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## Ethyl Macadamiate as a Botanical Silicone Alternative in Hair Conditioners

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# Ethyl Macadamiate as a Botanical Silicone Alternative in Hair Conditioners

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## abstract

This research explores the hair conditioning benefits of ethyl macadamiate compared to commonly used low viscosity silicones. Ethyl macadamiate is a macadamia oil derived ester used in cosmetics and personal care products for its silky silicone-like after feel, oxidative stability, and dispersion abilities. It continues to be challenging to find botanically derived ingredients that provide the same efficacy and feel as silicones. Silicones are used in hair conditioning and treatment products to provide heat protection, reduce wet and dry comb force, and deliver shine without weighing down the hair during use. A series of *ex vivo*, vehicle-controlled studies were carried out to determine the performance benefits of incorporating ethyl macadamiate as compared to silicones into leave-in hair conditioners. The results show that ethyl macadamiate functioned similarly to or better than phenyl trimethicone and cyclopentasiloxane, and was able to provide the following statistically significant benefits: reductions in wet and dry comb force and hair breakage, heat protection, increased shine, and increased consumer perception of smoothness/sleekness, shine, and softness. Ethyl macadamiate provides formulators with an effective natural silicone alternative.

## Introduction

Ethyl macadamiate is a botanically derived ester that has been proven to mimic the feel and function of silicones on the skin. It can be used alone or in combination with other ingredients to deliver moisturization and radiance to the skin with a silky, smooth after feel [1]. Silicones used in skin care products also function in hair care products to condition hair. This research explores the conditioning benefits (*i.e.* comb force, heat protection, and shine) of ethyl macadamiate compared to the commonly used cyclopentasiloxane and phenyl trimethicone in hair conditioners (see **Tab. 1**) at low and high loading levels of the respective conditioning agents. Consumer perception of these benefits provided by ethyl macadamiate as compared to phenyl trimethicone was also confirmed in both tress and take-home use studies in order to further demonstrate that ethyl macadamiate can also be used as a silicone alternative in hair care products.

## Materials and Methods

All studies were randomized, conducted single- or double-blind, as applicable, and carried out under controlled temperature and humidity conditions.

### Wet and Dry Comb Force

Naturally curly, brown hair tresses (De Meo Brothers, Inc.) were double-bleached (90 minutes per bleach cycle) using the Radical Bleach Kit (Beyond the Zone, Seattle, WA) and

### Hair Cream

| Ingredient   | % wt./wt. |
|--|-----------|
| Water  | 87.51     |
| Conditioning Agent   | 5.00      |
| Hydrogenated Sunflower Seed Oil Polyglyceryl-3 Esters (and) Hydrogenated Sunflower Seed Oil Glyceryl Esters (and) Cetearyl Alcohol (and) Sodium Stearoyl Lactylate | 3.00      |
| Citric Acid (and) Water  | 1.20      |
| Cyclopentasiloxane   | 1.00      |
| Phenoxyethanol (and) Ethylhexylglycerin  | 0.90      |
| Hydrolyzed Soy Protein   | 0.65      |
| Carbomer   | 0.25      |
| Aminomethyl Propanol   | 0.24      |
| Fragrance  | 0.15      |
| Disodium EDTA  | 0.10      |

### Hair Serum

| Ingredient   | % wt./wt. |
|--|-----------|
| Conditioning Agent                                 | 86.70     |
| Glyceryl Tribehenate / Isostearate / Eicosandioate | 10.00     |
| Polyglyceryl-3 Beeswax                             | 2.70      |
| Phenoxyethanol                                     | 0.60      |

**Tab. 1** Test Article Compositions (%wt./wt.).

washed with a 10% sodium lauryl sulfate (SLS) solution prior to use in the study. This was done to remove any oils present on the hair fibers.

Test article treatment consisted of a 30 second rinse with running lukewarm (30–32°C) tap water with constant pressure (100% flow) using the Intellifaucet Batch and Temperature Control System (Hass Manufacturing Company, Averill Park, NY), one application of the leave-in hair cream or serum test article (1.0 ml/1.5 g of hair or 0.5 ml/1.5 g of hair, respectively), combing to detangle hair and distribute the conditioner, two to four minutes of blow drying, and six passes of a flat iron at 450°F (232°C). Eight tresses per test article were evaluated. Peak wet and dry comb force (gram-force) measurements were made before and after test article treatment using a Test Resources Q Series (100Q) Universal Testing Machine (TestResources, Inc), and percent reduction in comb force was calculated. (The hair cream and hair serum test article compositions can be found in [Tab. 1.](#))

