

Production of microbial leather from culled sweet potato sugars via Kombucha culture

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Introduction: The sweet potato industry is confronted during most growing seasons with an abundance of potatoes that are not appealing to consumers for use as table stock or fresh produce. These process grade roots do not garner as high a value as premium grade sweet potatoes. These potatoes are currently used in baby food products as well as sweet potato fries, hash browns, and canned products. Further lower in grade are the cull sweet potatoes that are misshapen or have suffered a range of biotic or abiotic damage in the field or in storage. Despite their less than perfect appearance most of the roots exhibit the same functional composition as premium graded roots. Approximately 30% of the harvested crop may fall into less desirable grades depending on market and growing season conditions. During the 2012 growing season, for example, nearly 80 million pounds of sweet potato roots had limited marketing options. The industry is very interested in finding an alternative, stable, and higher value use for these potatoes. Sweet potatoes contain a significant amount of sugars and other valuable compounds (e.g. carotenoids).

Specialty chemicals or products from these culled potatoes could show a potential to offer the growers and processors an additional market with higher returns. One such potential product that is sparking interest in the fashion world is “Microbial Leather”. This is a bacterial cellulose (polymer) produced by the Kombucha culture when grown on sugars. When the polymer is dried it has some characteristics that are similar to leather. The purpose of this investigation was to extract sucrose from culled sweet potatoes and using a modification of available recipes, manipulate the *kombucha* culture to create a bio-based microbial leather.

Method: The Kombucha culture is comprised of many different yeast and bacteria. For example, *Saccharomyces cerevisiae*, *Brettanomyces bruxellensis*, *Candida albicans*, *Schizosaccharomyces pombe*, and *Zygosaccharomyces bailii* have been reported to be members of this microbial consortium. Others have reported that *Penicillium* spp. could be members of a Kombucha culture. This culture and the *Candida albicans* are opportunistic pathogens and could present a problem to the wearer of clothing made from this material. The inactivation or total removal of these two cultures will be required to improve the safety of the wearer. If culled and rotted sweet potatoes are to serve as the sugar source, its preparation could have a significant impact on the performance of the Kombucha cultures and required some experimentation. Internet recipes varied slightly, however most required 200 milliliters of organic cider vinegar, 200 grams of granulated sugar, one live kombucha culture, 2 green tea bags. With this process tea was steeped in 2L of boiling water for 15 minutes. Immediately following, 200g of sugar is dissolved and then add vinegar and culture once the mixture has cooled to 86°F. The culture was covered and stored, undisturbed for a period of three weeks. At the conclusion, the “leather” was removed, washed with non-abrasive liquid dish detergent and stretched onto cedar planks for drying and moisture transfer period.

Through modification of the popular recipe, the granulated sugar was substituted for culled sweet potato sucrose. Raw juice was extracted using a commercial juicer and heated in conjunction with grain for 60 minutes to 170°F. Once strained, liquid is referred to as wort while mash are the objects strained. Water is evenly poured over the mash to extract out fermentable sugars needed to interact with the kombucha culture. Enzymes are added to the mixture to expedite the process, however during experimentation, not adding enzymes created a thinner leather sample. The goal is to convert long-chain starches into simple fermentable sugars through the application of heat. Once finalized these fermentable sugars are cooled and substituted for granulated sugars. See Images 1-3 for examples of sweet potato sucrose fermentation process.

Results: Six separate trials were executed using the aforementioned methods, with slight ingredient adjustments. The first trial followed the recipe as found on <http://www.ecouterre.com/grow-your-own-microbial-leather-in-your-kitchen-diy-tutorial/>. Results were similar to those reported on the website. The second and third trials modified the kombucha culture to expedite the process, with mixed results. Leather consistency and quality were issues with modification of the culture. Trials four through six utilized the sweet potato sucrose with similar results to granulated sugar. Modifications to the kombucha culture for the sweet potato sucrose mixture have not been conducted, however will be completed within the next three months. Therefore, results indicate successful substitution of the granulated sugar with extracted sweet potato sucrose, however results of modifications to the kombucha culture were mixed and need further investigation.

Discussion: While the production of “grow your own leather” is not a new concept, approaching the process from a chemical and biological engineering perspective provides potential for a sustainable leather product. Additionally, the value loss for sweet potato farmers with higher percentages of culled crop can be devastating. Scaling this process and production for industrial quantities can provide a new market for these cull potatoes, while providing a sustainable leather product for the eco-conscious consumer. Lastly, bridging gaps between scientific disciplines and engaging in cross collaborative research enables apparel and textile researchers to utilize new tools and insights to meet challenges in current research initiatives. This innovative collaboration started with funding from the USDA for Agriculture and Biological Engineering and Sweet Potato Extension Specialists. Through their connections to service-learning, an apparel product development faculty was included. The idea was developed in a design process course by undergraduates and during a research mixer, a chemical engineer was added to the growing research team. The need for cross disciplinary research within the apparel and textile field is further amplified by the successful execution of similar projects.



Image 1. Early stage



Image 2. Mid-stage



Image 3. Late stage

