Unique combination of saccharides and mushroom extract for efficient heat and humidity protection in hair fibers

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Abstract

Background: Thermal damage can occur in hair fibers owing to high temperatures, frequent use, and prolonged direct contact with a heat-styling tool.

Methods: BIO5768 was added to shampoo, conditioner, and leave-in formulations, and their performance was compared with formulations with similar bases containing silicone benchmarks (amodimethicone, dimethicone and dimethiconol) and a placebo set. Swelling test was performed to evaluate the interaction of hair fibers with water. Heat protection was evaluated through protein loss assessment (BCA assay) and differential scanning calorimetry (DSC). Styling benefits were evaluated using the alignment coefficient determined using the Rumba system.

Results: Fibers treated with shampoo and conditioner formulations containing BIO5768 exhibited lower diameter variations than those treated with placebo or amodimethicone. Regarding heat protection, protein loss results demonstrated that leave-in formulations containing BIO5768 achieved higher protection than placebo and performed similarly to the silicone benchmarks. In addition, DSC results indicated that BIO5768-treated tresses were better protected than those treated with dimethicone and dimethiconol, and were comparable to amodimethicone-treated tresses. After the first flat iron pass, tresses treated with leave-in formulations containing BIO5768 exhibited a higher alignment coefficient than those treated with the placebo formulation, indicating an effect similar to the benchmarks. Moreover, after 24 h in high humidity conditions, BIO5768-treated tresses exhibited higher straightening maintenance effects than those treated with dimethicone and dimethiconol formulations.

Conclusion: BIO5768 formed a substantive film on the hair fiber surface, providing protection from heat and humidity and helping to achieve and maintain the desired hair style.

Keywords: Film forming; Humidity control; Saccharides; Styling; Thermal protection

Introduction

Human hair fibers are composed of four different structures: the cell membrane complex, cuticle, cortex, and medulla. The most external structure of the hair fibers is the cuticle, which is composed of protein overlapping longitudinally and peripherally on cells, covered with a lipid layer, resulting in a thick protective layer surrounding the hair shaft [1,2]. In one hand, owing to its location, the cuticle is important for the aesthetic characteristics of hair as it interacts more easily with cosmetic products than the other structures. On the other hand, it is also more susceptible to external damage such as thermal, ultraviolet (UV), and pollution exposure and combing processes [1].

The use of heat-styling tools is one of the most common steps in hair care routines. The use of these devices can cause severe injury to the hair fibers since thermal damage is a consequence of the high temperatures, prolonged direct contact, and high frequency of using heat-styling tools [3]. The commonly used heat-styling tools, flat and curling irons, can heat up to 230 °C, close to the keratin denaturation temperature (~240 °C), meaning that the frequent exposure of the fibers to these processes may compromise the mechanical properties of hair, increase its porosity, disbalance the water absorption, and affect some of its visual aspects, that is, softness, alignment, and frizz. Even when the fibers are subjected to temperatures lower than those mentioned above, it is possible to observe several consequences such as cuticle cracking and lifting, hazing of cuticle borders, and a decrease in hair mechanical properties, depending on the temperature and frequency of exposure [1,4].

These damages can be perceived as sensory and are usually correlated with the use of heat-styling tools by consumers. Among the interviewed consumers from China, Germany, the USA, France, and Brazil, 84% somewhat agreed or strongly agreed that flat iron and hair dryers damage the hair, whereas almost 20% of them perceived physical treatments (*e.g.*, hot iron and blow dryer) as causes for their hair issues [5]. Another interesting observation was made in Brazil where almost 30% of the consumers are often concerned about excess frizz/electrostatic as well as rebellious/ difficult to comb/flyways effects [6], characteristics that are often observed in hair styled using heat-styling tools. In addition, the hair styling provided by these devices is based on the rearrangement of hydrogen bonds present in the hair structure, making it vulnerable to high humidity conditions.

Therefore, this study aimed to evaluate a unique and specific combination of saccharides and mushroom extract, BIO5768, regarding its ability to target heat and humidity protection, and achieve and maintain the desired hair style.

Materials and Methods

Virgin Caucasian and textured dark brown hair tresses (5 g, 25 cm) were purchased from International Hair Importers and Products (USA). Before all the damage assessments were performed, the hair tresses were washed with a 10% sodium lauryl ether sulfate (SLES) aqueous solution (1 g/ 10 g) and left to dry overnight under controlled conditions (22 ± 2 °C and 50 ± 5% RH). The samples were divided into BIO 5768, amodimethicone, dimethicone and dimethiconol, and non-treated groups for the following protocols.