### Heat Protection

For the leave-in hair cream, naturally curly, brown hair tresses (International Hair Importers & Products) were washed with a 10% SLS solution prior to use in the study. Test article treatment consisted of a 30 second rinse with running lukewarm (32–36°C) tap water with constant pressure (100% flow) using the Intellifaucet Batch and Temperature Control System, one application of the leave-in hair cream test article (1.0 ml/1.5 g of hair), combing to detangle hair and distribute the conditioner, two to four minutes of blow drying, and 100 passes of a flat iron at 450°F (232°C). Eight tresses per test article were evaluated. Tresses then underwent a reversion period (*i.e.* the hair reverts back to a naturally curly state due to humidity exposure) in controlled temperature and elevated humidity conditions (30–36°C and 94–99% relative humidity) for four (4) hours. [2] The hair tresses were then allowed to acclimate overnight in controlled temperature and humidity conditions (22–24°C and ≤21% relative humidity). Grooming consisted of approximately one thousand (1000) controlled combs; broken hair fibers were collected and visually counted.

For the leave-in hair serum, naturally curly, brown hair tresses (De Meo Brothers. Inc.) were double-bleached (90 minutes per bleach) using the Radical Bleach Kit and washed with a 10% SLS solution prior to use in the study. Test article treatment consisted of a 30 second rinse with running (20–22°C) tap water with constant pressure (100% flow) using the Intellifaucet Batch and Temperature Control System, one application of the leave-in hair serum test article (0.2 ml/1.5 g of hair), combing to detangle hair and distribute the conditioner, two to four minutes of blow drying, and 100 passes of a flat iron at 450°F (232°C). Eight tresses per test article were evaluated. Tresses then underwent a reversion period in controlled temperature and elevated humidity conditions (27–35°C and 94–99% relative humidity) for four (4) hours. The hair tresses were then allowed to acclimate overnight in controlled tem-

perature and humidity conditions (21–24°C and 21–45% relative humidity). Grooming consisted of approximately one thousand (1000) controlled combs; broken hair fibers were collected and visually counted.

### Shine Analysis

Naturally straight, brown hair tresses (De Meo Brothers. Inc.) were washed with a 10% SLS solution prior to use in the study. Test article treatment consisted of dampening hair, one application of the leave-in hair cream or serum test article (0.5 ml/1.5 g of hair), combing to detangle hair and distribute the conditioner, air-drying overnight, and five passes with a flat iron at 450°F (232°C). Five tresses per test article were evaluated. Hair shine measurements were made using a Glossymeter GL 200 (Courage+Khazaka, Köln, Germany) on untreated hair/no heat, untreated hair/with heat, treated hair/no heat, and treated hair/with heat, and percent change in hair shine was calculated as compared to untreated hair.

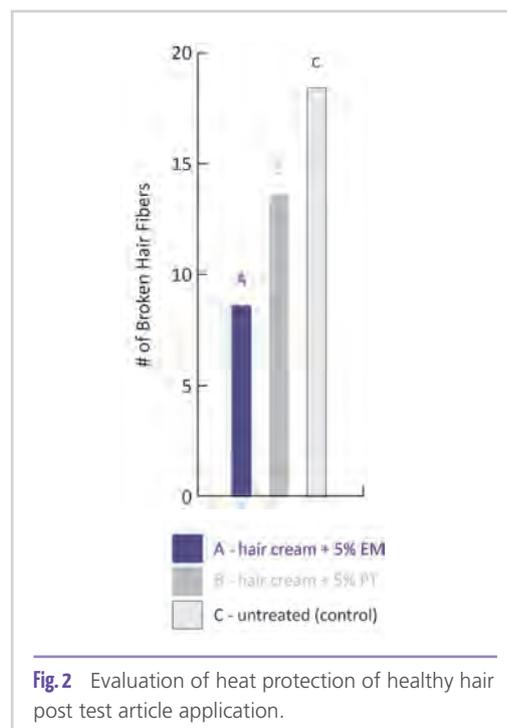
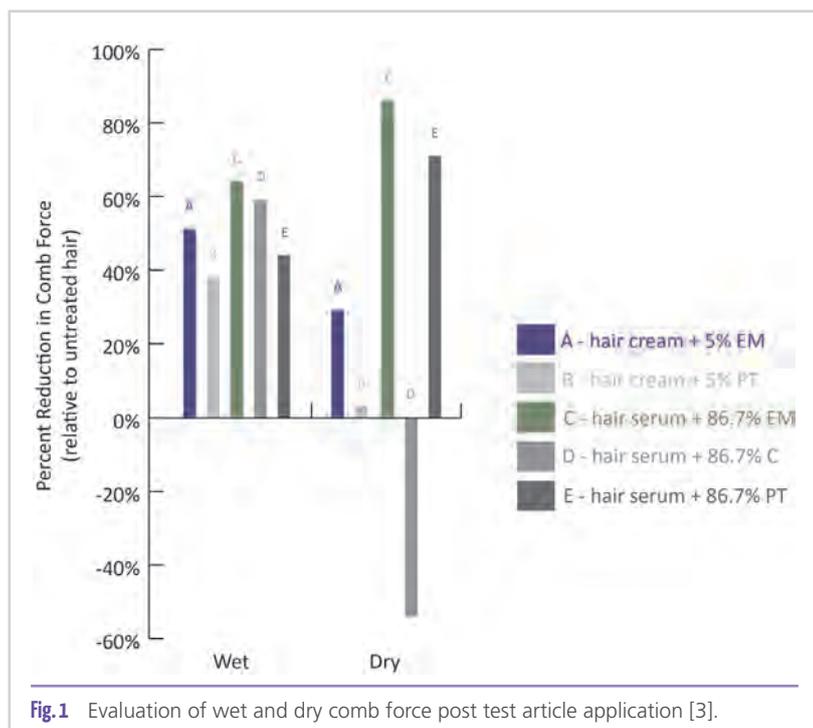
### Consumer Perception

