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Brazilian oils and butters: The effect of different fatty acid chain composition on human hair physiochemical properties

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Synopsis

This study evaluated the performance of five oils and three butters extracted from Brazilian plants with different fatty chain composition on hair mechanical properties, split end formation, combing analysis and gloss measurements. Oil treatment reduced the combing force percentage for wet conditions. However, the hair treated with butters showed poor combing. Except for ucuúba butter, oils and butters used in this work had generally no influence on hair tensile properties. In general, hair treated with oils showed a significant gloss increase and a decrease for split end formation. The fatty acid composition of the oils and butters tested showed an effect on the physicochemical properties of hair.

INTRODUCTION

Vegetal oils have been extensively used by hairdressers around the world as cosmetic treatments for human hair of different ethnic origin. As an example, the prolonged use of coconut oil is claimed to lead to healthy looking long hair, suggesting that oil may prevent cuticle cell damage. This behavior is expected due to the lubricating effects of oils on hair fiber that reduces abrasive damage (1). Another interesting aspect is that the diffusion of oils into hair fiber depends on oil triglyceride composition. Coconut oil is basically composed of lauric chains (C12), therefore, able to penetrate the fiber. Once inside the hair fiber, the oil seems to increase protein hydrophobicity and consequently reduces the cuticle swelling effect by water, providing a reduction of the fatigue imposed to the fiber by successive swelling cycles (2). The layers of cuticle cells form the outer barrier of the hair fiber and are mainly responsible for the cosmetic properties such as easy combing, gloss and smooth touch. Cuticle cells are susceptible to damage by grooming, weathering and daily care procedures. The loss of cuticle cells is the first step for the formation of split ends and the use of oil and butter may prevent this cuticle damage (3). Hair strength, on the other hand, is attributed to the cortex, which forms the bulk of the fiber and is responsible for mechanical properties (4).

This study evaluated the performance of five oils and three butters extracted from Brazilian plants with different fatty chain compositions on hair mechanical properties, split end formation, combing analysis and gloss measurements. The five oils used in this work were passion fruit seeds extract (*Passiflora edulis*), Brazilian nuts extract (*Bertholletia excelsa*), palm olein (a low-melting fraction of palm oil (*Elaeis Guineensis*)), buriti extract (*Mauritia flexuosa*) and palm stearin (the most solid fraction of palm oil (*Elaeis Guineensis*)). The three butters used in this work were tucumã (*Astrocarium tucuma*), ucuúba (*Virola surinamensis*) and sapucainha (*Carpotroche brasiliensis*). Mineral oil was used as the control. The composition of the fatty acids is described as follows: passion fruit seed (77% linoleic acid), Brazilian nut (38% oleic acid and 35% linoleic acid), palm olein (47% oleic acid), buriti (79% oleic acid), palm stearin (42% palmitic acid and 41% oleic acid), tucumã (48% lauric acid and 27% myristic acid), ucuúba (75% myristic acid), sapucainha (47% chaulmoogric acid, 27% hidnocarpic and 19% gorlic acid).

MATERIALS AND METHODS

HAIR SAMPLES

The tresses of virgin dark-brown and bleached hairs were obtained from De Meo Brothers Inc. (NY, USA). The hair samples were cleaned with lauryl sodium sulfate solution (10 w/v), combed using a polypropylene comb and stored at room temperature prior to use. Hair treatment: 0.5 ml of oil was applied to a 5 g hair tress and rubbed on it for 1 minute. The tresses were then kept in a climate controlled room for 15 minutes before the measurements. For dry combing tests the tresses were maintained in a climate controlled room (25 ± 5°C) for 24 h after the measurements in wet condition.

TRIGLYCERIDES SAMPLES

The samples were extracted from Brazilian plants. The Tucumã, Ucuúba and Sapucainha butters were processed by Natura Inovação e Tecnologia de Produtos Ltda (Brazil). The palm olein and stearin palm were processed in association with Agroplama (Brazil). The passion fruit seed oil was supplied by Croda Brazil, Brazilian nut oil by Cognis Brazil Ltda and buriti oil by Beraca Ingredients (Brazil).

