Investigation into the ultimate tensile strength of dehydrated SCOBY when grown using varying sugar sources

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Introduction:

SCOBY is a cellulose pellicle formed as a by-product of kombucha (a fermented drink). The SCOBY can be dehydrated to form a biomaterial that is fully biodegradable, readily regenerative, and relatively cheap and accessible to produce. Due to these characteristics, it poses as an attractive alternative to some plastics. Currently, it is slowly being incorporated in industries such as fashion, biotechnology, medicine, etc. [1]

Aims:

Determine how varying sugar sources affect the cellulose production and material properties of dehydrated SCOBY.

Objectives:

- Culture SCOBY samples using 4 different sugar sources:
  - White sugar
  - Brown sugar
  - 50% glucose 50% fructose
  - 70% glucose 30% fructose
- Observe the growth of SCOBY and then dehydrate to find the ultimate tensile strength of the samples to determine how the various sugar sources affect the strength of the material.
- Investigate whether increasing the glucose-to-fructose ratio makes an impact on cellulose production

Method:

Sugar (10%) and black tea (10%) mixtures were produced for each sugar type. Petri dishes were then filled with 20ml SCOBY culture and 60ml sugar solution with a line drawn to mark 80cm^3 volume. Six dishes were made for each sugar mixture type.

Petri dishes were incubated for 14 days at 28°C, feeding with sugar solution when required to maintain the liquid level at 80cm^3. After that, they were lightly pressed to remove excess liquid and then dehydrated and cut into four 50mm x 70mm x 15mm strips [3] and tensile tested using an Instron machine.

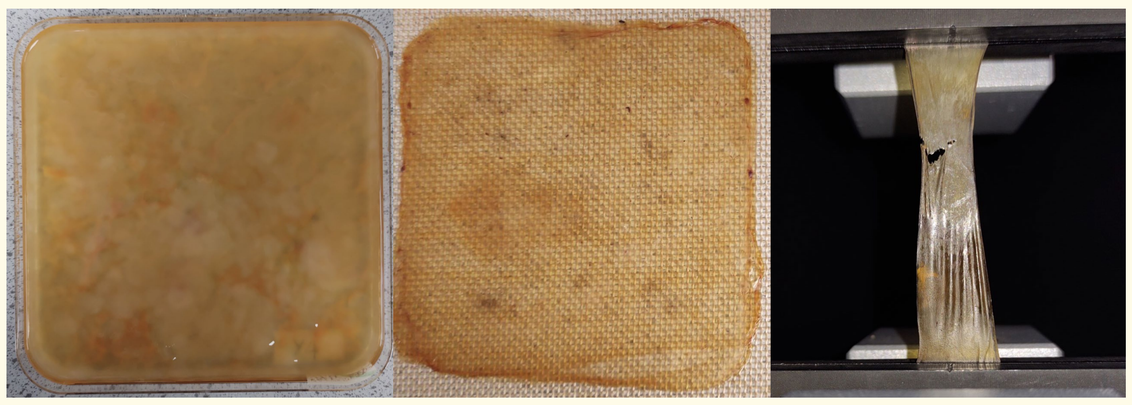

Figure 1: (Left to Right) Sample 4 from 70/30 glucose/fructose in its petri dish, Sample 3 from 50/50 glucose/fructose dehydrated, test trip B from 50/50 glucose/fructose sample 2.

Conclusions:

White sugar produces the strongest dehydrated SCOBY samples. Increasing the glucose-to-fructose ratio to 7:3 rather than 1:1 produces a greater cellulose yield. When it came to dehydration, it was difficult to get all samples to the same level of dryness – the goal was to get it to a dry feel, however, when it came to the brown sugar it was either sticky or brittle and film-like. Brown sugar appears to be not as easily digestible food stock in comparison to the others as it produces a comparatively low cellulose yield. White sugar is meant to be the same as 50% glucose and 50% fructose, but the results vary. One explanation may be that the fructose syrup did not reach a stable dry state, unlike the other sugar ingredients which came as a power, thus producing a tackier feel and compromising strength but further exploration should be carried out regarding this.

