Validation of biomaterials for 3d printing

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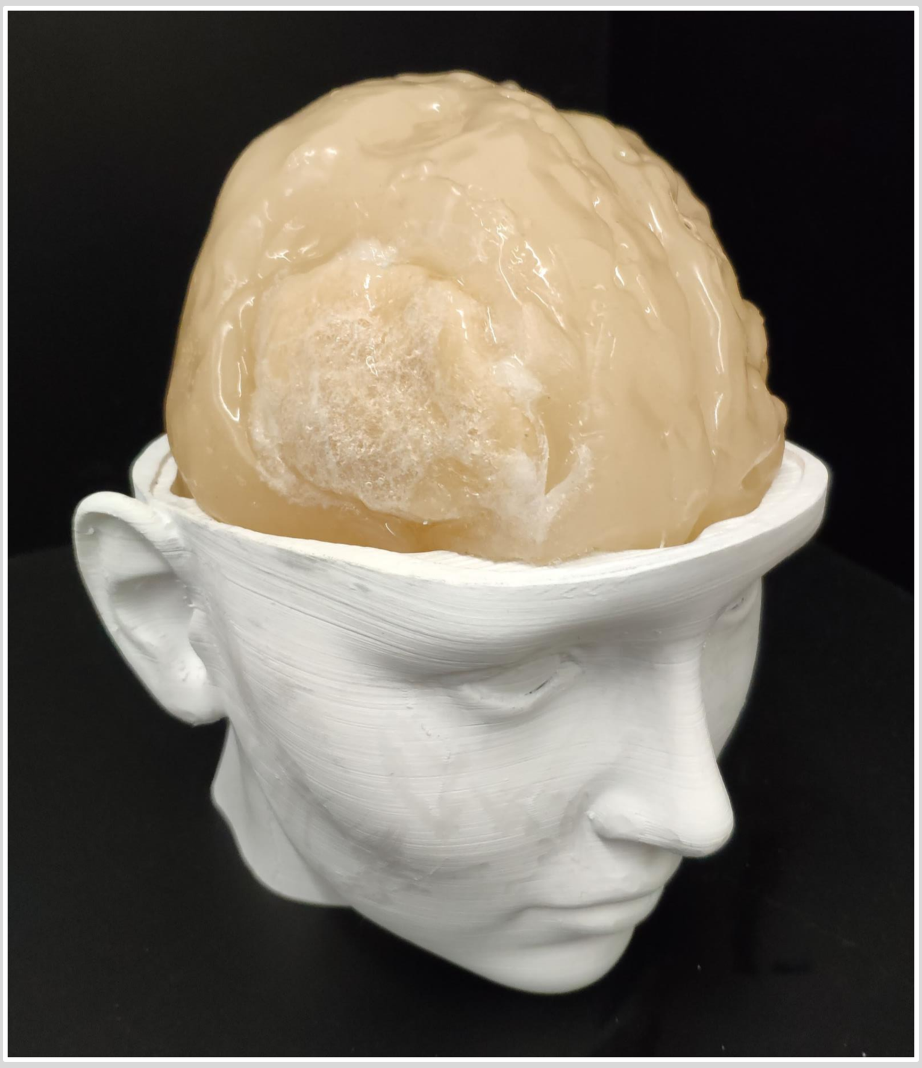
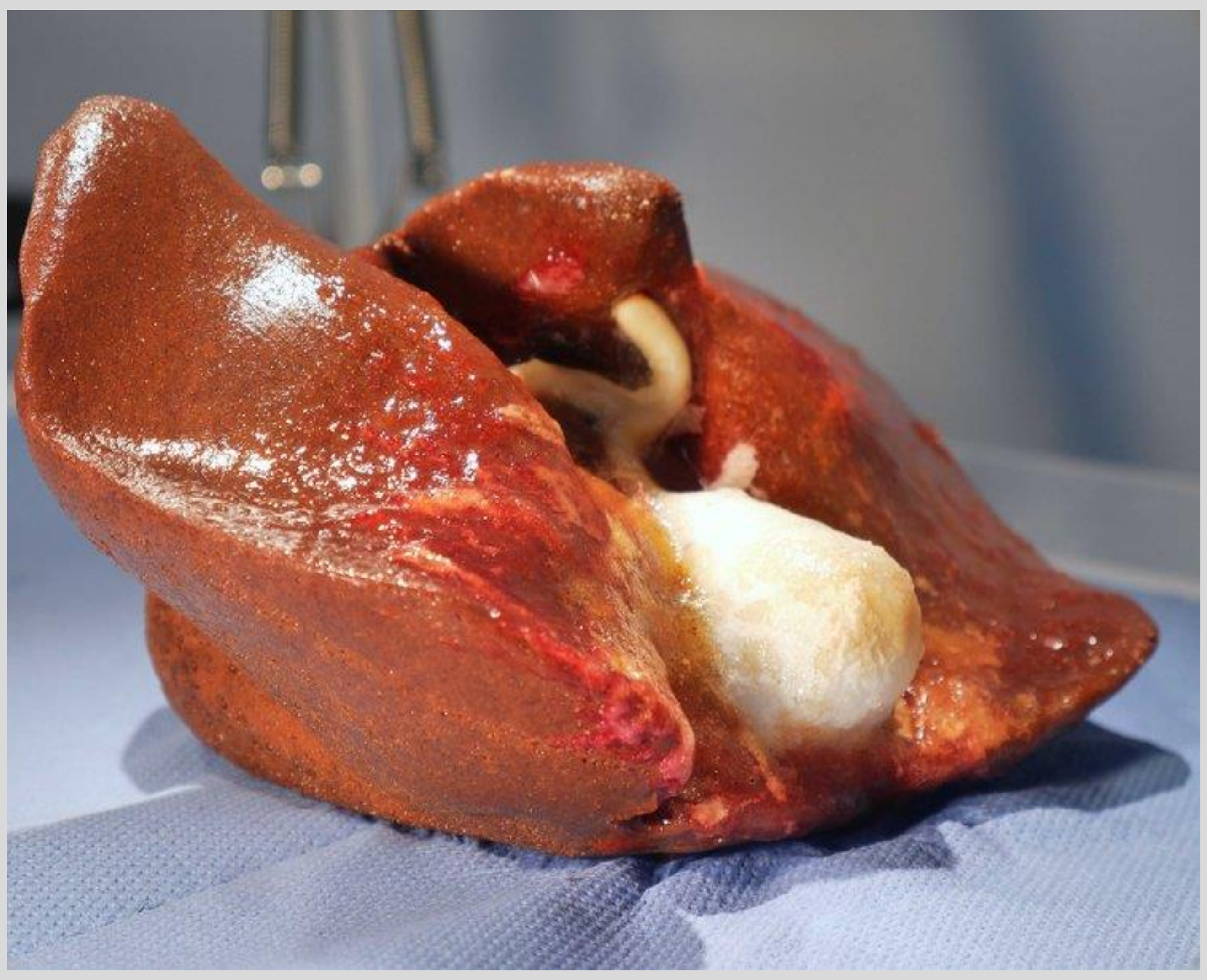