MECHANICAL PROPERTIES

Mechanical properties of the treated hairs and the reference (hair without treatment) were achieved by stress/strain curves obtained using 50 bleached hair fibers of each treated hair sample. The analysis was performed by a 4301 Instron Machine using a 10 N load cell at 50 mm/min constant speed. The fibers were maintained at 25 ± 5°C and 50 ± 5% RH for 24 h prior to the measurements. The diameter of each fiber was measured after conditioning using a Mitutoyo micrometer. The results were interpreted using the Xlstat software applications with Anova and Turkey statistics tools at 90% confidence level.

FORMATION OF SPLIT ENDS

The bleached hair tresses were submitted to cycles of combing and drying (1 h) using combing equipment that was developed by Natura especially for this experiment and that simulates the daily care combing. The equipment was automatically operated and has an accessory with four fixed combs that moves in a circle with speed 40 times/min, permitting a combing of the tresses (18 cm and 5 g) that were fixed in front of the equipment. During the experiments, a hair dryer (1800W) was put 5 cm distant from the tresses at 70°C. After the time, the formation of split ends was quantified by visual counting (number of split ends per gram of hair).

EVALUATION OF THE GLOSS

Gloss measurements were performed in a Glossmeter Rophoint using specular reflection at the angle of 85°. The tresses were attached to a slide, which permitted the alignment of the fibers. The tresses were dried in a climate controlled room at 25 ± 5°C for 24 h before the test. The gloss was given by the difference between treated and no-treated tresses, which was analyzed by the *t*-test at 95% confidence level. Five measurements were recorded for each tress and three tresses were used for each treatment.

COMBING EXPERIMENTS

The measurements were performed by a 4301 Instron Machine with the comb fixed accessory developed by Natura, using a speed of 500 mm/min and a 10N load cell. Tresses of dark-brown hair 20 cm long and weighing 3 g were used. Before the measurements the tresses were manually combed once for disentanglement. The results of wet and dry combing experiments (reported in percentage) were the average of 10 tresses per each treatment (one time per tress). The measurements of reference conditions were realized before the application of oils to the tresses. The wet combing was performed to the tresses after 15 min of the treatment at 25 ± 5°C, and dry experiments were performed after 24 h of wet experiments. For this test, the tresses were maintained in a climate controlled room at 50 ± 5% RH and 5 ± 5°C. Statistical analysis was performed using the *t*-test at 95% confidence level.

RESULTS

GLOSS MEASUREMENTS

Figure 1 shows the gloss difference of the hair tresses after different treatments. Gloss difference means the difference value of gloss between hair tress before treatment (reference) and the same tress after treatment.

All treatments provide an increase in the gloss difference of the hair tress compared to reference (tresses before treatment). The results were analyzed by *t*-test with $p < 0.05$. Treatments were statistically different among themselves and between the hair tresses treated and the reference. The buriti and mineral oils render the highest significant values of gloss difference. As expected, oils promote higher gloss difference than butter. These effects are closely related to the lubricating and the easy spreading characteristics of oils on the hair.

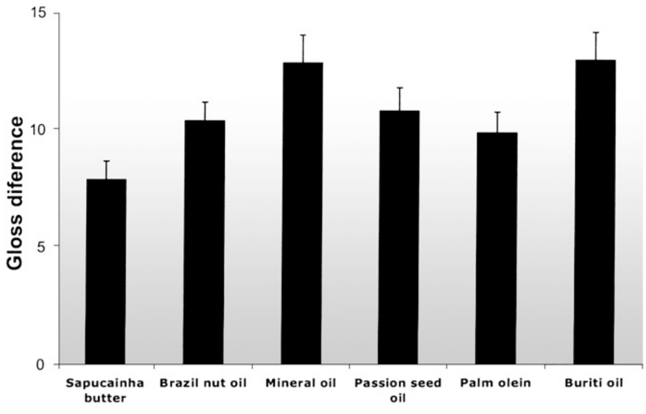

Figure 1. Average values of gloss difference obtained for hair tresses treated with several oils and sapucainha butter.

