4th International Workshop
for Young Scientists

BioPhys Spring 2005

BPS

Institute of Agrophysics
Polish Academy of Sciences
Lublin, Poland

and

Czech University of Agriculture
Praque, Czech Republic

Center of Excellence for Applied Physics
in Sustainable Agriculture
„AGROPHYSICS"
in the frame of 5FP of EU

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BOOK OF ABSTRACTS

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INTRODUCTION

The first three BioPhys Spring Workshops were organized in Prague at Czech University of Agriculture, with the help and participation of the Polish colleagues; participants and lecturers. The participation of scientists from Germany and Poland increased international level of this event. The previous three workshops indicated that the BPS became a really good starting point for young physicists to be active in applied biology. The BPS provided good opportunity for training of scientific presentation abilities of young researches and exchange of experiences and insights between scientists who are active in different areas of applied physics, biology and agriculture. The idea of such an event has been supported by all participants of the previous workshops and this is why we would like to continue this activity also next year at the similar rules.

During the last meeting we decided to alternate Prague and Lublin as the holding places of the BPS to bring new individuals into this activity. The BPS 2005 in Lublin is continuation of the previous tradition: mixing school and workshop training with presentation of the young scientists' results, all this organised as an opened English spoken event without any fee.

The year 2005 is the World Year of Physics - an international celebration of physics and its importance in our everyday lives. The BPS focused on application of physics into sustainable development of biological, agricultural and food systems is an event of this celebration. We hope that the Workshop will contribute to better understanding and tightening links among researchers applying different approaches to the biosystems.

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LECTURES

HIDDEN AND MASKED IN BIOLOGICAL PHYSICS

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The main present aims of the Biological Physics are discussed from the position of the experimental physicist. Every experimental science is a combination of experimental results and the theories, comparing of new and known, and discovery of the hidden and the masked. I try to give some examples from BioPhys where the hidden and masked could be found. It is done in form of Secrets.

<u>Matter Structure</u> – secrets of critical structure unit

The main structure units are particles and pores with their different and complicated properties. In BioPhys Mater the most important role is played by cells. In details of their structure and responses to the external impacts there are hidden and masked keys to the properties of whole the structure.

<u>Matter State</u> – secrets of molecule interaction

Biological matter in most cases is a complicated composite in which different substances take place. The substances are so different that among them we can find all the physical states: solids, liquids, and gases. It is important that resulting state behaviour of such composite is not determined by only the concentration of the components, but rather by hidden and masked details in cohesion forces among the quasi-solid structural units of the composite. This is problem of bonding forces between molecules and their parts that can be classified into two groups: strong with bonding energy in hundreds $kJ.mol^{-1}$ and soft with bonding energy in units and/or tens of $kJ.mol^{-1}$. The first ones are the base of the conservative bonding and in so manner of the <u>elasticity</u>, the second ones form the dissipative bonding that is expressed by <u>flowing</u>.

<u>Soft Matter (SM)</u> – secrets of soft interactions

Soft Matter plays very important role in cells and cellular structures. It is characteristic by soft bonding and from point of deformation by the flowing. In cellular structures the soft matter can be divided into two parts: intracellular (very important for physiology of living organisms) and intercellular playing crucial role in deformation of the cellular structures. Soft matter has very interesting special properties, partly still hidden and masked, now studied intensively by physicists.

<u>Flowing</u> – secrets of sources and rates

The matter flowing is impossible without any flowing sources, i.e. the critical soft bonds in the matter structure. Such sources can be thermally activated and the whole process is rate controlling, i.e. there exists strong dependence between the actual stress level and the flowing rate. The behaviour can be described simply by rate theories with activation enthalpy and activation volume as the main parameters.

<u>Flowing sources</u> – secrets of molecule configurations

Macroscopic behaviour is a superposition of different sources. One of them plays most important role and there is termed as controlling. Other sources are "hidden" or "masked". During long deformation these sources can start to play controlling role. It can be done either by exhausting the clothing controlling mechanism in case of the hidden mechanism or destroying the crossing controlling mechanism in case of the masked mechanisms.

<u>Common in methods of study of hidden and masked</u> (HM Hunting)

- to test systems in the extreme conditions
- to apply physical theory
- do not omit any strange results without any analysis

INFRARED IMAGING FOR INVESTIGATIONS OF PLANTS AND PLANT PRODUCTS

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Measurements by thermography

Thermography is the temperature visualisation of self-radiation of the object under consideration. The surface temperature of plants and plant varies with different transpiration rates due to the latent heat necessary for water evaporation. Changes in the transpiration rate e.g. by surface damage or infection can be recognised by thermography. The application of infrared imaging in horticulture was tested for the evaluation of climatic stress at post-harvest stage for fruits with high and low transpiration; the assessment of the freshness status and of microbial infestation by local temperature differences of plant parts; the ripeness and mealiness of apples and differences between apple varieties; the optimisation of the air flow which produce is exposed to under display conditions, in order to increase the shelve life of the products; and the control and optimisation of air conditioning in potato storage houses.

In recent laboratory experiments, studies were performed on the development of infestation of wheat plants, which were infected by powdery mildew and by stripe rust. Whereas the temperature differences between healthy and infested plants, infected by stripe rust, did not exceed ± 0.1 K usually, temperature differences of up to 0.9 K were observed at plant parts infected by powdery mildew. Normally, the temperature of the infected plant leaves decreased in the course of infection. In some trials, the temperature of leaves of infected plants, which looked healthy, increased later on and reached higher values relative to healthy plants (Fig. 1). As a result, this largely complicates the recognition of plant infections, as different effects occur at different states of infection. The field trials indicated a second difficulty for the application of thermal vision. The crop stand has a natural temperature variation of several Kelvin. Although infected plants can be recognised by thermography, information for plant protection cannot be get by commercial thermal vision systems as stand-alone solution.

Measurements in the NIR range

Infection by fungi and other microorganisms can affect the surface structure, e.g. drying and different kinds of changes caused by cuticula decomposing enzymes or formation of mycelia. Therefore, spectra of healthy and infected leaves were investigated and infrared images of healthy and infected plants were taken by band-pass filters with transmission ranges inside and outside the water absorption band (around 1.4 pi). Outside the water absorption band, the NIR reflection of infected plants leaves slightly decreased compared to that of healthy plants. In contrast, a slight increase was measured in the water absorption band for the infected leaves. The differences between healthy and infected plants are marginal and the standard deviations of the means overlap nearly total. Discrimination because of these small differences is not possible. Since the intensity changes are opposite inside and outside the water absorption band, the ratio of intensities improves the chances for differentiation.