Hair Care Formulations (BIO 5768): Shampoo and conditioner with 1.0% BIO5768 were applied five times on each tress (0.1 mL of product/g of hair, massaging for 1 min, followed by 1 min of rinsing under running water (33 ± 3 °C, 4 L/min)) and left to dry overnight under controlled conditions (22 ± 2 °C and 50 ± 5% RH). For leave-in formulations, test products containing 2.0% BIO5768 were applied once on each tress (0.1 mL of product/g of hair followed by massaging for 1 min) and left to dry overnight under controlled conditions (22 ± 2 °C and 50 ± 5% RH).

Hair Care Formulations (Silicones Benchmarks): Shampoo and conditioner containing 0.5 and 2.0%, respectively, of each one of the silicone benchmarks (dimethicone and dimethiconol and amodimethicone) were applied five times on each tress (0.1 mL of product/g of hair, massaged for 1 min, followed by 1 min of rinsing under running water (33 ± 3 °C, 4 L/min)) and left to dry overnight under controlled conditions (22 ± 2 °C and 50 ± 5% RH). For leave-in formulations, test products containing 2.0% of silicone were applied once on each tress (0.1 mL of product/g of hair, followed by massaging for 1 min) and left to dry overnight under controlled conditions (22 ± 2 °C and 50 ± 5% RH).

Bleaching: Three tresses per group were bleached for 30 min at 45 °C using a commercial mixture containing two parts of hydrogen peroxide emulsion (12%) and one part of bleaching powder (Yamá, Brazil). After the procedure, the tresses were washed three times with 10% SLES and left to dry overnight under controlled conditions (22 ± 2 °C and 50 ± 5% RH).

Thermal Damage: Five virgin tresses from treated and non-treated groups were subjected to four passes of flat iron (15 s each at 230 °C) (Nano Titanium - Babyliss Pro, USA) with constant application of force throughout the tress length.

Swelling Test: Fifty bleached fibers from treated and non-treated groups were randomly collected and fixed in plastic tabs one by one. Their diameters were measured while the fibers were soaked in water for 180 s using an ALS1500/DSM770 (Diastron Ltd., UK) and a laser scan micrometer LSM-6200 (Mitutoyo, JPN). Variations in the diameters of the fibers were computed using the UVWin software (Diastron Ltd., UK).

Protein Loss Assessment: Four milliliters of deionized water were added to 250 mg of cut hair from each tress (five tresses per group) and the samples were incubated at 45 °C for 72 h. The amount of protein in the supernatant was determined using a BCA protein assay kit

(Sigma–Aldrich, USA). The absorbances at 562 nm were measured using a UV-visible spectrometer (Lambda 25, PerkinElmer, USA).

Differential Scanning Calorimetry (DSC) Analysis: DSC stainsteel capsules were mounted (6 mg of chopped hair and 50 µL of water) for each treatment group (five tresses per group). DSC analyses were performed using a DSC 4000 system (PerkinElmer, USA), with a nitrogen flow of 20 mL/min and heat flow of 5 °C/min in the temperature range of 70–180 °C. The peak temperature from the event of interest for each tress was obtained using the Pyris Manager software (PerkinElmer, USA).

Straightening Effect Assessment: Leave-in test products were applied to five textured hair tresses per group, as described in the hair care formulation treatment, and the initial time images (T0) were captured using the Rumba system (Bossa Nova Vision, USA). The tresses were subjected to six passes of flat iron at 230 °C, and after each flat iron pass, a new image was captured (T1–T6). The alignment coefficients for the different times (T0–T6) were obtained using the Rumba system software (Bossa Nova Vision, USA).

Straightening Maintenance Assessment: Leave-in test products were applied to five textured hair tresses per group, as described in the hair care formulation treatment. Each tress was divided into two parts and each part was subjected to 15 passes of flat iron at 230 °C. After 15 passes, images at initial time (T = 0) were captured using the Rumba system (Bossa Nova Vision, USA). The tresses were transferred to a humidity chamber for 24 h (70% RH at 25 °C) and images at different times (T = 6 h and T = 24 h) were captured. The alignment coefficients of T = 0, 6, and 24 h were obtained using the Rumba system software (Bossa Nova Vision, USA).