For the leave-in hair cream, naturally curly, brown hair tresses (International Hair Importers & Products) were washed with a 10% SLS solution prior to use in the study. Test article treatment consisted of one application of the test article (0.5 ml/1.5 g of hair), combing to detangle hair and distribute the conditioner, and air-drying overnight. Three tresses per test article were evaluated, and hair tresses were prepared no more than seven days before Day 1 of the study.

Prior to the start of the study, each tress was combed with five repetitions with the fine-toothed end of a comb. On Day 1, female subjects (n=25) reported to the clinical site to read and sign an Informed Consent Form and complete a short Eligibility Questionnaire. The subjects were given the opportunity to ask any questions about the study and were then given a copy of the Informed Consent Form along with the Subject Instructions.

Upon completion of the required paperwork, subjects were instructed to wash their hands to remove excess skin oils. Subjects then entered the testing room individually to evaluate each set of tresses and record their evaluations on the Consumer Preference Questionnaire. (Percent preference was calculated using the data of the subjects that indicated a preference.) Subjects were only able to perform tactile evaluations on one of the three treated tresses per test article (*i.e.* this was the only tress that subjects could physically touch). Subjects were also asked to wash their hands between evaluations to prevent carryover between test articles. One tress that underwent the pre-treatment phase, but that did not receive treatment, served as a visual comparator. No evaluations were conducted on this tress.

The leave-in hair serum was evaluated using a split-head, consumer use study comparing the two test articles for their ability to effectively condition hair as evaluated by consumer perception. Female subjects (n=24) underwent a one day wash