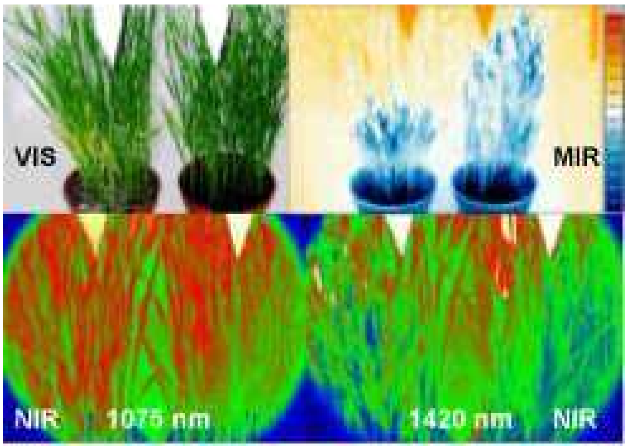

Fig. 1: Images of wheat plants infected by powdery mildew (left pot) and of healthy wheat plants (right pot). Air temperature 24.1°C, relative humidity 52 %
VIS: Digital camera image (0.4-0.7 |Jm);
MIR: Thermal Image (8-12 pjn);
NIR 1075: Image of NIR camera and band-pass filter 1075 ± 75 nm;
NIR 1420: Image of NIR camera and band-pass filter 1420 ± 75 nm.

The NIR images at wavelengths of 1075 nm and 1420 nm differ from each other (Fig. 1). In the water absorption band (1420 nm), plant parts are darker then with the band-pass filter of 1075 nm. The differences between infected and healthy plants depend on the angle of image taking and changes in the course of infection. Thus suitable information for plant protection cannot be derived by simple methods like threshold evaluation. A pixel processing of two or more identical NIR images with different wavelength ranges may provide a better solution for successful analyses because intensity ratios improve the discrimination potential in the NIR range.

METHODOLOGICAL ASPECTS OF PLANT CELLULAR STRUCTURE PARAMETERISATION

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The latest research programs, also those of the European Union, adopt - as the primary objective of studies - scientific progress generating knowledge with significant impact on the practical implementations. Among this group of research problems one should include work concerning the knowledge and control of the material properties of numerous media.

Highly developed technologies in particular require increasing amounts of knowledge concerning the properties of materials. This is true also with relation to agricultural materials, used both for direct consumption and for industrial processing. In both cases we face increasing demands concerning the quality of the raw material and the final product, as well as the monitoring of material properties throughout the process of production.

Monitoring, as a tool for product quality control, permits traceability of the history of the product and provides a record of changes in its properties over the whole production path, and is necessary for: i) determination and preservation of features characteristic for the product at every stage of its processing, and ii) flexibility of the production process, also in terms of the economic dimension. The enormous amount of products generated by agriculture, their biological diversity, variety of purpose, and therefore also differentiated quality requirements, cause that their monitoring can be classified among tasks of a very high level of difficulty and complexity.

One of the fundamental physical features characterizing the material studied is its structure which has a decisive effect on the other physical, chemical and biological properties of the material. In the case of plant materials it is a cellular structure with considerable heterogeneity and instability, and with frequent areas of discontinuity of significant dimensions. Such materials are especially susceptible to various effects, e.g. mechanical or thermal, and the resultant structural changes may cause a number of processes resulting in a deterioration in the quality of the product. Among the plant materials of agricultural origin, soft tissues are especially susceptible to structural changes and to damage of various kinds.

The continually improved and perfected techniques of microscopy permit examination of structure in the form of magnified images, and digital techniques for recording the images obtained permit analysis of the information they provide.

The analysis can be qualitative in character, and then its purpose is the identification of objects visible in the images, or it can be quantitative and provide information on the number of objects viewed and on their size, shape and distribution.

Quantitative analysis is necessary for the monitoring of the structure of cellular plant material or medium in order to permit comparison of similar objects or changes in the same object. Such analysis should be conducted according to suitable research methods, ensuring objectivity and accuracy of the appraisal of the microstructure as well as representative character of results and their replicability.

There are specialized dedicated software packages for image analysis that provide perfect performance in routine work, about new materials usually have structures that require new methods of analysis. Among such new materials we should include also cellular plant structures which, due to their complexity and variation, require original procedures of analysis. The study of those materials requires a great number of determinations, which in practice necessitates the application of automated analysis of images.

Automatic computer procedures for quantitative analysis pose, first of all, demanding requirements concerning the quality of images to be analyzed. Images for analysis should have sufficient level of contrast all the elements of the structure should be clearly discernible without any problems. The image, first of all, should clearly show the cell walls which determine the dimensions of the whole cell, and their arrangement in the plane of observation provides information on the spatial organization of the elements of the structure. This is difficult in the case of studying plant tissues, as they have low level of natural colouring and sometimes are totally transparent, and additionally, due to high water content, are subject to rapid drying and deformation in the course of observation. This is also related to the problem of a suitable method of structure image acquisition, preferably in natural state, without any preparation, and of image recording and analysis, selected for the object studied.

The application of any method of preliminary preparation through fixation of the structure may introduce disturbances to the structure under observation which should be taken into account in image analysis. Such methods may, however, be necessary in the case of the need of recording changes in the structure, e.g. under the influence of mechanical effects causing inner cracking.

In practice, the application of automatic analysis of images is not always possible, even for good quality images which may nevertheless require evaluation by the observer. Small gaps in the cell walls, resulting from the properties of the microscope or from errors during the slicing of soft natural samples, or visible other objects which are not subject to further analysis, can be corrected manually and further analysis of the image can proceed in the automatic mode. With a skilled observer, such a semi-automatic procedure does not cause major delays in the whole analysis while considerably reducing the level of measurement errors. The above procedure, due to its high labour requirements, is applicable primarily to homogeneous structures free of large intercellular spaces. Fully automatic analysis procedures also require continual evaluation by the observer due to the risk of accidental identification of incorrect objects.