Statistical Analyses: Microsoft Office Excel and XL-STAT were used to perform the graphs and statistical analyses. For statistical analysis of the instrumental tests, comparisons among treatments were performed using Student's t-test or one-way ANOVA, followed by Fisher's least significant difference (LSD) test at a 95% confidence interval.

Results

To evaluate the film-forming properties and humidity protection benefits, a swelling test was performed by comparing tresses treated with shampoo and conditioner containing 1.0% BIO5768 with non-treated and silicone benchmark-treated tresses. The results (Figure 1) demonstrated a significant humidity protection effect of 53% ($P = 0.023$) and 87% ($P = 0.001$) when compared to placebo and amodimethicone treatments, respectively.

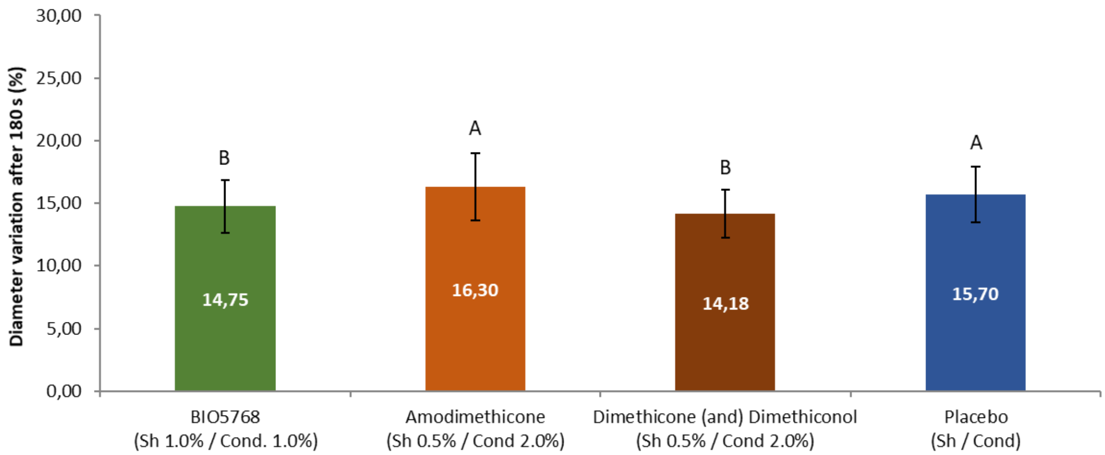

Fig 1. Swelling test results. Tresses treated with shampoo and conditioner containing 1.0% BIO5768 exhibited lower diameter variation after 180 s of water immersion than placebo-treated tresses. Same letters indicate that $P > 0.05$ whereas different letters indicate that $P < 0.05$. The results were computed using one-way ANOVA followed by Fisher's least significant difference (LSD) test.

The results of protein loss assessment obtained using a BCA protein assay kit (Figure 2) demonstrated that tresses treated with leave-in formulation containing 2.0% BIO5768 were more protected ($P = 0.001$) than those treated with placebo, and as protected as the ones treated with leave-in with the same concentration of the silicones that are the most used for this purpose.

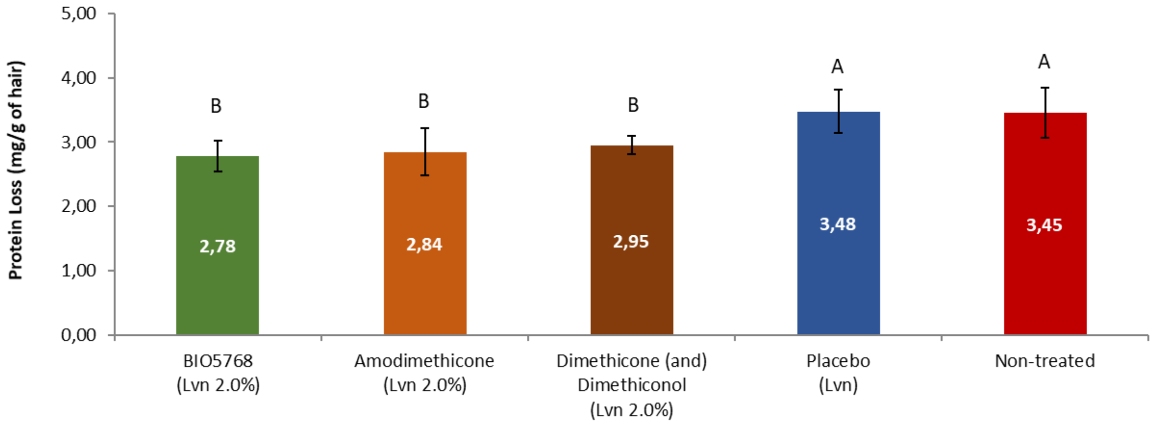

Fig 2. Protein loss assessment results. Tresses treated with leave-in formulation containing 2.0% BIO5768 exhibited higher thermal protection after four passes of flat iron (15 s each at 230 °C) than those treated with placebo, and the same protection level as the evaluated silicones benchmarks. Same letters indicate that $P > 0.05$ whereas different letters indicate that $P < 0.05$. The results were computed using one-way ANOVA followed by Fisher's LSD test.

