therefore they can pose serious risk for the consumers. Hence adequate pesticide residue control intended to ensure the safety of foodstuffs is needed. A brief overview concerning the analysis of pesticide residues by chromatographic methods in samples of plant origin is presented. The basic principles and recent developments in the sample preparation (extraction and clean-up), detection and quantification are discussed. Comparison between traditional solid phase extraction techniques and so-called QuEChERS (quick, easy, cheap, effective, rugged, safe) approach is emphasized. Possibilities and limitations of single quadrupole mass spectrometer for quantitative determination are also discussed.

EXPERIMENTAL AND NUMERICAL STUDY OF THE HENS EGG BEHAVIOUR AT THE IMPACT

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ABSTRACT

Hens eggshell behavior at the impact by a circular rod is studied. The instrumentation of the rod enables to obtain time history of the force at the point of the bar impact. The velocity of the rod is gradually increased up to some critical value at which the eggshell failure starts. At the same time the surface displacement of the eggshell is also recorded. The numerical simulation of the egg behavior under this impact has also been performed. LS DYNA 3D finite element code has been used for the evaluation of the force and surface displacement at the points of their experimental detecting. The experimental results well agree with numerical ones. The elaborated computational procedure has been future used for the numerical simulation of the Hens eggshell behavior at the impact on a rigid plate. Qualitative features of the numerical simulation agree with results recorded using of the high speed camera.

INTRODUCTION

Eggs can be regarded as naturally packaged food. When examining the quality of the packaging, one primarily considers the strength of the eggshell. The eggs are exposed to many different kinds of loading occurring during their collection, within the sorting equipment, and during transport. There exist several techniques to determine the material strength of an eggshell see e.g. (Kemps et

al., 2006).These experimental methods can be defined as quasi – static and dynamic. Most of works performed up to now have been performed under static loading. Owing to the fact that practice loads on the eggshell have a dynamic nature and so the dynamic strength of an eggshell could relate better to conditions experienced during handling and transportation of the eggs. As the measure of the shell strength the dynamic stiffness K_d was introduced (Coucke, 1998).To determine K_d, the egg is excited by a small impact, and the vibration behavior is registered. Subsequently from the resonant frequency and the mass of the egg, the K_d is calculated.
In the given paper the method of the measurement of the dynamic strength of the eggshell is described. This met odd enables to measure not only vibration behavior but also the time history of the loading force. Preliminary experimental results together with the results of a numerical simulation are presented.

MATERIAL AND METHODS

For the experiments eggs of Rhode Islands hens co to bylo za vejce have been used. The eggs have been loaded by the impact of a free-falling cylindrical bar(6 mm in diameter, 200 mm in height – made from aluminium alloy) – see Fig. 1.

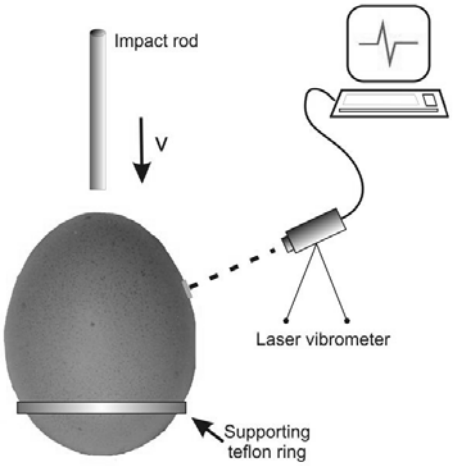

Figure 1.
Schematic of the experimental method.

At the point at the egg equator surface displacement as well as the surface velocity have been measured using of the laser-vibrometer. Eggs have been loaded by the bar impact on the pole (sharp or blunt) and on the equator. The height of the bar, *h*, has been changed up to the value at which eggshell fracture starts.

RESULTS AND DISCUSSION

In the Fig. 2 the experimental record of the forces at the point of contact between bar and egg is presented. One can see that there is a deviation from the shape of this function at the moment of the fracture origin.

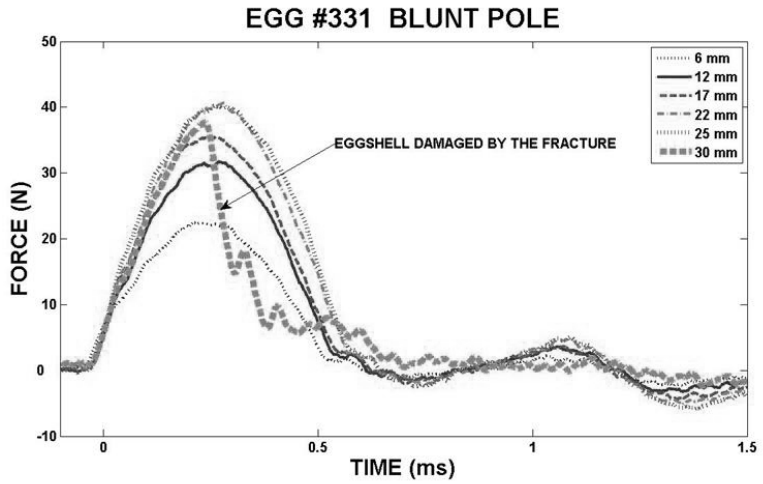

Figure 2.
Experimental records of the time history of the force at the bar impact.
The different values of heights h are given in the upper right corner.

For each type of the dynamic loading (i.e. impact on the blunt pole, sharp pole and on the equator).The value of the force F_{max} at which the eggshell breaks has been evaluated.
Even if the number of the tested eggs is limited one can see that the values of the force at which the fracture starts is very closed to that obtained at the quasi-static loading e.g. by a compression between two plates. The effect of the loading orientation is also the same like at the quasi static loading. This conclusion support a hypothesis that the mechanical properties of the eggshell are independent on the loading rate and/or on the strain rate, respectively. This is different result from the conclusion of the paper, where this dependence has

been reported. The next research and much more number of tests are needed for the explanation of the loading rate influence.

Numerical Simulation.

Similarly as in our previous works the eggshell is considered as linear isotropic elastic material. Its behavior is than described by the Young modulus E and by the Poisson constant ν. The same description is used for the eggs membrane. Eggs liquids are considered as compressible. No other rheological model can be implemented into the LS DYNA software.

Numerical procedure has been used for the simulation of the egg falling on the rigid plate with the striking velocity 1.4 m/s. This experiment has been recorded by the high speed camera and than it was simulated using of the LS DYNA finite element code. The numerical and experimental records of the eggshell fracture development exhibited a good agreement. Numerical simulation can not describe the real flow of the eggs liquids after the eggshell break. This is a consequence of the neglecting of the real behavior of the eggs liquids.

Concluding remarks.

In the given paper the experimental method of the eggshell dynamic strength evaluation has been described. This procedure extends the up to now used method of the evaluation of the dynamic behavior of the eggshell. Preliminary results show that the mechanical properties of the eggshell can be strain rate independent. The experimental method has been numerically simulated. The agreement between experimental and numerical results promise the evaluation of the stress state at the moment of the fracture origin. From the numerical computation the stress at which the eggshell fracture occurs can be obtained. This stress represents the eggshell strength. This strength is independent on the eggs shape as well as on the eggshell thickness. It seems that this strength is an intrinsic material parameter which may be affected by the eggshell microstructure, by its chemical composition and by some elements distribution.

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