Determination of parameters describing the cellular structure requires development of research methods applicable to the object studied. The primary requirement in this respect is to demonstrate whether anisotropy of structure occurs for a given type of tissue and, if so, to take this fact into account in taking samples for observation and during the generation of images. Anisotropy may be related to the form of the whole object, or to the place and direction of taking samples form observation and analysis of microstructure. It is also necessary to take into account the optimum number of structure elements under analysis to ensure that the features measured will be representative for the whole population. On the other hand, depending on the size of the structural elements, it may be necessary to apply the method of combining images to eliminate the problem of failing to include in the final analysis large objects that may exceed the boundaries of a single image.

It should be emphasized that every formulation of conclusions concerning the characterization of the microstructure of a plant tissue may only be based on actual results of quantitative analysis of the parameters of the structure, especially those related to the size of the cells.

Studies concerned with the quantitative description of the structure of cellular plant media have been initiated at the Department of Mechanics of Plant Materials, Institute of Agrophysics, Polish Academy of Sciences, and the work continues. For up to date information: www.mam.ipan.lublin.pl.

CELLULAR AUTOMATA METHOD IN BIOPHYSICS – AN EXAMPLE OF DISEASE SPREADING

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Most mathematical models of biological processes are based on differential equations, which describe a statistically significant and representative characteristic of the system. Usually deterministic rules of time evolution are applied. Time is then a continuous variable. However it is not so often that we may solve the set of differential equations. Also, it is not uncommon that the system may be described more appropriately as a probabilistic one. Then we can apply discrete time approach with a set of rules to predict the time t to t+1 transition of the system, not necessarily as a deterministic recipe. In any case, the time scale should be suitably chosen so that parameters characterizing the system do not change much in a single time step.

From many approaches in computer simulations, based on discreet time, perhaps the most common is the cellular automata technique. In the version described here, the cells may be interpreted in real space when different components of the system are associated with these cells or boxes, labeled by space coordinates. Our knowledge on possible interactions between the system components may then be incorporated into the evolution rules. In many cases only short range order interaction, say between nearest neighbors, is dominant. Good example of such a case may be a disease caused by direct infection from a neighbor. This is why the cellular automata technique is often used to describe dynamics of the infection by some viruses. In basic epidemiological models, a disease may be transmitted horizontally through infection (say, due to a direct contact) and/or vertically, i.e. from parent to offspring.

Here we confine ourselves to very simple description when the whole population is localized on a two dimensional N×N lattice with cells free or occupied by one item only, either infected or free of the virus. The dynamics is controlled by a proposed set of parameters (how infectious the disease is, is it lethal or can item recover, etc.) in each evolution step. If we are lucky, the system may tend to a dynamic equilibrium after sufficiently large number of iterations at which we can extract from computer experiment all relevant characteristics such as space or/and age distribution of items, at different phases of the infection development.

For example, the study of influence of vertical and/or horizontal transmission of infection leads to different age distribution of population. Migration plays important role in propagation of the disease, yet not always it is the factor limiting the disease spread. Computer simulation of dynamic of BSE disease is another example. The model parameters used for the simulation correspond to the mad cow disease. Main results show some critical probability p of the BSE transmission above which the disease is present in population while below it the population recovers and it is free of the disease. This critical value is, however, vulnerable to spatial clustering of the population (migration) and it depends, too, on the mechanism responsible for disease propagation.

TESTING FLOWABILITY OF POWDERS – REVIEW

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A great deal of work has been done to develop usable theory of gravity flow of granular materials. The most widely accepted approach has been formulated by Jenike in his work "Gravity flow of bulk solids" published in October 1961. This work was probably the most significant contribution in granular mechanics till now. Following impulse delivered by Jenike numerous researchers have began investigations in granular mechanics around the world. These people were in their 60-ties or 70-ties in the last decade of 20th century. Good time for recapitulation. Probably this was the reason that a number of papers summarizing the state of the art in the field have been published those days.

Simultaneously, in recent decades increases in the number of processes and operations involving granular materials have resulted in a growing need for new theory and technology. This was accompanied with growing interest in investigations of physical properties of granular materials. Elaboration of effective design methods of technological processes requires detailed knowledge of physical properties of the processed material as well as proper understanding of their interrelations with construction materials. Development and refinement of methods for determination of physical properties of granular materials has been particularly important. Despite unquestionable progress in measurement methods mechanical properties of granular materials measured in various laboratories can vary greatly. A significant source of the wide range of results is due to the large number of measurement methods and a lack of standard experimental procedures. Moreover some influencing factors such as moisture content, bulk density, packing structure and load history remain out of control that contribute to observed variability.

Flowability is a measure of the quality of granular product that influences its end-use value for some materials used in the chemical, mineral, pharmaceutical and food industries. Variation in flowability of ingredients is a significant source of errors during the weighing and proportioning, resulting in non-uniformity in the finished product.

This work reviews equipment and methods for determination of flowability offered by established consultants to following industries: chemical, environment protection, food, glass, metallurgy, mineral solids, paper, pharmaceuticals, mining, plastics and metal powders.

AGROPHYSICAL INVESTIGATIONS IN PLANT GROWTH ENVIRONMENT

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Agrophysics is a discipline of science dealing with an application of physical methods for the investigation of properties of various agricultural materials and products as well as processes occurring in systems: soil-plant-atmosphere and soil-plant-machine-agricultural products. Agrophysics also directs its particular attention to sustainable plant and animal production, and modern processing technologies with special consideration given to the quality of raw materials and food products.

The characteristic feature of soil-plant-atmosphere system, as a plant growth environment, is time and space variability of its parameters and biological activity of agricultural materials. Therefore in agrophysics, like in other natural sciences, modelling is the basic method of the description of the investigated object as well as phenomena and physical processes taking place in it.

The development of numerical methods and computers enabled the construction of physical-mathematical models, making it possible to simulate the real processes taking place in the soil-plant-atmosphere system. It is characteristic for such models that they use the constitutive physical equations for the description of physical processes. By solving these equations analytically or numerically under defined initial and border conditions, we can predict the changes of any given physical quantity in time and space.