In addition, DSC results (Figure 3) demonstrated that tresses treated with 2.0% BIO5768 leave-in formulation exhibited higher thermal damage protection than those treated with 2.0% dimethicone and dimethiconol ($P = 0.012$). Additionally, tresses treated with BIO5768 were equally protected as those treated with 2.0% amodimethicone.

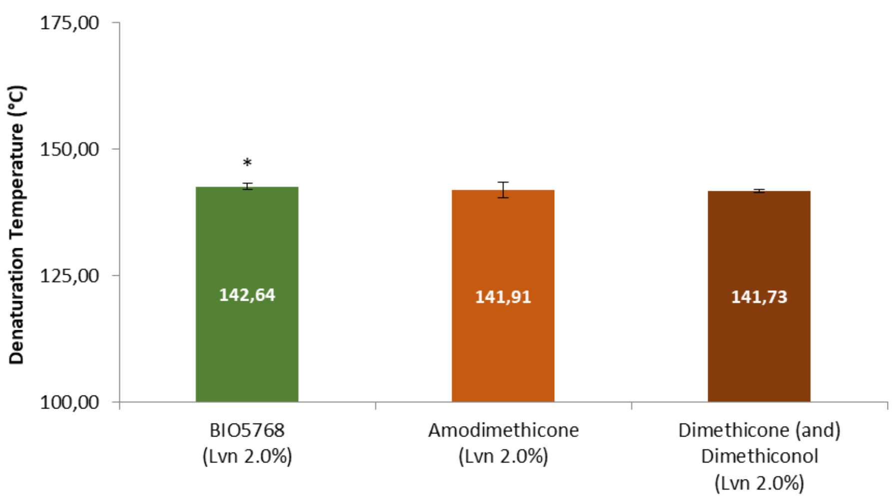

Fig 3. Differential scanning calorimetry (DSC) assay results. Tresses treated with leave-in formulation containing 2.0% BIO5768 exhibited higher thermal protection after four passes of flat iron (15 s each at 230 °C) than tresses treated with leave-in formulation containing 2.0% dimethicone and dimethiconol, and same level of protection as the ones treated with 2.0% amodimethicone. *$P < 0.05$ versus dimethicone and dimethiconol, Student's t-test.

Styling benefits were evaluated through a straightening effect assessment in which the alignment coefficient for each tress was obtained from the coefficients determined in each pixel of the images taken by the Rumba system. Thus, the higher the alignment coefficient, the more aligned the tresses. The results demonstrated that after one flat iron pass, textured tresses treated with leave-in formulation containing 2.0% BIO5768 exhibited similar alignment coefficients to those treated with silicone (Figure 4), and higher alignment coefficients than those treated with placebo (P = 0.017).

