Utilization of brewer's spent grain and other selected by-products to create edible cutlery

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FOOD DEVELOPMENT

Introduction

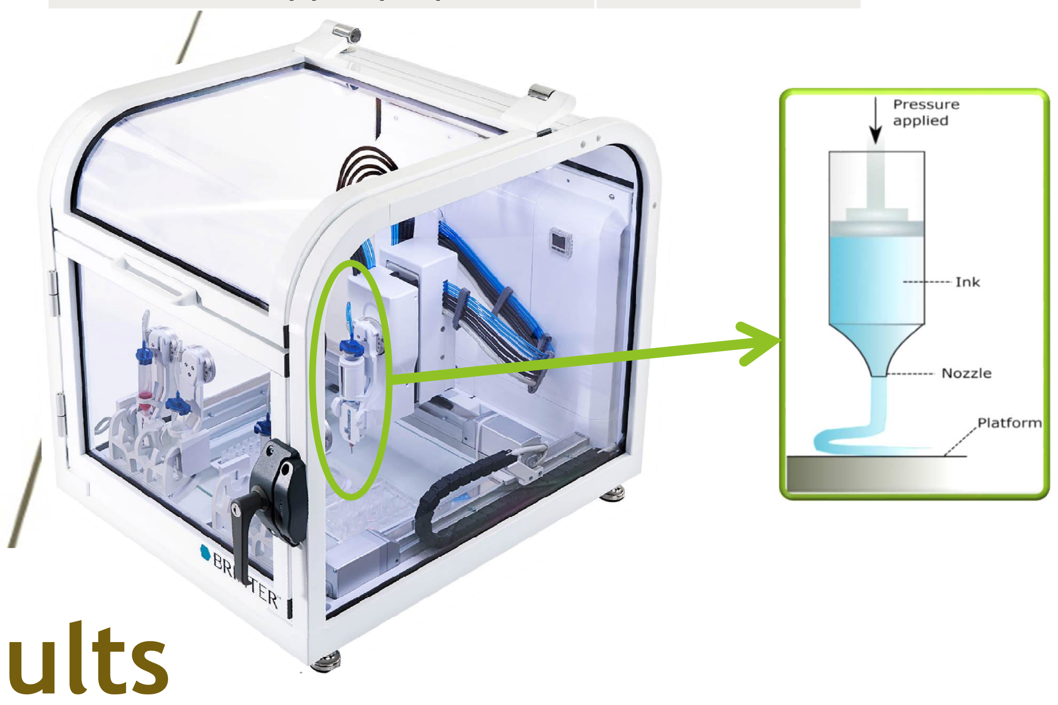
Food production negatively impacts the environment in many ways, notably by generating significant waste. The issue of single-use plastic utensil pollution has been tackled through sales bans or by substituting plastic with materials like paper or biodegradable composites [1].

Additionally, turning raw materials into edible food generates a substantial amount of by-products and residues, posing transportation and disposal challenges. To address this, the circular economy concept, aiming to minimize and repurpose waste, is being introduced into the industry [2]. Concurrently, the precision and low-waste capabilities of 3D printing technology are becoming popular. Thus this work explores the suitability of selected sidestreams to create edible spoons through 3D printing [4].

Materials

Six food ink recipes were developed, utilizing sidestreams from local companies: brewer's spent grain (BSG), solid phase (SP) after berry oil extraction, and fruit pulp from wine and apple pulp from cider production.

Full name	Code name
Base ink (BI)	BSG
BI + Sea buckthorn berry SP	TM
BI + Sea buckthorn seed SP	TS
BI + Blackcurrant seed SP	MS
BI + Fruit pulp	FR
BI + Apple pulp	AP



Methods

Ink formulations were tested for their printability by rheological tests using serrated plate-plate geometry. Spoons were evaluated for water and oil absorption and subjected to sensory analysis using a 9-point hedonic scale.