The task of agrophysical metrology is to develop monitoring systems of physical parameters, characterising soil, canopy and agroclimatological factors. The monitoring systems give us a possibility to describe and analyse the spatial and time variability of physical parameters determining the plant growth conditions. The knowledge of the physical parameters variability is needed for the elaboration, calibration and verification of the physical and mathematical models of mass and energy exchange processes in the soil-plant-atmosphere system.

It should be emphasised that agrophysical investigations which are especially connected with metrology and modelling of physical processes in the soil-plant-atmosphere system are extremely important and should be intensively developed, because the environment can be optimally used, protected and managed only when we have to our disposition the fullest possible information about physical parameters describing this environment and about their dynamics.

It should be stressed that both research methods, modelling and agrophysical metrology are universal, i.e. they refer to all the disciplines being a part of natural sciences and they constitute a modern and effective research working methods and are also complementary to each other.

THERMOPHYSICAL PROPERTIES OF BIOLOGICAL MATERIALS

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The present work deals with thermophysical properties of biological materials, particularly vegetable agricultural products.

The brief characterization of biological materials is presented. The influence of the presence of the water in these materials is shown. The moisture content and the temperature are the most important physical properties that considerably influence not only material's properties but physical and physiological processes running in the biological materials as well.

Physical processes running in materials during processing are reviewed. Some of the thermal processes are described in details.

Basic thermophysical properties – the specific heat, the thermal conductivity, the thermal diffusivity, the heat transfer coefficient – are defined and overview of measurement methods is given. Principle of the thermal conductivity measurement method – hot-wire method, which is suitable for biological materials and experimental apparatus is described in details. Methods of thermal analysis – thermogravimetry and differential scanning calorimetry are presented and principles of the modern measuring equipments – DSC calorimeter and TGA analyser are described. Some results of the specific heat at the constant pressure measurement and results of the thermal conductivity measurement of biological materials are presented.

Dependency of the thermophysical properties on the temperature, the moisture content, the structure (bulk density) is presented. Thermophysical properties are the important information for the analysis of the material's behaviour during processing. Temperature dependency of the specific heat gives information about endothermic or exothermic processes in the material; temperature dependency of the thermal conductivity provides information for instance about heat transport running in the material.

Knowledge of thermophysical properties is basic condition for the following detailed analyses of the optimal material storage and the thermal processing regime proposal. Influence of the thermophysical properties on the effectiveness of the thermal processing is discussed.

ORAL CONTRIBUTIONS OF YOUNG SCIENTISTS

SURFACE AREA AND DENSITY OF THE POTATO AND WHEAT EXTRUDATES

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The extrusion-cooking is suitable and facile method of modification of some foodstuff functional properties. Frequently modern and common starch products and starch containing food are products from extrusion-cooking. The relation between parameters of the extrusion-cooking process and the extrudate properties could be found.

The density of solids refers to the density of solid particles collectively. It is expressed as the ratio of the total mass of solid particles (M_S) to their total volume (V_S), excluding pore spaces between particles. The particle density is calculate from the formula $\rho_S = M_S/V_S$.

The potato and wheat extrudates represented the meal extrudates. The effect of some conditions of the extrusion-cooking process on the density and the surface area of these extrudates were investigated.

The specific surface area of the extrudates were obtained from sorption-desorption of water vapour data. The adsorption-desorption isotherms of water vapour were measured by gravimetric method. Before the adsorption measurement the soil samples were dried in a vacuum chamber with the concentrated sulphuric acid until the weight of samples reached constant values.

The specific surface area of the extrudates were evaluated from adsorption-desorption isotherms in the BET range of relative water vapour pressure, using the Brunauer-Emmett-Teller (BET) method. The first step in the application of the BET method is to obtain the monolayer capacity (N_m) from the BET plot. The second step is to calculate the surface area S from the dependence $S=N_m\times M^{-1}\times L\times\omega$, where L is the Avogadro number (6.02×10^{23} molecules per mole), M is the molecular weight of water (gram per mole) and ω is the molecule cross-sectional area (10.8×10^{-20} m^2 for water molecule). This procedure agrees with the Polish Standard PN-Z-19010-1 for measuring the surface area of soil.

The particle or true density was determined using the Ultrapycnometer 1000 (Quantochrome) which is specifically designed to measure the volume and true density of solid objects. This accomplished by employing Archimedes principle of fluid displacement and Boyle's law to determine the volume. The displaced fluid is the gas which penetrate the finest pores. For this reason helium is recommended since its small atomic dimension assures penetration into crevices and pores approaching 10^{-10} m in dimension.

The adsorption-desorption isotherms showed effect of some physical properties of these products for, e.g. density and expansion ratio on the sorption capacity of the investigated extrudates. The amounts of sorbed water vapour by native and extruded material at the relative water pressure from 0.01 to 0.80 were similar. For potato extrudates the specific surface area estimated from sorption isotherm ranged between 214 and 340 $m^2\ g^{-1}$ and between 330 and 350 $m^2\ g^{-1}$, if the desorption isotherm was used. For the wheat extrudates the average BET-surface area obtained from sorption and desorption data was 60 $m^2\ g^{-1}$ and 80 $m^2\ g^{-1}$, respectively.

The true density of the potato extrudates ranged between 1.15 and 1.4 g cm^{-3}. For the wheat extrudates the true density were similar and close to about 1.35 g cm^{-3}.

The result observed might be due to reactions between protein and starch and lipids taking place in the cooker. The effect of the extrusion-cooking conditions upon all the density, expansion rate and shearing stress for wheat flour and potato starch extrudates was similar [Jamroz et al. 1998].

Acknowledgements

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ACOUSTIC EMISSION IN TEXTURE PROFILE ANALYSIS OF RAW FOOD MATERIALS

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Texture is an important factor in the appreciation of food quality related to its mechanical properties. Mechanical characteristic of texture would be described in Texture Profile Analysis test (TPA). In the TPA, sample is placed on the baseplate and compressed and decompressed two times till the same deformation level by a platen probe.

Many parameters of foods are related to sound emission and fracturing during eating. However, it is still unclear which aspect of sound gives the best description of the sensory sensation. Deformation of a tissue can cause cracking which would be a source of acoustic emission [1]. For example, the onset of potato tissue cracking appears much before bioyield point on a stress-strain curve. The fracturing before bioyielding is not noticeable on the stress-strain curve. It is still not clear how this micro-cracking before bioyielding influences on texture sensation by consumers.

