

Modeling small strain behavior of subcutaneous fat

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Modeling small strain behavior of subcutaneous fat

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Introduction

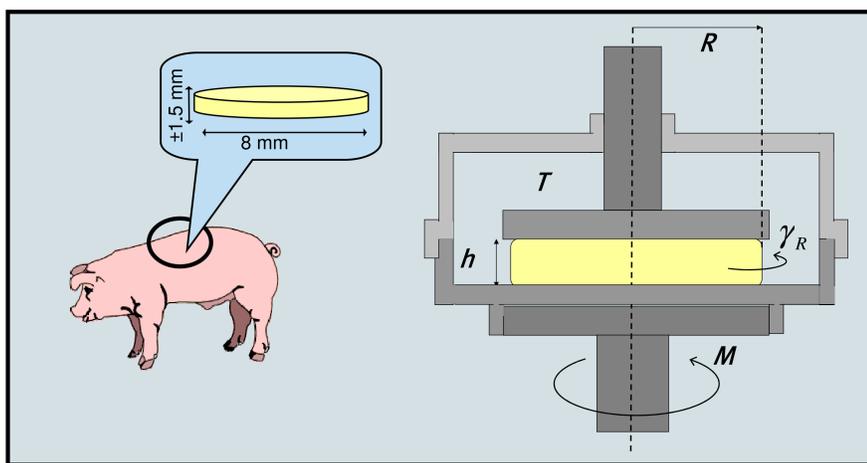
Until today mechanical properties of the subcutaneous fat layer have been hardly considered as important and hence, a constitutive model describing its behavior is lacking. However, numerical models including the subcutaneous fat layer are needed in a wide field of applications such as skin device contact, needle insertion procedures, and the removal of skin adhesives.

Objective

Implementing models that cover the small strain-behavior of the subcutaneous fat layer.

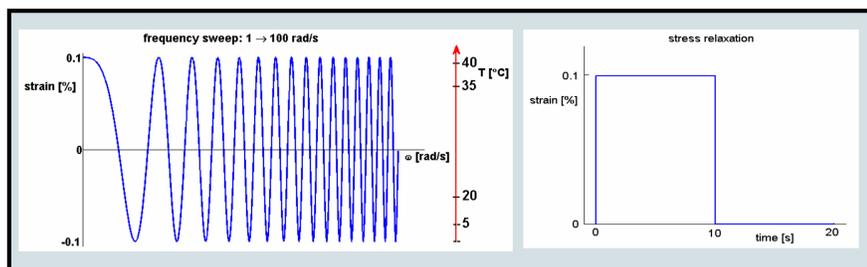
Experimental testing

Experimental set-up



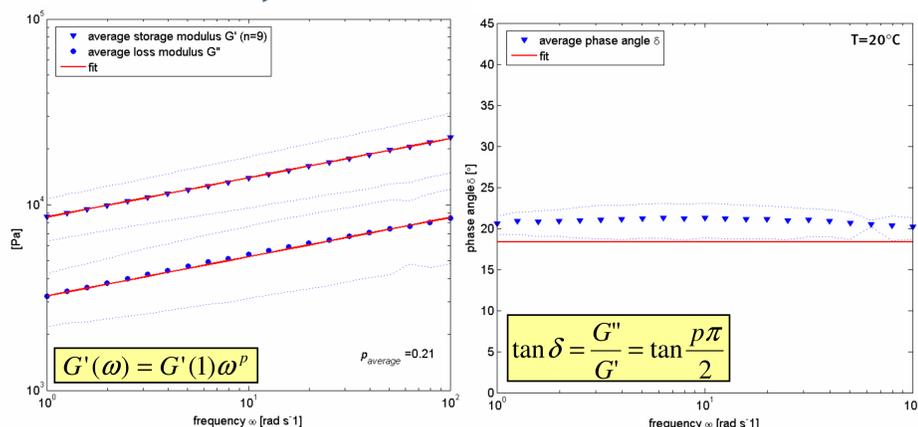
Testing protocol

- Presetting: 2 frequency sweeps (T=20°C)



Model application

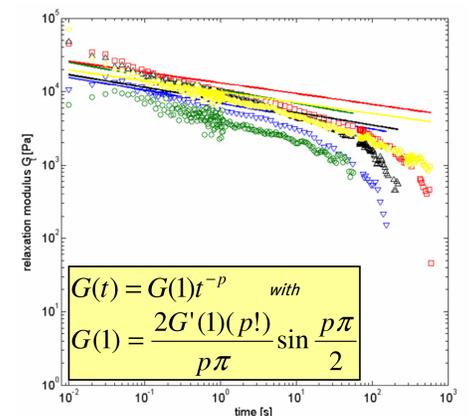
Small-oscillatory strain behavior



The experimental data for the storage modulus G' , the loss modulus G'' , and the phase angle δ are adequately described by a power-law relation with only two constants: $G'(1)$ and an exponential p -value¹.

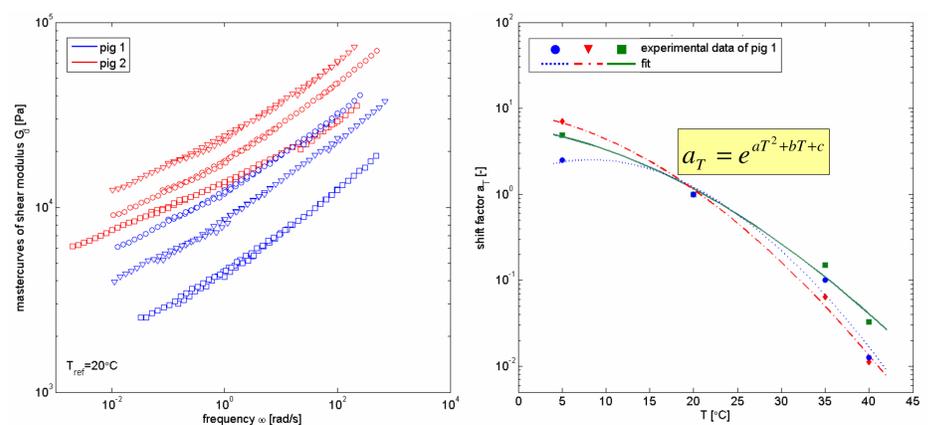
Stress relaxation

Frequency sweeps were followed by a stress relaxation test. By expressing the obtained relaxation function $G(t)$ as a function of $G'(1)$ and the p -value², the power-law model also captures these experimental data.



Time-Temperature Superposition

During consecutively applied frequency sweeps the phase angle remained constant over the temperature range. Therefore only horizontal shifting of the shear modulus G_d to a reference temperature T_{ref} was performed to obtain a mastercurve. The relation between the shift factor a_T and the temperature T is fitted by an exponential function.



Conclusions

- A common rheological model with only 2 constants, $G'(1)$ and p , is successfully introduced to describe the small strain behavior.
- Time-Temperature Superposition is applicable, meaning that the frequency domain can be widened to outside the experimental limits.
- The power-law function model forms a good basis for a constitutive model describing small and large strain behavior during all kinds of loading, which can be implemented into numerical models.

References

- [1] R.I. Tanner, Engineering Rheology, second ed., Oxford University Press, 2000.
- [2] A.C. Pipkin, Lectures on Viscoelasticity Theory, second ed., Springer-Verlag, New York, 1986.