Fig.. 1: Left - isometric view of moulded brain with a tumor, Right – liver with integrated gall bladder

The latest developments in 3d printing with biomaterials are based on the extrusion of viscous materials through pressure. Primarily, extrusion heads utilize pneumatic pressure systems (syringes) or stepper motors to force the substrate out of a nozzle onto a surface. These methods are well developed for high viscous materials. However, processing low viscous liquids with such extruders may cause leakages at the nozzle's tip. Additionally, in order to process gelable substrates, such as gelatine and agar, tempered print heads should be utilized.. Figure 1 shows a brain structure moulded from ballistics gel and a liver with integrated gall bladder moulded from different biomaterial compositions. Hereby, the consistence of the simulated tumor tissue varies from the brain tissue. The applied materials are visualizable through medical ultrasonic and can be examined while conducting surgery (fig. 2).

The production of such a model is expensive and time consuming. Consequently the aim of the presented work is to develop a 3d print system for the processing of gelable biomaterials. The system should be able to establish multiple temperature zones in order to simplify the handling of gelable biomaterials and to provide a precise controll of the gel point. That implies the following requirements:

- regulation of temperature in multiple temperature zones for controlled cooling of material close to gel point
- bubble free and consistent transport of material through system
- processability of different viscosities of liquids

In terms of gelable materials, the substrate's temperature in the reservoir may be set a few degrees Celsius above the gelling temperature to reduce the overall viscosity. Afterwards, the substrate can be cooled-down close to the gelling point inside the nozzle for optimal regulation to the gel point (fig. 3).

First experiments were performed using a composition of agar and gelatin to enhance the geling properties of the gelatin while maintaining the properties of the gelatin. Based on this approach, a temperature regulation system using multiple temperature zones is under development, which will be implemented into a 3d print system, using the FDM technology. Until now a multi-zone temperature control has been achieved using an Arduino developer board. The existing setup is capable of tempering a pre-heated biomaterial solution. After the implementation further improvements will include a thermal-efficient housing as well as additional sensor banks.

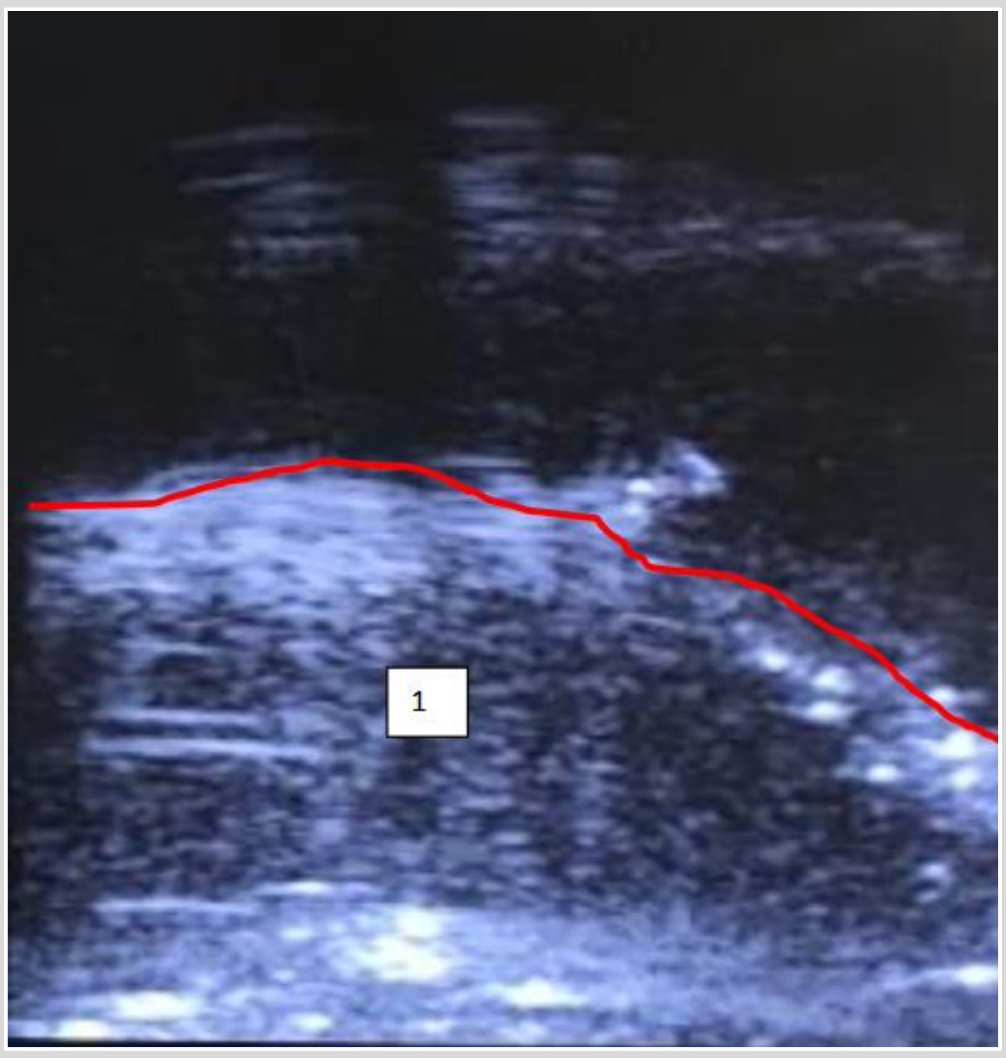

Fig. 2: Ultrasonic image of the moulded brain with indication of the tumor tissue (red line)