In this research acoustic emission will be recorded during TPA test. The aim is assessment of differences in ultrasound emission during TPA among different raw plant foods.

Apple variety Idared and potato variety Ibis was used in the experiment. These two materials have different microstructure and mechanical properties. Apple having about 25% intercellular spaces fails mainly through intercellular lamellas while potato with less than 1% spaces fails through cell wall fracture. The differences in mechanical properties would be also related to different cell size that in apple is much bigger. Cylinders having a 13mm in diameter and 13 mm length were cut. Texture Profile Analysis was performed with a universal testing machine Lloyd LRX in 20 repetitions for each material. Compression and returning of TPA were carried out with the same velocity 20mm/min. Degree of deformation of 40% for potato and 20% for apple was applied. The AE sensor (WD type, Acoustic Research Co., 100 kHz-1MHz) was positioned to the side of upper flat plate of testing machine. Counts were used as parameter of AE signal. Details about apparatus and signal processing were described by Zdunek and Konstankiewicz [1].

Examples of the TPA curves together with acoustic emission counts are shown in Fig. 1. Acoustic signal appears much earlier in the case of apple than in the case of potato. In apple, acoustic counts are recorded almost from the beginning of compression. It would be result of weak intercellular bonds and further friction between cells during deformation. Probably, high amount of intercellular spaces magnifies this process. In potato, where tissue fails through cell walls, process of cracking starts later and more gradually, from small number of counts to very high at the pick of the first bite. In both materials, the level of deformation was close to their bioyield points. A few samples (shown in Fig.1) revealed sudden rupture before reaching the deformation level of the first bite. Rupturing was always accompanied by high AE counts. The acoustic emission was recorded mainly during downward movement of machine probe. During upward, some signal was observed just after probe returning, while AE signal disappeared at the end of returning. It was clearly visible that acoustic activity of apple is much higher than potato during the whole first bite. The second bite of TPA also caused acoustic emission. However, the signal was usually weak and in a few cases no counts were recorded, especially in the case of apple. Similarly to this, the peak of the second bite is always smaller that the first one in both materials. The material is weakened and only small acoustic emission appears due to propagation of already existed cracks within material.

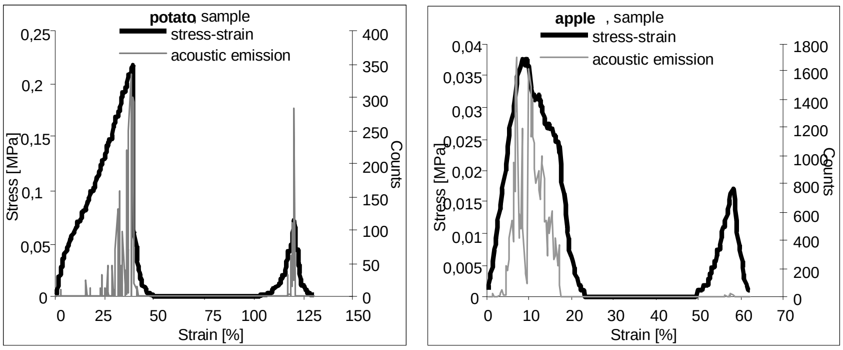

Fig. 1. Examples of acoustic emission during TPA test for potato and apple

Results of the experiment showed that acoustic emission is strong during TPA test. The differences in acoustic profiles of potato and apple show possibility of application of acoustic emission method to texture analysis of plant materials. Taking into account that sonic sensation during eating is considered as one of the most important for consumer, the acoustic emission would deliver interesting information about quality of raw fruits and vegetables.

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THE SMALL PHOTOVOLTAIC SYSTEMS AT THE CUA IN PRAGUE

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The natural resources are running out and it is necessary looking for a new power sources. The classical fossil resources have one other big handicap. They emit the tons of CO_2 and other emissions to the Earth atmosphere and they are limited. For sustainable development is necessary use other ecological power sources. The source with the biggest future is solar energy.

The internal grand was solved at the Department of Physics at the Czech University of Agriculture in Prague last two semesters. The influence of the quantity of produced electricity upon the new construction components was systematically searched. The two small photovoltaic (PV) solar systems were constructed. The first system was stable with $40W_p$ amorphous photovoltaic solar panel. The second system involved tracking stand TRAXLE^{TM}, 100Wp bifacial PV panel and 40Wp amorphous PV panel to balance the system.

It was assumed that the difference of yield of produced electricity of the first and the second system is approximately 30%. The only few number of half-bright days and any sunny days were during the autumn. The results showed the average yield was 23%.

The economical light sources were tested for using in off-grid solar system.

THERMOPHYSICAL PARAMETERS OF CHOSEN BIOLOGICAL MATERIALS

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Biological materials have complicated structure. This complicated structure is caused of great variability of their chemical, biological and physical properties. During processing biological materials, concretely nutrive raw materials as corn, wheat and products made from their grains are heating, cooling, drying, moisturing or mechanical manipulation. It is necessary to know thermophysical properties of nutrive raw materials to choice optimal technological procedure. Nowadays we know many methods of measurement, aparatures and instruments for thermophysical measurements. For our measurements we choice Isomet-instrument made by firm Applied Precission. It is used for quick and exact measurement thermophysical parameters of various materials. We can use Isomet for measurement of thermophysical parameters as temperature, thermal conductivity, thermal diffusivity etc. Definitely we used Isomet for measurements of thermal conductivity and thermal diffusivity of corn flour and wheat flour. We made relations of thermal conductivity λ, thermal diffusivity a to moisture content and to bulk density.

Isomet use for measurements hot wire method. The simple measurement consist of measuring the temperature rise *vs.*, time evaluation of an electrically heated wire embedded in a tested material. The termal conductivity is derived from the resulting change in temperature over a known time interval. The ideal analytical model assumes an ideal – infinite thin and infinite long line heat source (hot wire), operating in an infinite, homogenous and isotropic material with uniform initial temperature T_0. If the hot wire is heated for the time $t = 0$ with constant heat flux q per unit wire length, the radial heat flow around the wire will occur. The temperature rise $\Delta T(r,t)$ in any distance r from the wire as a function of time.

