Lost in the Sauce: A Biodegradable Condiment Packet

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Introduction

Background: In the United States, approximately 35.7 million tons of plastic are produced annually, with ~40% of the waste originating from single-use packaging. Condiment packets contribute significantly, with 855 billion of them discarded into landfills yearly. Made from non-recyclable aluminum and plastic films, they take centuries to decompose.

Goal: Our goal is to address this issue by developing biodegradable packets capable of containing liquids with a shelf life comparable to conventional options. To achieve this, we're utilizing whey protein isolate, deionized water, and beeswax as a lipid plasticizer or hydrophobic barrier.

Film Formation Methodology: The whey protein is first dissolved in deionized water, using a magnetic stirrer. It is then heated for 30 minutes at 90 °C, for heat denaturation. The solution is transferred to petri dishes and left to dry overnight at room temperature.

Design Considerations

The critical success factors for our product include water and oxygen permeability, food solubility concerns, as well as manufacturing integration and cost concerns when bringing to market. Water and oxygen permeability are what determine how long condiments stay fresh for. Previous research had been done on many biodegradable films that we further pursued.

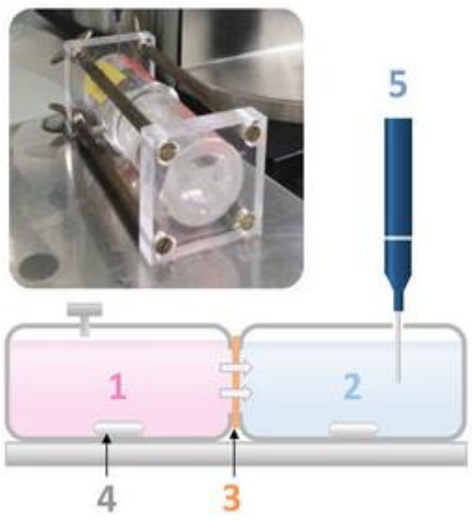

Figure 1: Schematic detailing a testing apparatus to determine a films water and oxygen permeability. 1: water tank, 2: air tank, 3: film, 4: stirrer, 5: moisture measurement device.

Our Product

Our revolutionary juice box design allows us to produce a biodegradable body for the rest of our packet using current manufacturing processes. In combination with our biodegradable coating, we were able to create a 100% biodegradable and sustainable packet with low water and oxygen permeability to keep condiments fresh for longer.

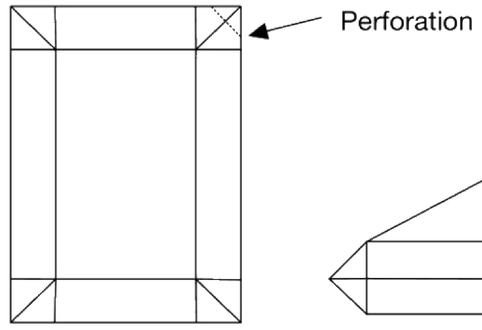

Figure 2: Schematic of our juice box design, a foldable paper shell that can be covered with our biodegradable coating to create the biodegradable sauce packet.

Manufacturing Methods

The final packet is created using a mother roll process. This process starts with dip coating, in which a piece of cardstock is ran through a solution of whey protein isolate and water, dried, and then coated in beeswax. The coated paper is then ran through a rotating creaser and folded along the indents, before finally being folded, filled, and sealed with a biodegradable glue.

$$h_f = k\frac{E}{LU_0},\ k = \frac{cM}{\alpha\rho}$$

Figure 2: Equation used to determine dry film thickness. In the equation, c is solute concentration, M is solvent molecular weight, α is the porosity of deposited film, p is solute density, E is solvent evaporation rate, L is the width of coated film on substrate, and U_0 is the withdrawal speed.

Results

Laboratory testing found that the original WPI film was not structurally sound on its own and potentially water soluble. Adding a beeswax coating greatly decreased this solubility as well as permeability. The cardstock added structural integrity. Overall, this design showed promising decreases in permeability and the possibility of mass production, though further testing is needed.

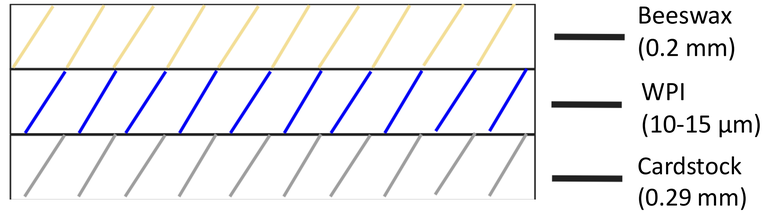

Figure 3: Schematic of the internal coating and juice box layer of our condiment packet. Comprised of a layer of cardstock, whey protein isolate, and beeswax.

Conclusion

A future design consideration is refining the emulsification of beeswax or similar lipid plasticizers in the film to achieve a colloidal suspension, enhancing functionality of the film and decreasing the brittleness. Additionally, we'll explore alternative lipid plasticizers such as mineral oils and vegetable oils to find which plasticizer optimizes the water vapor permeability. Ultrasound treatment presents another avenue for reducing water-vapor permeability beyond heat treatment alone.

Additional Questions?

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