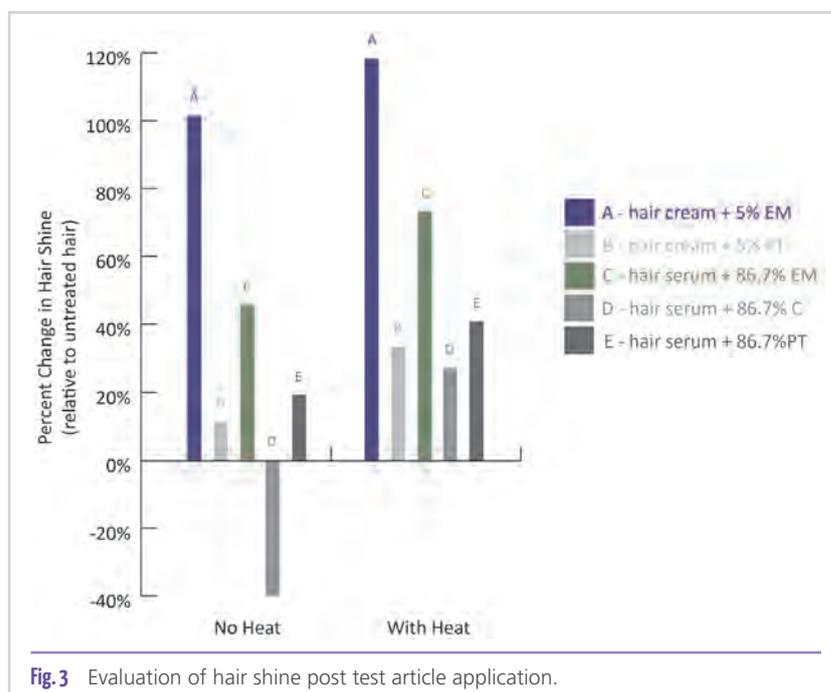


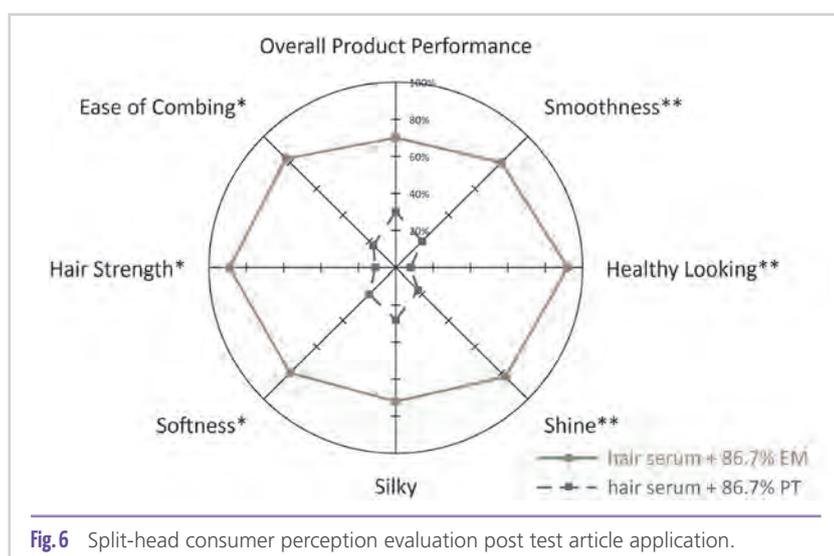
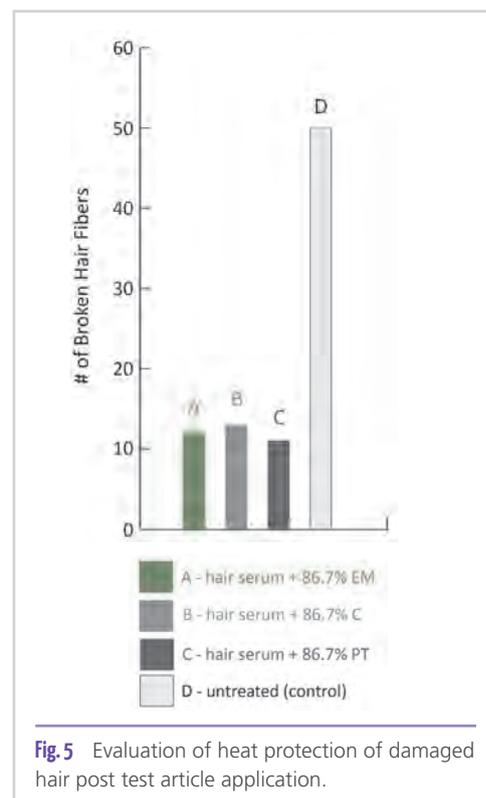
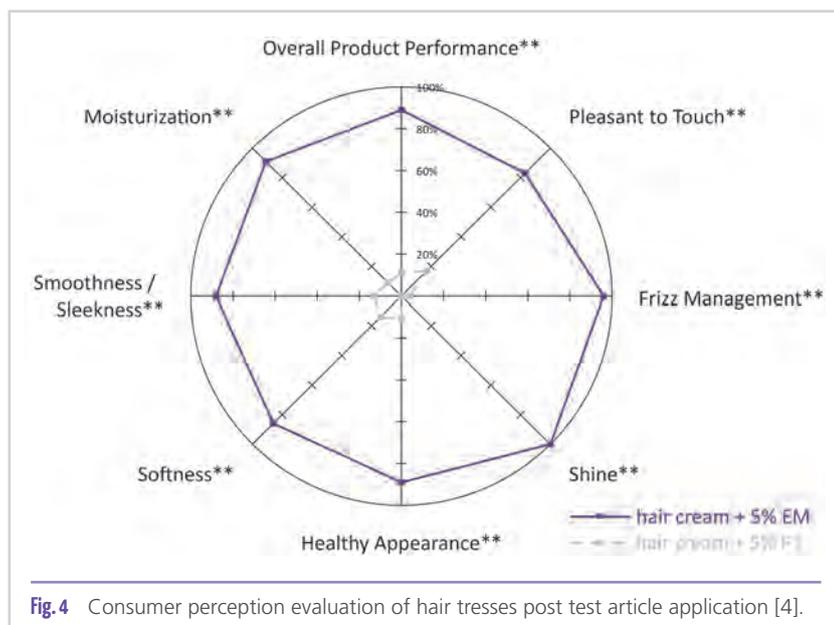
out in which they were not allowed to wash or condition their hair (e.g. shampoos, conditioners, hair serums, or hair oils). Subjects were then given the two leave-in hair serums, to be used on the right or left side of their head as assigned, and a standard shampoo [Garnier Fructis, Pure Clean Shampoo (L'Oréal, Paris, France)], to be used every other day for one week. Subjects were instructed to wash their hair with the provided standard shampoo followed by application of the test article leave-in hair serums by applying a 1/2 dime sized amount of serum to the hair on the assigned side of the head. This was done by rubbing the test article between their hands, then pulling through the hair to the ends, avoiding the roots. Subjects reported back to the testing facility after four total test article uses, where they were required to complete a Consumer Perception Questionnaire. Percent preference was calculated using the data of the subjects that indicated a preference.