We had to use several corrections to account for the heat capacity of the wire, the thermal contact resistance between the wire and the test material, the finite dimension of the sample and the finite dimension of the wire embedded in the sample.

Measured relations of thermal conductivity and thermal diffusivity to moisture content had linear increasing progress for corn and wheat flour. Relations of the same thermophysical parameters to bulk density had polynomical decreasing progress. Thermal conductivity λ and thermal diffusivity a have different values for different sort of flour. Linear functions show, that relations of thermophysical parameters to moisture content have the same direction for corn and wheat flour in the first series of measurements and also in the second series of measurements. The moisture content and the bulk density are very important parameters which determine thermophysical parameters of nutrive raw materials.

EFFECT OF SOIL MOISTURE CONTENT AND SURFACE CONDITIONS OF LOAMY SAND ON SOIL EROSION

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Erosion by rainfall occurs from raindrops striking soil, and water flowing over the soil. Surface runoff represents this part of water supplied to soil, which can not infiltrate or be stored on its surface. Generally, it is assumed that soils developed from silt are the most susceptible to runoff and erosion. Relatively small attention is put to runoff and erosion processes on soils developed from sandy loam.

The purpose of the studies was evaluation of the effect of initial moisture content and soil surface status on runoff and soil loss of loamy sand.

Studies were conducted on loamy sand characterised by 49% of sand, 47% silt, 4% clay, and pH 6,6 of KCl. Soil samples were placed in box (50 x 50 x 25 cm) equipped with TDR probes and located under 9% slope. Air-dry soil samples were initially wetted by rainfall (28 mm/h during 150 minutes - cycle *R0*). After 2 days, soil surface was loosened (cultivated) to depth of 11 cm. On such prepared soil samples, rainfall of intensity 28 mm/h was simulated during 1 hour (wet-unsealed, cycle *R1*). The next simulations were performed on following initial conditions: wet-sealed (cycle *R2*), and dry-sealed (cycle *R3*). Different initial soil moisture and status of soil surface conditions were result of sequence of rainfall simulations and breaks between the simulations (*R0* → 2 days and soil loosening → *R1* → 1 day → *R2* → 5 days and drying → *R3*). Studies were conducted in 3 replications. During each rainfall simulation, runoff and soil loss was collected in 5 minutes intervals, and soil moisture was recorded at the depth of 1.5, 5 and 10 cm. To determine soil bulk density, soil cores were taken from depth 0-5 cm before *R1* and after *R3*. Initial soil conditions (soil moisture and bulk density at the depth of 1.5 cm) were significantly different for cycles *R1* and *R3* (soil moisture before *R1* - 23.4 $cm^3\ cm^{-3}$, before *R3* - 10.6 $cm^3\ cm^{-3}$). Soil sample surface for *R1* was unsealed due to earlier loosening, whilst for *R3* was sealed due to previous 2 rainfall applications. For *R2,* initial soil moisture content was the highest θ (1.5 cm) = 28 $cm^3\ cm^{-3}$ and soil surface was sealed by 1 rainfall application. Soil bulk density measured at the depth of 0-5 cm was before *R1* - 1.28 Mg m^{-3}, and after *R3* - 1.64 Mg m^{-3}.

During *R1*, *R2* and *R3* cycles, surface runoff have started almost directly after rainfall simulation. Hydrographs can be put in the following sequence according to runoff volume increment *R2*>*R1*>*R3*. Steady-state runoff rate appeared the quickest during *R2* (after 10 minutes), then during *R1* (after 20 minutes) and *R3* (after 25 minutes). Level of runoff stabilisation was similar for simulations, and its average rate was 23.3 mm/h.

Differences in total surface runoff were reflected in changes of soil moisture in samples profiles. Most rapid increase of runoff and its total volume (at R2) corresponded to small increment of soil moisture content (in the range of 0.6 to 1.1 $cm^3\ cm^{-3}$).

Studies showed that runoff was started directly from the beginning of rainfall simulation and independently on initial soil conditions. Despite the differences at the beginning of simulation, runoff achieved a comparable steady-rate level in all cycles of measurements. In contrast to this, large variation of wash among different cycles was observed. Conducted studies showed that sandy loam soil was very susceptible to runoff and wash.

MEANS OF ESTIMATION OF THE WETTABILITY OF SOLIDS

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Any liquid can more or less spread on a solid surface. It depends on the interparticle forces between liquid and solid. If interactions between both phases are higher than these between the molecules of the liquid, the liquid moistens the solid, i.e. the solid is wettable. If the forces between the liquid molecules are higher than these between both phases, the solid is nonwettable and the drop of the liquid does not moisten the solid surface. A quantitative measure of the wettability is a solid – liquid contact angle which determines whether the surface is lypophobic or lypophilic. However, the measurement of contact angle value depends on the surface pretreatment and the way the liquid drop is deposited on the surface. Therefore, to conclude about wetting properties of a solid surface one should be careful about the interpretation of the measured quantity. Contact angle can be measured directly by observation of a small drop of a liquid settled on a solid surface using a goniometer.

Because direct measurement of the contact angle, particularly for water on granular materials (soils) is almost impossible, one derives this from experiments on migration of a range of polar and nonpolar liquids (usually water, formamide, n-octane and n-decane) in the horizontal soil bed using a thin column wicking technique.

Surface free energy of solids and its components are important parameters characterizing surface properties of solids and interfacial interactions. However, determination of the surface free energy components is still unresolved, because the known methods, which are based on contact angle measurements, an adsorption or enthalpy of wetting are indirect ones. Another important problem is interpretation of interfacial free energy.

The approach of van Oss, Good and Chadhury to the formulation of the surface free energy was applied for determination of apolar Lifshitz – van der Waals component, γ_s^{LW} and polar acid base, electron donor, γ_s^- and electron acceptor, γ_s^+ components of the tested soil sample. The components were determined using contact angle and thin layer wicking methods. Also water drop penetration time test (WDPT) and capillary rise method were used to estimation of the wettability of the solid surface. Water drop penetration time test as formulated by Van`t Woudt consisting of placing a water drop on the soil surface and recording the time required for the water to infiltrate was applied. Capillary rise method is based on the capillary rise of various liquids in a column of powder by using the Krűss Processor Tensiometer K12®. Powder at various water potentials was placed initially in a glass tube with a porous glass base. The tube was fixed to the microbalance, then placed automatically in contact with a receptacle containing the liquid. The speed of capillary rise, measured as the increase in weight of the sample, is recorded in relation to time by the computer.

