to adhere to the hair.

**Figure 6.** Restorative effect on damaged hair by heat perm or dyeing- SEM.

### 4. Conclusion

In this study, it was verified as to whether the hair treatment and hair essence added with the natural product fermentation mixture could restore the tensile strength and glossiness of the hair damaged by heat perm and dyeing.
After fermenting the leaves of *Sasa Borealis* using malt, the effectiveness (anti-inflammatory activity, *M. canis*, dermal papilla cell proliferation rate) was examined, and the dermal papilla cell proliferation rate was also excellent. The 25°C fermentation broth was excellent in anti-inflammatory activity and *M. canis* against *M. canis*, and the he dermal papilla cell proliferation rate was also excellent. The human hair treatment and hair essence were prepared by adding a fermented mixture of a fermented product of a natural product obtained in the previous experiment (*green coffee bean, Smilax china L. leaf* and *Sasa Borealis* leaf fermented product, and as a result of such experiment, regardless of the cause of hair damage, the group treated with the fermented mixture and the hair essence at the same time demonstrated the excellent tensile strength and glossiness <Figure 4>.

As a result of the SEM observation, regardless of the cause of hair damage, when hair treatment with fermented mixture sample and hair essence were applied concurrently, the cosmetics filled the damaged and floating parts of the cuticle, and pressed the floating cuticle, and the ability to adhere to the cuticle surface was excellent, and it was determined that the coating had an excellent recovery effect on damaged hair <Figure 5>. As a relevant study, there is one which reported that an extract with antioxidant effect has potential as a raw material for products for the recovery of hair damaged by dyeing[36].

The distinction of this study is that it is fermented using the natural ingredients that are edible and clinically safe, and that it is environmentally safe using only water as a solvent. Furthermore, since the sealed convection bath method is used, there is an advantage in that it is possible to reduce energy consumption and environmental pollution by increasing thermal efficiency. Furthermore, while the existing hair cosmetics studies focused on the pre-treatment and studied the hair protection efficacy, this study is distinct in that it focused on the post-treatment and confirmed the recovery effect of the damaged hair.

Research on fermented cosmetics using natural products is expected to increase in interest due to the increase in environmental pollution and the trend of decreasing the age at which hair loss begins. In addition, since Koreans have been using fermentation technology in their daily life for a long time, it is expected that various studies will be conducted to apply it to medicinal herbs handed down to the private sector, as well as cosmetics, medicine, food, and household products.

5. References

5.1. Journal articles


5.2. Books


6. Appendix

6.1. Author’s contribution

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<tr>
<th>Initial name</th>
<th>Contribution</th>
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<tr>
<td>MC</td>
<td>-Design ☑</td>
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<td>-Getting results ☑</td>
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<tr>
<td>Corresponding Author*</td>
<td>-Play a decisive role in modification ☑</td>
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<tr>
<td>EC</td>
<td>-Significant contributions to concepts, designs, practices, analysis and interpretation of data ☑</td>
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