FORMATION OF SPLIT ENDS

Figure 2 shows the number of split ends per gram of hair formed during 1 h of treatment. The treatment consists of an extensive process of combing during hot drying, after the application of the oils. Treatments using oils reduced the formation of split ends in the hair compared to reference. Tresses treated with Brazilian nut and mineral oils gave the lowest formation of split ends which was around 4 split ends per gram of hair.

COMBING ANALYSIS

Figure 3 shows the values of the wet tress reduction of combing force (%) after treatments using oils and butters. Oil treatments rendered about a 60% reduction of combing force at wet conditions. The reduction of combing forces is a combination of water wetting and the lubricant effects of the oil on the fibers. Butters however, increased the combing force giving negative values for the reduction of combing force percentage. As expected, butters in raw state are not as fluid as oils and do not spread easily along hair tresses. The Brazilian nut, passion fruit seed, palm olein, buriti and mineral oils (control) produced a combing force reduction statistically different from the reference (hair tress before treatment).

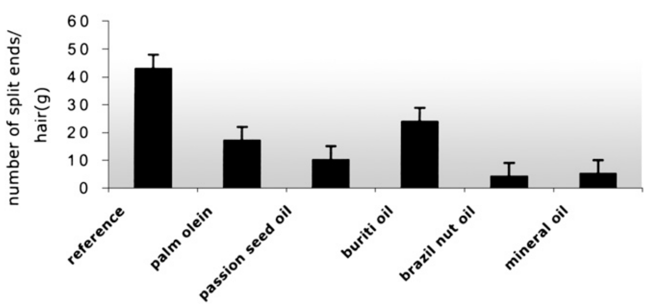

Figure 2. Average values of number of split ends per gram of hair formed during the extensive process of combing during hot drying for 1 h. The reference tress corresponds to the tress without treatment.

Figure 4 shows values of the dry tress reduction of combing force (%) after treatments using oils and butters. In dry condition combing analysis, the reduction of combing force percentage is around 19% and statistically different after treatments with Brazilian nut, passion fruit seed and mineral oil. Once again, butters rendered negative values of reduction of combing force percentage. This results point that the lubricating effect of oils is low pronounced to dry tresses.

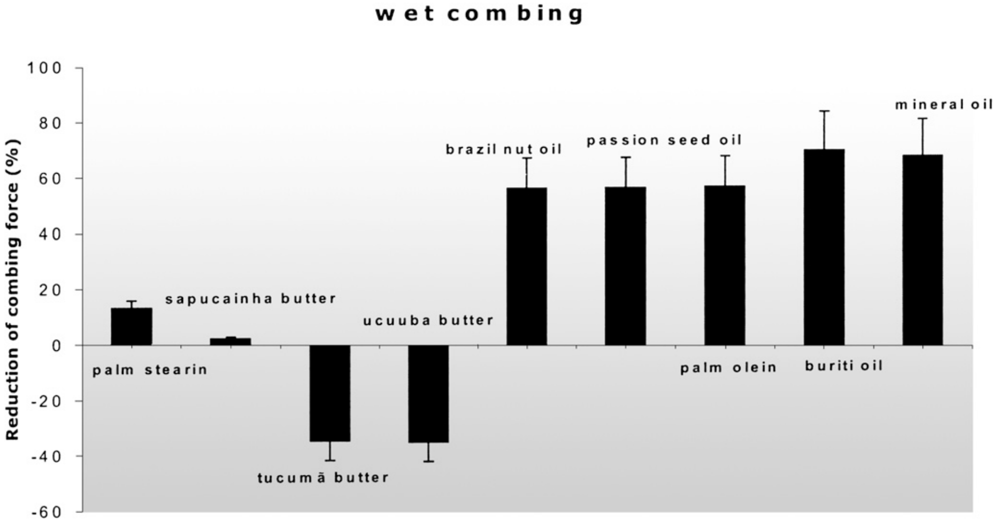

Figure 3. Average values of wet tresses reduction of combing force percentage (%) after treatment with oils and butters.