The present paper describes and compares the above methods.

MEASUREMENT OF ELECTROKINETIC POTENTIAL

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A difference of potential exists between two phases, being in a contact. It is connected with an existence of electrical double layer in the interphase (Fig.1.).

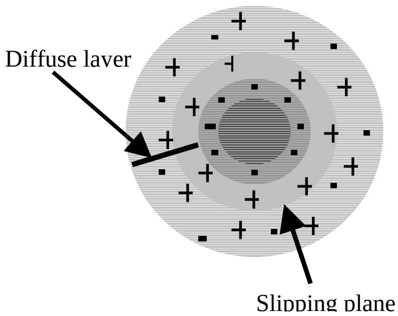

Fig.1. Scheme of electrical double layer.

In most cases, solid particles dispersed in a liquid carry the electrical surface charge. The system has to be electroneutral, so the surface charge is counterbalanced by equal but opposite sign charge of ions in the solution [1]. The electrical double layer consists of two parts. There is an inner region (Stern layer), which is created by the ions strongly bound to the surface, and an outer diffuse region. The latter one contains two parts: ions which move with particles and these that don't.

The potential, existing in the slipping plane (separating superficial liquid from the solution) is called the electrokinetic potential (ζ). Its value is an important indicator of the stability of colloidal system. It depends on pH and ionic strength of solution.

The measurement of electrokinetic potential is based on the electrokinetic phenomena. These are:

- electrophoresis,
- electroosmosis,
- streaming potential,
- sedimentation potential.

Some of methods, which are used in dispersed systems combine the techniques of electrophoresis (Fig.2.) and Laser Doppler Velocimetry [2,3]. The charged particles suspended in a dispersing medium move towards the electrode of opposite charge under the applied electric field.

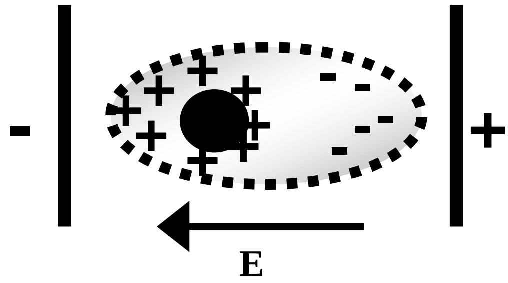

Fig.2. Movement of particle in the electrical field [4].

The velocity of particles depends on strength of electric field (or voltage gradient), dielectric constant of the medium, viscosity of medium and the electrokinetic potential. This dependence is described by Henry's equation:

$$U_E = \frac{2\varepsilon\zeta f(ka)}{3\eta}$$

where: ζ – electrokinetic potential, U_E – electrophoretic mobility, ε – dielectric constant, η – viscosity, *f(ka)* – Henry's function.

In aqueous media, under moderate electrolite concentration, Smoluchowski's approximation (f(ka)=1,5) is used and in non-aqueous measurements, Huckel's approximation (f(ka)=1) is used.

The electrophoretic mobility is measured by the use of LDV technique. Particles, which are moving, cause the change of the scattered light intensity. The rate of fluctuation is proportional to the speed of particles.

The measurements of electrokinetic potential are commonly made:

- during preparation of colloidal dispersions (inks, paints, cosmetics, pharmaceutics, food products, agricultural chemicals),
- in production of brick, cement, catalyst supports, in the ceramic industry,
- in medicine (the electrokinetic potential of blood elements, tissue cells, vessel walls),
- in protection of environment.

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RELATIONSHIP BETWEEN GEOMETRICAL PARAMETERS OF POTATO TUBER AND FAILURE STRESS OF ITS PARENCHYMA TISSUE

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The present work is the continuation of research on relationship between the geometrical parameters of potato tuber and mechanical properties of its parenchyma tissues. Tubers of Ibis variety were tested. Eight tubers of different size and shape were selected. Tubers were measured in three mutually perpendicular directions X, Y and Z (Fig.1). Tubers shape ratio (TS) was defined as:

$$\frac{(Lx + Lz)}{2Ly}$$

where: Lx, Ly, Lz – length of tuber in X, Y, Z directions respectively.

From each tuber two cylindrical samples 14 mm of high and 10 mm in diameter were cut out from two places – inner and outer core (Fig.1). Samples were subjected to uni-axial compression by universal testing machines Lloyd LRX along main axis of cylinder with constant speed 100 mm /min. Failure stress was analysed.

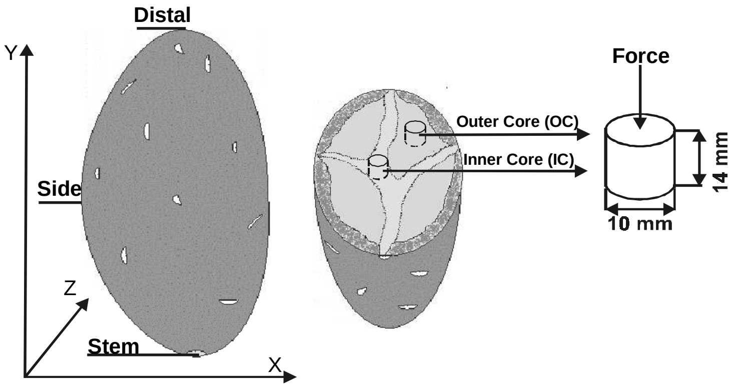

Fig.1. Coordination system used in experiment and places of sampling.

Research showed that correlation of the ratio of tuber shape and length of tuber with strength of parenchyma tissue exists (Fig.2). Increasing length in Y direction causes decrease in failure stress for the inner core. However for the outer core such relationship was not observed (Fig.2a). Tubers more elongated (lower value of TS) revelad lower failure stress (Fig.2b).

