Biodegradable & Food-Safe Toothbrush

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Introduction & Background

Traditional Manual Toothbrush

- 1 billion toothbrushes are thrown away in the US every year.
- 50 million pounds of toothbrushes are added to landfills in the US annually.
- 50% of total ecocost of manual toothbrush occur during manufacture and distribution process.
- 64% Americans are willing to pay more for sustainable products.
- 78% Americans are willing to purchase environmentally friendly products.

Nylon
Manufacturing Nylon creates nitrous oxide, which is 310 times more potent than CO2.

Propylene Plastic
Toothbrushes end up in waterways and oceans where marine creatures mistake them for food.

Goals and Objectives

- Create a “fully” biodegradable, food-safe, and environmentally friendly toothbrush
- Identify viable materials to replace nylon bristles and plastic handles
- Design a biodegradable toothbrush that performs comparably to traditional plastic toothbrushes that are not biodegradable
- Test the toothbrush against traditional plastic toothbrushes for strength and durability

Product Overview

- Beeswax Coating
- Plant-based Fibers
- Beeswax Coating
- Dextrin Glue
- Dextrin Adhesive
- Attached bristles by looping bristles through holes
- Drilled bristle holes, made inlay for bristle overextension on the back, and coated base with wax

Figure 1: Toothbrush schematic. Our design features waterproof beeswax coating the wooden body, plant-based bristle fibers, and food-safe dextrin glue.

Figure 2: Bristle attachment. Our method of attaching bristles without using any other materials while maintaining strength and durability.

Economic Analysis

- $6.8 Billion market value in 2019
- 2.9% CAGR 2020-27
- 78% Manual vs electric toothbrush

Cost of Fiber (cost/kg)

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Cost/kg</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jute</td>
<td>$3</td>
</tr>
<tr>
<td>Sisal</td>
<td>$4</td>
</tr>
<tr>
<td>Nylon</td>
<td>$5</td>
</tr>
<tr>
<td>Hemp</td>
<td>$6</td>
</tr>
<tr>
<td>Flax</td>
<td>$7</td>
</tr>
</tbody>
</table>

Figure 3: Fiber costs. Cost of plant and nylon fibers (cost/kg for bulk orders).

Wood costs

- $3 – 7 price of our toothbrush
- $5 – 9 of traditional toothbrush

Table 1: Comparison of plant fibers. We performed several tests (water, strength, shape retention) on hemp, jute, and sisal fibers. This table shows comparisons between each fiber tested.

<table>
<thead>
<tr>
<th>Fiber</th>
<th>Raw Long</th>
<th>Combed Hemp Light</th>
<th>De-gummed Hemp</th>
<th>Combed Hemp Dark</th>
<th>Hemp Combed Top Roving</th>
<th>Jute</th>
<th>Sisal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nylon (Control)</td>
<td>Plastic, stiff, straight, 1.5 cm</td>
<td>Wirey, stiff, long fibers, wavy, 10 cm or longer pieces</td>
<td>Cotton fibrous, softer than de-gummed, 13 cm</td>
<td>Cotton bally, soft, not strong, hard to measure</td>
<td>Fibrous, less soft, wavy, stronger than de-gummed, 6 cm</td>
<td>Fibrous, soft, wavy, stronger than combed light, thick bristles</td>
<td>Originally bundled, comes in long rope form, stiff</td>
</tr>
</tbody>
</table>

Figure 4: Wood costs. Comparison of cost of different woods as compared to plastic (cost/kg for bulk orders).

Acknowledgments

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