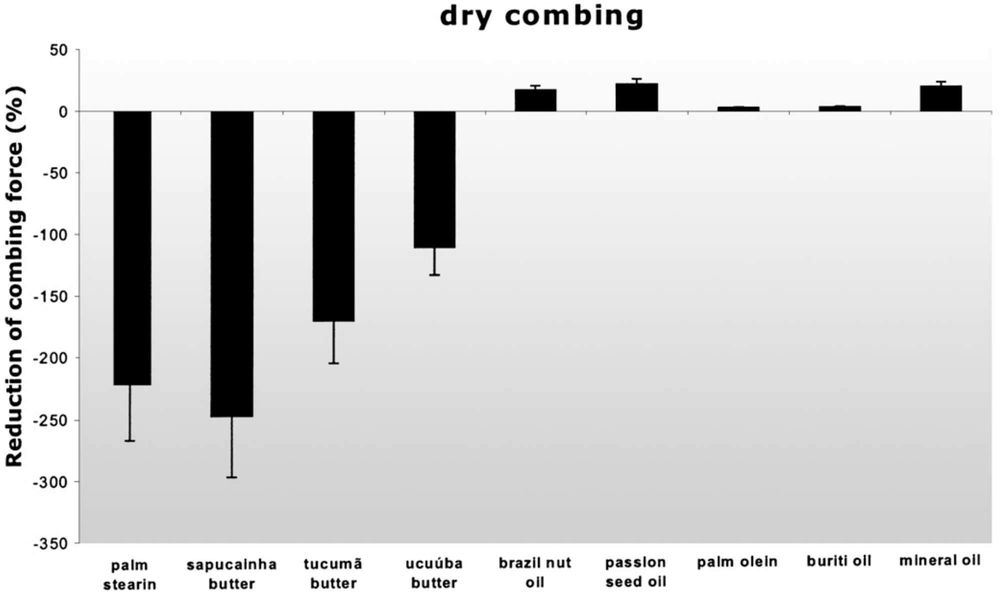

Figure 4. Average values of dry tresses reduction of combing force percentage (%) after treatment with oils and butters.

MECHANICAL PROPERTIES

Mechanical analysis were performed in order to verify the effect of raw oils and butters on the tensile properties of human hair. Figure 5 shows the stress at break (MPa) data obtained for reference and treated hair fibers using oils and butters. A slight but statistically ($p < 0.1$) increase in the stress at break was observed for the hair treated using ucuúba butter. The other treatments showed no difference compared to the reference.

Figure 6 shows the Young's Modulus data obtained for reference and for the treated hair fibers using oils and butters. A decrease in the modulus was observed after treatments with palm stearin and sapucainha butter. The other treatments showed no difference compared to the reference.