References:

[1] Phruksaphithak, N., Kaewnun, C. and O-Thong, S. (2019) 'Bacterial cellulose production and applications,' ResearchGate [Preprint]. https://doi.org/10.14456/sehs.2019.1.
[2] Cultured Analysis (2021) Science of Kombucha Brewing. https://www.youtube.com/watch?v=ulZr3gkEl-I.
[3] Hervy, M. et al. (2017) 'Sample geometry dependency on the measured tensile properties of cellulose nanopapers,' Materials & Design, 121, pp. 421–429. https://doi.org/10.1016/j.matdes.2017.02.081.
[4] https://sugarnutritionresource.org/news-articles/what-is-table-sugar

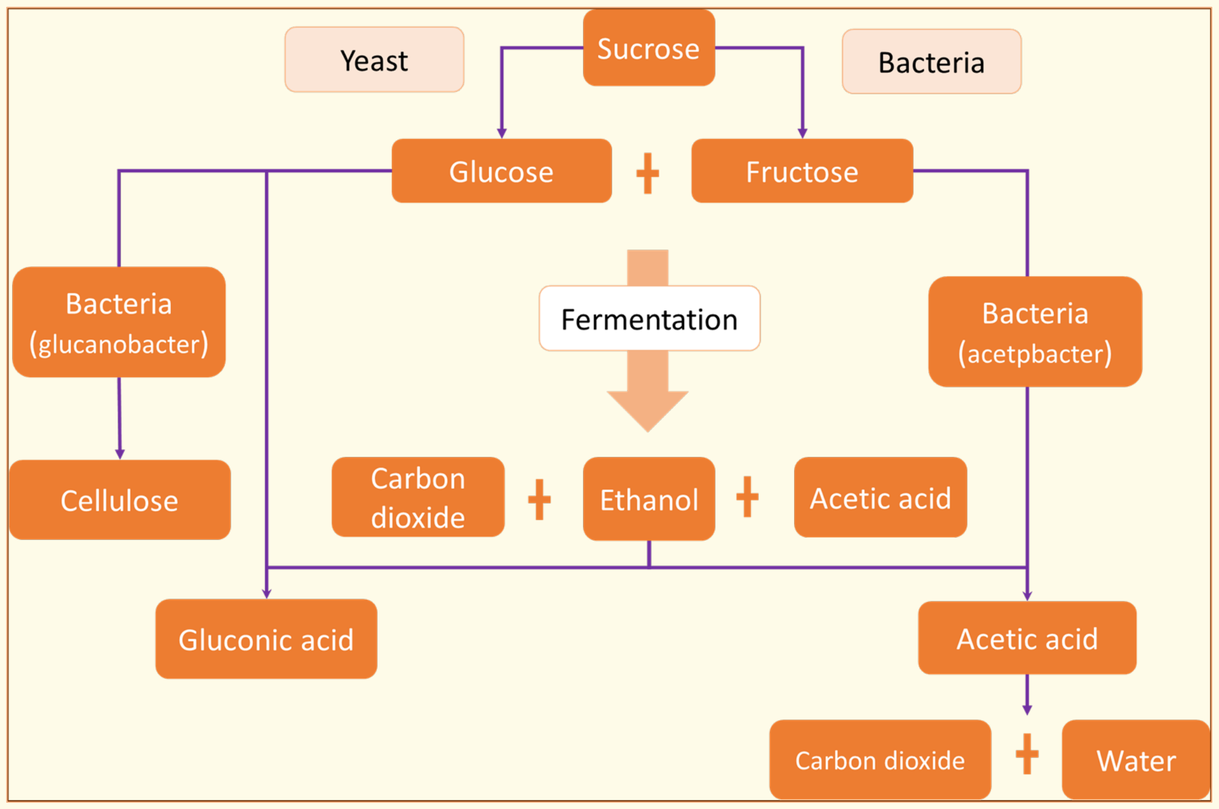

Figure 2: Schematic diagram of Synthesis of sugars in the kombucha fermentation process adapted from [2]

Results and Discussion:

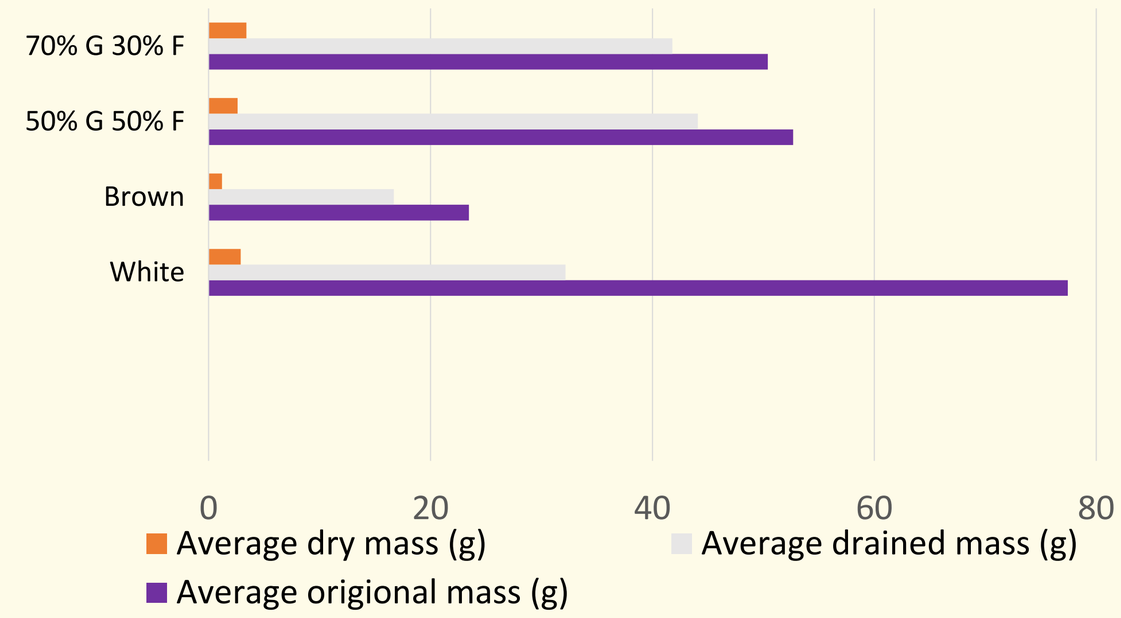

Figure 3: Average of sample mass pre- and post-dehydration, taken from 6 samples of each sugar type.

- Liquid was physically removed to achieve drained mass. Drainage of white sugar samples was a lot more aggressive than for the others, so ultimately it needed to be rehydrated using a water mister to achieve desired texture.
- Following dehydration, different textural results were achieved. White sugar samples were the least tacky and brown sugar the most. The glucose-fructose mixtures were similar and closer to the white sugar sample.

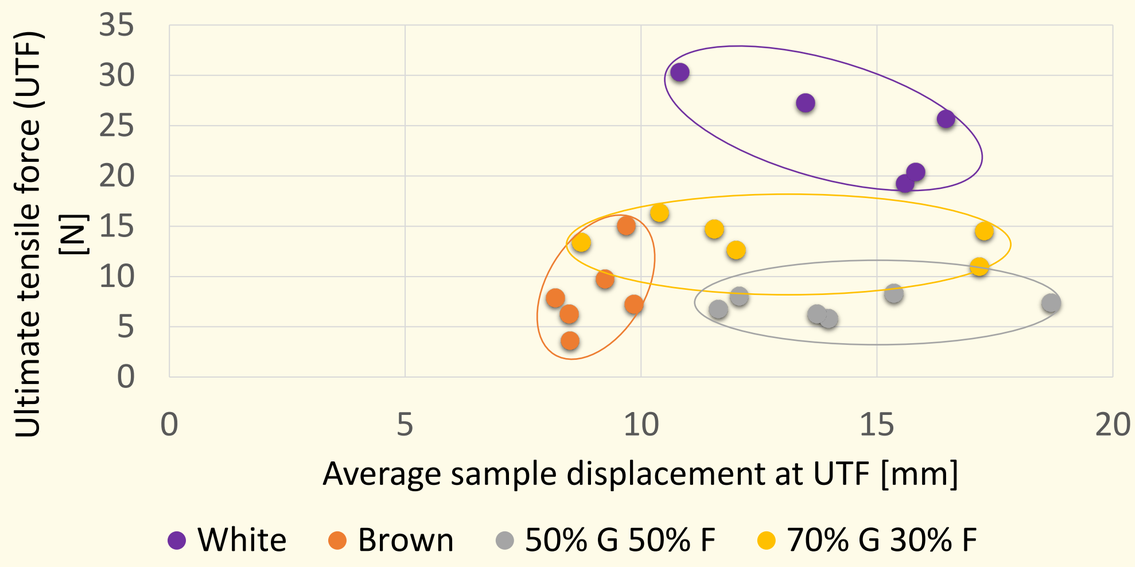

Figure 4: Displacement at the point when the maximum tensile force was reached. Each dot represents the average value taken from four strips from one sample.

- The experiment was done under the assumption that white sugar is 50% glucose and 50% fructose [4], and whilst the dry mass and stretch are very similar for the white sugar test and 50% glucose and 50% fructose tests, the white sugar samples proved significantly stronger. This was likely down to the textural differences as the white sugar samples were a bit drier and harder.
- Flat grips were used when tensile testing to avoid prematurely puncturing the SCOBY. However, often the initial breakage happened at the edges of the strip where they were clamped to the machine, indicating the fault was created due to the tightness of the clamp so presumably the material could have stretched further.