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Modelling of the resistance to compression of dehulled rapeseed under unidirectional pressure

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Background:

Mechanical extraction of dehulled rapeseed is made difficult by the absence of fibres which acts to reduce the plasticity of the cake. Hulls are not only giving mechanical resistance to the cake, but they also help the oil outflow by reducing the resistance to percolation. To design presses that take this limitation into account, it is necessary to model the cake behaviour in function of parameters that influence its plasticity (water, temperature).

Objective:

The goal of this work was to establish a model for predicting the coefficients a, b and c of the tangent curve which fit the observations related to the evolution of the force (F) exerted to a bed of material as a function of the reduction of its volume (x).

$$F = a.\tan(x.b)^c \quad (1)$$

Methods:

A 40 mm diameter micro-press capable of producing a force of up to 50kN was used. An experimental design was carried out by varying the water content of dehulled rapeseed to 5, 7 and 9%, the press temperature to 30, 65 and 100°C and the compression speed to 0.1, 40 and 80 $mm.s^{-1}$. The curves obtained were modelled individually with high fidelity by the tangential model and the values of the adjustment coefficients were in turn modelled using a polynomial quadratic model. For the 'a' coefficient, the effects of interactions were also incorporated in the model. In a second time, the whole dataset was used for global modelling.

Results & discussion:

The established model explains more than 90% of the data variability. According to the model's predictions, the best results would be obtained at low temperature for the seed at 5% water with the slowest compression speed. It was observed that for all temperatures, the increase in water content results in a reduction in the compression ratio at which the pressure increases significantly. All other things being equal, higher temperature also translates into higher pressures, but unlike the effect of water, this does not translate into a reduction in the compression ratio at maximum pressure. Faster piston displacement leads to a reduction of the maximum compression rate and to increased resistance against volume reduction. We interpret this effect by hypothesizing a reduction of the pressure at which the networks of capillaries, through which the oil can flow, collapse when the plasticity of the material rises. The effect of temperature is more complex because it acts on both the viscosity of the oil and the plasticity of the cake.

Conclusions:

These preliminary results are bringing new light to the question of the poor performances in mechanical extraction of low fibre material by evidencing the importance of maintaining as long as possible the capillary network in the cake. This could lead to screw designed with more progressive compression avoiding excessive pressure and heat generating friction.

Reference:

(1) Sigalingging, R. *et al*. (2015). Application of a tangent curve mathematical model for analysis of the mechanical behaviour of sunflower bulk seeds. *International Agrophysics*, 29(4).