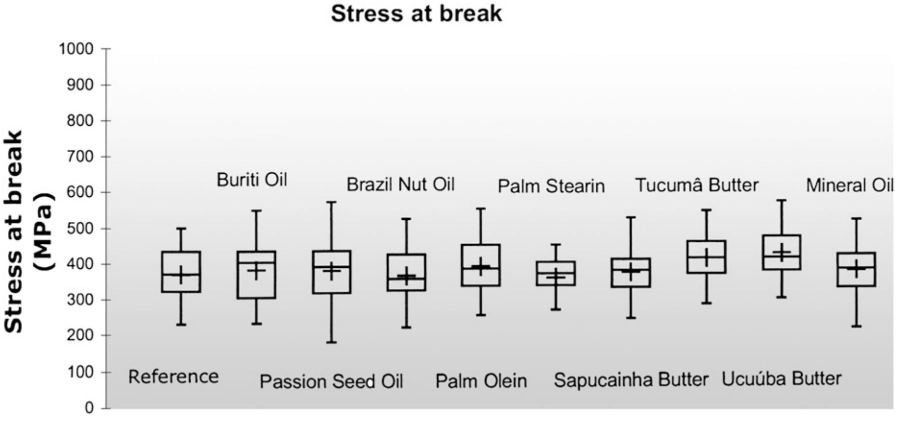

Figure 5. Stress-at-break (MPa) data for reference and treated hair using oils and butters. Each box plot corresponds to 50 hair fiber analysis measurements from each hair treatment and the reference.

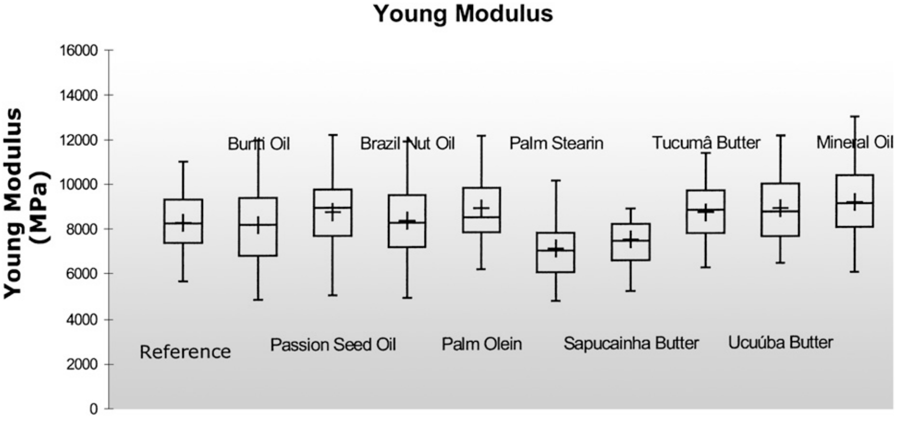

Figure 6. Young's Modulus (MPa) data for reference and treated hairs using oils and butters. Each box plot corresponds to 50 hair fiber analysis measurements from each hair treatment and the reference.

DISCUSSION AND CONCLUSIONS

The ability of various oils to perform conditioning functions is related to their molecular characteristics, such as surface energy, cohesive forces, and surface attaching conformation (7).

All oils show good performance in reduction of split ends formation (%), combing resistance and gloss difference. For these analyses, the influence of the properties of the oils on film formation are very important.

The combing facility is the result of the decrease in friction on the hair surfaces. The degree of the triglycerides attachment to the hair surface is influenced by its molecular chain conformation and is responsible for the increase or decrease of frictional forces. The oils composed of triglycerides with linear chain, lower ramification and higher number of carbons may increase the film formation, which results in the best spreading. The triglycerides chains with more ramifications and high melting point may decrease the spreading by increasing frictional force, which explains the behavior of butters on the hair observed in this study.

Preliminary studies showed that Buriti oil is very homogeneous in its fatty acid distribution, 79% of oleic acid. This may result in a more smooth surface and, consequently, in a high specular light reflection (gloss) from its surface.

Ucuúba butter showed a slight increase in the stress to break. This butter has a high amount of low molar mass triglycerides composed of short and straight linear fatty acid chains (75% miristic acid (C14)). This may point to the conclusion that low molecules from vegetal origin are able to diffuse into hair fiber. It is observed with coconut oil, which has lauric acid in its major composition (6).

Mineral oil is known to give a conditioning effect to the hair but, since it has no affinity to hair's proteins, this oil is not able to diffuse in the fiber. Mineral oil main effects are its higher spreading capability on the hair surface which improves gloss, combing facility and reduces split end formation.

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