Background:

Bacterial cellulose has applications in a variety of areas, ranging from cosmetics to the biomedical field; however, researchers have been looking for a way to reduce the cost of producing this material as current methods can be high in cost which translates poorly for larger scale manufacturing. On top of this, research has been conducted regarding the sustainability of current production methods, and how to improve it. One of the main ways to tackle both issues is through using food sources, food waste in particular, as a replacement growth environment for the bacteria. This project focuses on observing how different food waste sources affect not only the yield of the bacterial cellulose produced, but also the quality and how well the cellulose can retain its original properties to ensure it can still be used in its various worldly applications.

Worldly implications:

Over 400 billion dollars in food is wasted annually. This equates to around 100 billion pounds of food, and this is just in the United States alone (*Food Waste in America | Feeding America*, n.d.). Food waste has been, and continues to be, a major economic and environmental issue. However, even as such a prevalent issue in today's world, the impact of food waste continues to be overlooked. One way to begin tackling this issue is by looking for alternate ways to use this food waste that will in turn, be financially and environmentally beneficial. In terms of this project, an example of an alternate path is using certain food waste to aid in growing bacteria. This approach will be beneficial as grown bacteria will already have an abundance of applications; however, by being grown with natural food waste, this not only makes the bacteria more biocompatible, but it is also increasingly cost-efficient.

This project targets a specific cellulose-producing bacterial strain known as *Komagataeibacter hansenii*. It is considered a model microorganism when it comes to creating bacterial cellulose. What makes this strain a well perceived option is its excellent properties ranging from strong biocompatibility and high purity to high crystallinity and polymerization (Yang et al., 2023). Additionally, this strain in particular was designed for the purpose of enhanced production of bacterial cellulose (Hur et al., 2020). Because of this, *Komagataeibacter hansenii* is a commonly used cellulose-producing strain by researchers in this field.

Previous Studies:

A commonly used production medium for growing this bacterial cellulose is known as Hestrin Schramm (Costa et al., 2017). While this medium is effective at producing yield, it can be costly, especially when scaled up to an industrial sized manufacturing. Researchers have been actively looking into what happens when the carbon source of the medium is altered. In other words, does changing the environment of where the bacterial cellulose is being grown affect the final result? A study conducted by Kaczmarek et al., in 2022, dived deeper into confirming the effects using this strain of bacteria would have on the production of cellulose. They set up thirteen strains, some with, and some without ethanol, to check for the direct influence of the strain on the production of cellulose. While there was an outlier in strain 11, the rest of the data provided visual evidence of the efficacy of involving *Komagataeibacter hansenii* in growing cellulose.

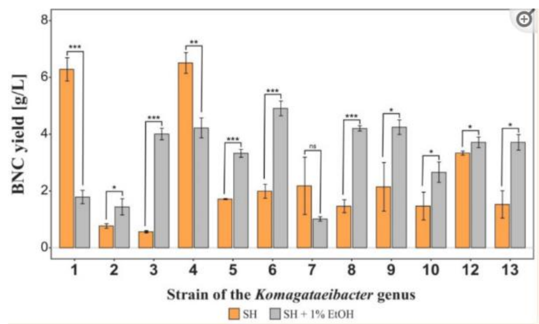

Figure 1: A graph depicting the influence of bacterial strain on cellulose production, Kaczmarek et al., 2022, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8950309/

Broad Research Solution:

To target the concern of higher costs associated with the production of this bacterial cellulose, the use of food waste has been increasingly researched. To explain why, it’s important to recognize and understand what exactly makes a good culture medium for bacterial cellulose to grow in. How well bacterial cellulose grows is dependent on its production medium, meaning its environment. The amount and quality of the produced yield is specifically dependent on the carbon source used in that environment. Currently, things like glucose, fructose, and sucrose, are used in the culture medium to improve efficiency and quantity. Knowing this, the connection between its production and the use of food wastes can be made. Many foods are high in different types of sugars, especially things like juices which can be derived from fruit waste.

Specified Research Solution:

Juices are an excellent starting point for doing research on how their properties will affect the overall growth of bacterial cellulose. From there, it is much more reasonable to branch out and use that initial knowledge to test out different common food wastes. For example, options that are typically more expensive such as pure glucose and peptone could be replaced by food source alternatives including apple wastes and various tea mixtures (Amorim et al., 2023). As mentioned before, initializing this change will not only have the potential to produce a higher and more biocompatible yield, but it is much more cost efficient. This method translates better for larger scale production sites where this change in cost could have a big influence on their ability to successfully produce large quantities.

Knowledge Gap:

The main knowledge gap in this area is surrounding what kinds of foods and what properties in those foods make it such a good option for bacterial cellulose growth. Seeing as factors like specific sugars impact how well the bacterial cellulose will grow is important to consider when making the decision on what foods are the best options of course, as some may aid in higher yields. To this day, research is still being done on how specific foods impact the production of the bacteria as there are a lot more factors to consider than just the sugar content. For example, with things like juices, even if a specific juice is high in a specific sugar, it may also be more acidic which would then have a different effect on the growth. Through this project, the knowledge gap was addressed by offering more insight into how various cost friendly food sources prove to be effective alternatives for growing *Komagataeibacter hansenii*.