## Results

It was determined that ethyl macadamiate performed similar to or better than commonly used silicones in hair care products. At low concentrations, ethyl macadamiate produced a significant ( $p < 0.05$ ) reduction in wet and dry comb force as compared to phenyl trimethicone and compared to baseline (**Fig. 1**). Ethyl macadamiate also provided heat protection of healthy hair thus reducing hair breakage 37% better than phenyl trimethicone ( $p < 0.10$ ) and 53% better than untreated hair ( $p < 0.05$ ) (**Fig. 2**). With re-

gard to hair shine, ethyl macadamiate increased hair shine almost eight times more than the hair cream with 5% phenyl trimethicone without the use of heat ( $p < 0.05$ ), and greater than two and a half times more with the use of heat ( $p < 0.05$ ) (**Fig. 3**). These results were also perceived by consumers, who indicated at least an 88% preference for ethyl macadamiate over the phenyl trimethicone with regard to smoothness, shine, and softness of hair ( $p < 0.05$ ) (**Fig. 4**). At higher concentrations, ethyl macadamiate produced very similar results to lower concentrations, demonstrating a 45% greater reduction in wet comb force than phenyl trimethicone ( $p < 0.05$ ), and larger reductions in dry comb





force than both phenyl trimethicone and cyclopentasiloxane ( $p < 0.05$ ) (Fig. 1). Ethyl macadamiate provided similar heat protection to damaged hair as phenyl trimethicone and cyclopentasiloxane ( $p < 0.05$  relative to untreated hair for all test articles) (Fig. 5). Ethyl macadamiate also provided up to two times more shine than the silicones without the use of heat ( $p < 0.05$ ) and almost two times more shine than cyclopentasiloxane with the use of heat ( $p < 0.05$ ) (Fig. 3). Additionally, when consumers utilized the hair serums in the take-home use study, at least 80% of them preferred ethyl macadamiate over phenyl trimethicone for smoothness, shine ( $p < 0.05$ ), softness, and ease of combing ( $p < 0.10$ ) (Fig. 6).

## Discussion

Previous research demonstrated the ability of ethyl macadamiate to mimic the sensory profile and function of silicones in skin care products. [1] Its light, silky emolliency gives it a skin and hair feel similar to that of low viscosity silicones

without the volatility. Ethyl macadamiate has excellent oxidative stability allowing for the formulation of stable finished products. Current research indicates that ethyl macadamiate is also an ideal silicone alternative for hair care applications. Its ability to reduce comb force and breakage can be attributed to its high spread; and its lack of volatility allows it to lightly coat the hair, providing heat protection without weighing the hair down. Additionally, the high refractive index of ethyl macadamiate lends to its ability to increase shine even more so than silicones. The instrumental results were also perceivable to consumers on both tresses and in actual use of the product, resulting in a higher preference for smoothness/sleekness, softness, shine, and ease of combing. The characteristics of ethyl macadamiate shown in this research qualify it as a substitute for low viscosity silicones in leave-in hair care products.

## References

- [1] T. Quinn and R.A. Harper, A natural silicone alternative in skin care products, Personal Care North America, 97-99 (September 2018).
- [2] C.F. Forney and D.G. Brandl, Control of humidity in small controlled environment chambers using glycerol-water solutions, Technology & Product Reports, 2(1), 52-54 (1992).
- [3] For all figures EM = ethyl macadamiate, PT = phenyl trimethicone, and C = cyclopentasiloxane.
- [4] For Figures 5 and 6, statistical (\*\*) and directional (\*) significance was apparent where indicated ( $p < 0.05$  and  $p < 0.1$ , respectively). The preference data does not include subjects that indicated no preference.

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