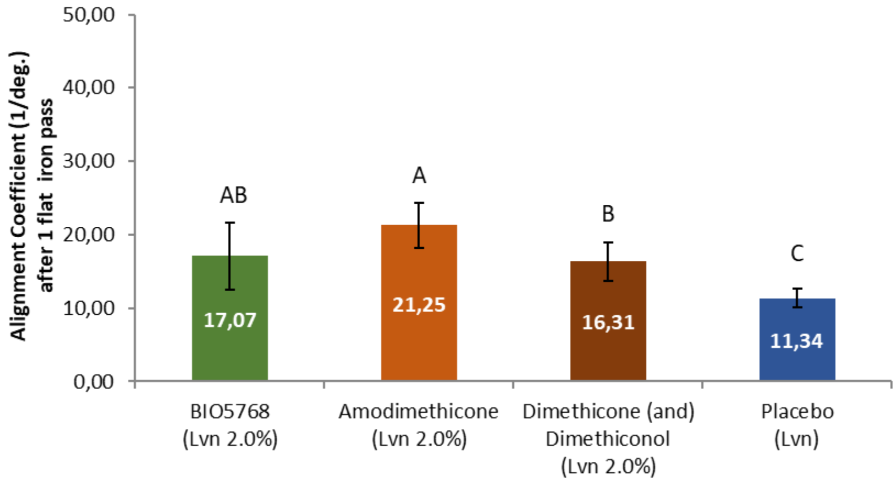

Fig 4. Straightening effect assessment results. Tresses treated with leave-in formulation containing 2.0% BIO5768 exhibited alignment coefficients similar to the silicone benchmarks evaluated after one flat iron (230 °C) pass. Same letters indicate that $p > 0.05$ whereas different letters indicate that $P < 0.05$. The results were computed using one-way ANOVA followed by Fisher's LSD test.

Furthermore, to test the performance of BIO5768 in promoting long-lasting styling, textured tresses were subjected to 15 passes of flat iron and maintained under high humidity conditions. After 24 h at 70% RH, tresses treated with leave-in formulation containing 2.0% BIO5768 were 41% more aligned than those treated with the formulation containing 2.0% dimethicone and dimethiconol (P = 0.007) and exhibited similar alignment to those treated with 2.0% amodimethicone (Figure 5).

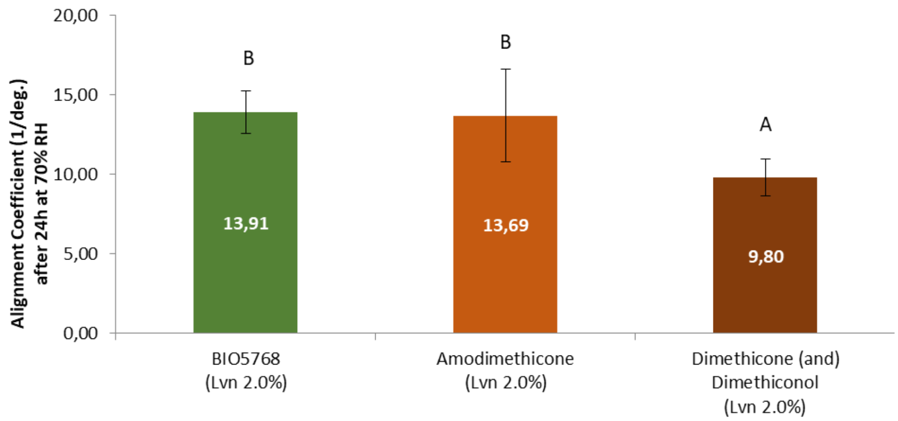

Fig 5. Straightening maintenance assessment results. Tresses treated with leave-in formulation containing 2.0% BIO5768 exhibited similar alignment coefficients to those treated with 2.0% amodimethicone. Same letters indicate that $P > 0.05$ whereas different letters indicate that $P < 0.05$. The results were computed using one-way ANOVA followed by Fisher's LSD test.

Discussion

In the swelling test in which water absorption was related to an increase in the diameter variation of hair fibers, BIO5768 was able to reduce the uptake of excessive water by the hair structure, which could lead to an increase in the diameter, demonstrating protection against high humidity. This effect was observed owing to the substantive film formed by different molecular weight saccharides and mushroom extract, as the smaller components filled in areas that the larger components could not cover, increasing their interaction with the fiber surface.

With regard to protection against high temperatures, BIO5768 exhibited a performance similar to that of the most used silicones for this purpose. The natural substantial film formed on the hair surface provided efficient thermal protection because BIO5768 absorbed part of the energy generated by the hot-styling tools without losing its properties, preventing heat accumulation points that could cause more severe damage.

Furthermore, BIO5768 could also protect the hair against other factors that contribute to the high intensity of heat damage, such as high frequency of use and prolonged direct contact with the hot-styling tools. As BIO5768 made the styling easier, it was possible to decrease the prolonged contact of the flat iron with the hair, and it also promoted a long-lasting styling effect, decreasing the repetitive use as the hair style could be maintained over time, even under high humidity conditions.

Conclusion

In conclusion, due to the unique composition of BIO5768 which combines different molecular weights of saccharides and mushroom extract, it works as a holistic ingredient that forms a substantive film on the surface of hair fibers, providing high thermal protection.

BIO5768 also protects the hair from humidity and prevents excessive water uptake, providing styling benefits such as more aligned hair fibers, and maintaining the desired style over time (up to 24 h) under high humidity conditions.

Acknowledgments

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Conflict of Interest Statement

None

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