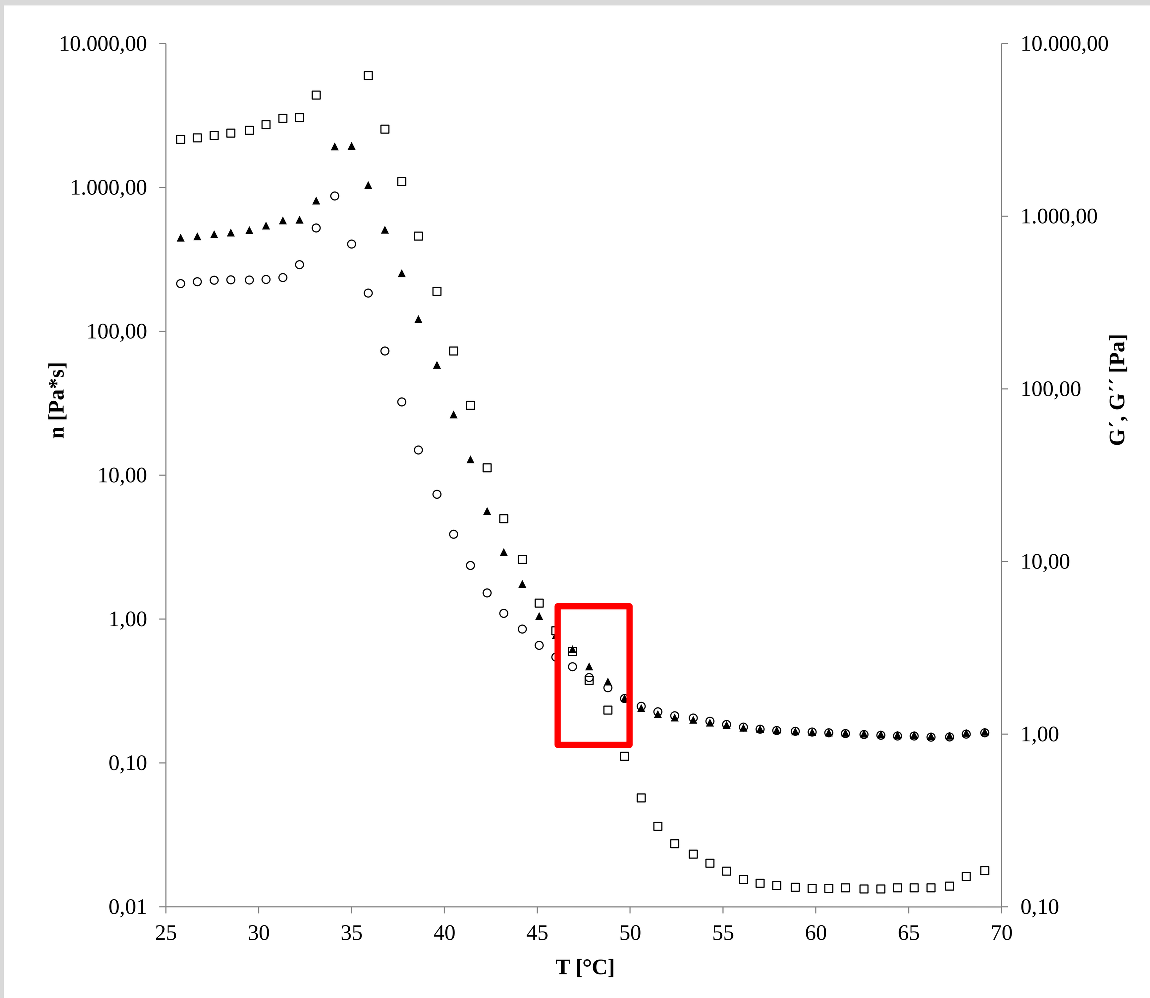

Fig. 3: Viscosity, G' and G'' of a 3% Agar solution. The red rectangle marks the gel point of the Agar.