Rheological measurements of inks [4]:

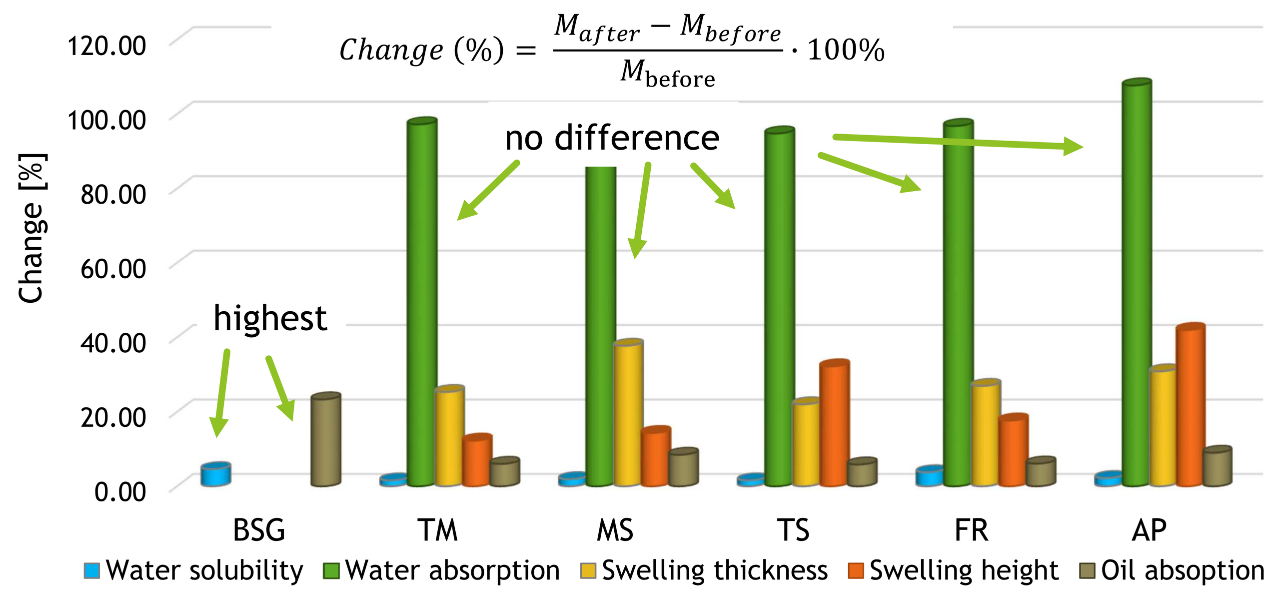
- Yield stress (point) - how much pressure to print;
- Amplitude sweep - LVR, stability of the printing;
- Frequency sweep - printing velocity;
- Creep-recovery - resistance to deformation under its weight;
- Tixotropy - deformation and recovery of internal structure.

Spoon tests [3]:

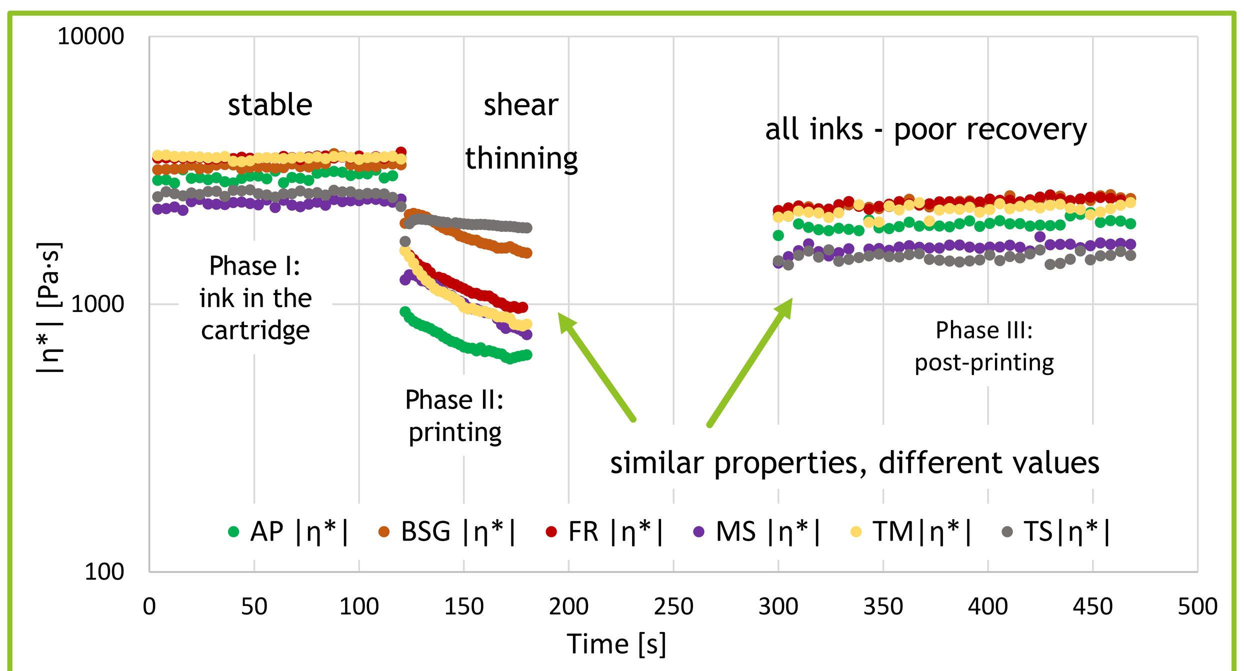
- Water absorption;
- Water solubility;
- Oil absorption;
- Swelling;
- Sensory evaluation.

Results

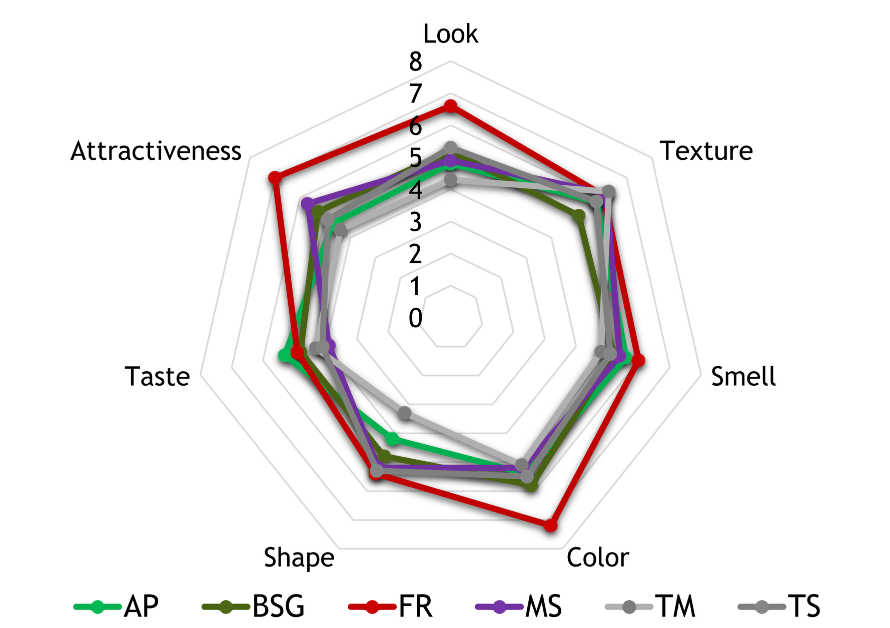
The results, mirroring the tests, fall into two categories: ink-related and spoon-related. Ink underwent evaluation for its printing behavior, while spoons were assessed for selected physicochemical properties and sensorially evaluated by panelists.



- Spoons doubled in weight after 24-hour water immersion.
- Thickness increased more than height.
- Water absorbed more than oil.
- Significant statistical changes observed in:
- Water absorption across all samples.
- Swelling in thickness, except for FR.
- Oil absorption, except for TM and TS.
- Only water solubility showed significant recipe differences.



- Inks have a yield point; they stay in the cartridge and keep shape post-printing.
- They are shear-thinning: viscosity decreases for easier printing.
- Poor recovery of internal structure post-printing affects spoon shape and mechanical properties.
- Significant differences were observed across recipes.



- Fruit pulp spoons rated significantly higher than other recipes in sensory evaluation.
- Taste was the lowest scoring attribute.
- Malty flavor detected, with some spoons bitter or sour.
- Average hedonic scale score: 5.5/9.

Conclusions

- Edible spoons from food sidestreams pose as a sustainable alternative to plastic utensils.
- Inks are suitable for 3D printing but need improvement in mechanical properties.
- Fruit pulp-based spoons were most favored in sensory tests.
- Low taste rating show the need for flavor enhancers.
- Significant recipe variations suggest need for fuctional additives.

References

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