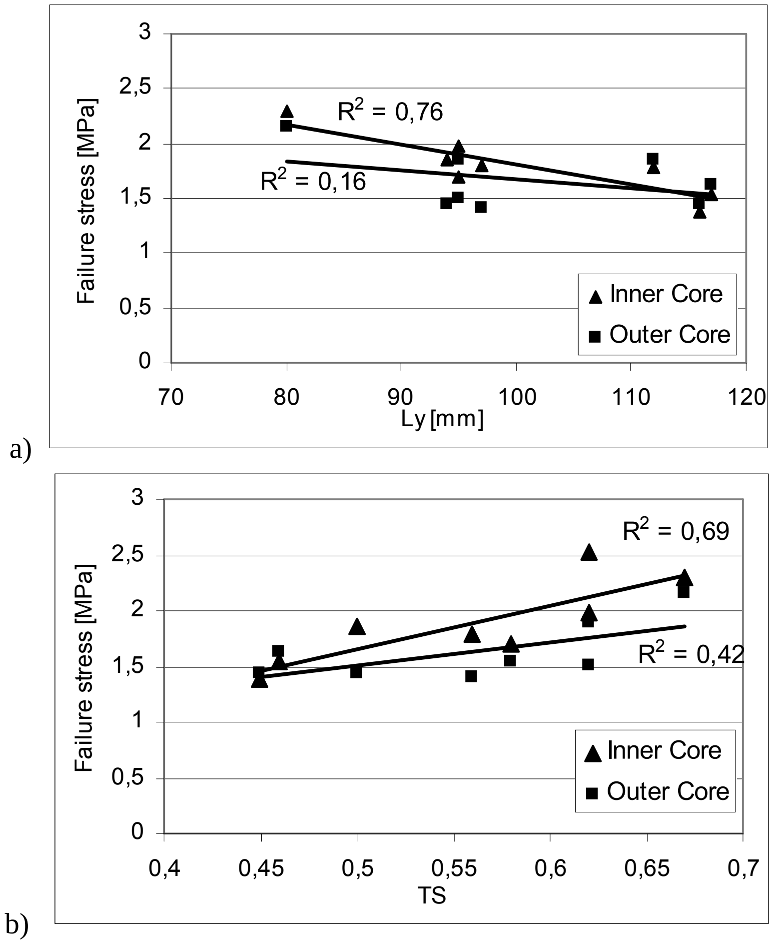

Fig.2. Relationship between geometrical parameters of potato tuber (Ly and TS) and failure stress of its parenchyma tissue

Keywords: potato tuber, ratio of tuber shape, mechanical properties, maximal stress, strength of tissue

APPLICATION OF SKCS 4100 SYSTEM FOR ESTIMATION OF UTILITARIAN VALUE OFWHEAT GRAIN

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Common wheat is a species from *Graminae* family and is one of the most popular cereal grain in the world wide range. Its cultivation is provided on the circa 240 millions of hectares; approximately 90% of this acreage is used to grow common wheat (*Triticum aestivum* L.) and rest of this agricultural surface is used with cultivation of durum wheat-(*Triticum durum* L.). World wheat grain yield production in the 90ties had achieved almost 600 millions tons.

In the technological point of view wheat grain as same as other vegetable raw materials should be uniform in the aspect of utilitarian characteristics. High level of uniformity of wheat kernels ensures effective processing in safe food, wanted by modern consumer. In practice many separating devices are in use to gain straight raw material, however there is still a need of control the level of uniformity in grain before technological processing.

Laboratory of Physical Bases of the Evaluation of Quality of Grain in our Institute is equipped in unique in Poland measuring set for single kernel characterization of wheat kernels (Single Kernel Characterization System-SKCS, type 4100), designed by American company Perten Instruments. SKCS appoints four basic physical properties of wheat grain: weight, diameter, hardness index and moisture of single kernels. Hardness index is one of the most important factors in evaluation of usefulness of grain in the process of bread production.

During measuring cycle 300 kernels are analyzed. According to algorithm mean values and standard deviations are being estimated, the class of hardness too. In case if sample contains kernels with wide range of hardness index, grain is classified to the MIXED group.

Procedure of particular operations related with evaluation of quality characteristics of analyzed grain proceeds as follows:

Device collects single kernels from singulator hopper, estimates their weight and diameter. After that, crushing constituent crushes kernels and measures crushing force peak and moisture of milled grain transferred between rotor and hunting crescent. During this time histograms of measured characteristics are displayed on the screen of VGA monitor. Set delivers information about form of grain based on quantity of discarded kernels according to specified values, typical for wheat grain.

After measure comes to an end kernels are classified to one of five hardness classes, depending on percentage contribution of kernels in the sample with different hardness index, according to algorithm elaborated by USDA/GIPSA. First step of analysis is to examinate if mean value of hardness index exceeds value 46(indefinite unit). Secondly results are analyzed forward with next steps of algorithm to classify sample to one of two subclasses of HARD class. Sample of grain with mean hardness index below 46 is classified by computer as one of two subclasses of SOFT class.

Results of measurement are printed in the form of report containing histograms with mean values of measured characteristics and their standard deviations. Raw data files are stored on hard disk drive of main computer unit and can be imported and taken under further analysis with statistical software.

There is possibility of estimation of density of kernel using simplified formula for volume of kernel, based on the parameters of SKCS: diameter and weight of single kernel what brings more information about utilitarian value of raw material.

SKCS gives opportunity of analysis of single kernel what makes this set very useful in monitoring of variability of characteristics within wheat ear. Distribution of estimated grain characteristics in different parts of ear may be very useful in breeding process.

Procedure of measures of crushing force peak to estimate hardness index and electric conductivity to estimate moisture may be used in phytosanitary control. Short time of operation cycle gives a possibility of analysis of large portion of raw material.

At present, initial research is leaded to evaluate degree of grain infestation by granary weevil (*Sitophilus granarious* L.).

Keywords: SKCS, wheat grain, hardness index

EFFECT OF SOIL EROSION DEGREE ON CROP PRODUCTIVITY IN LOESS AREAS OF POLAND

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In eroded loess areas of Poland crop productivity was most often determined in the hilltop-slope-valley. There are only few studies that take into consideration a direct impact of the various degree soil erosion degree. The purpose of this paper is to summarise and assess the effect of different soil thickness reduction on crop yields. The following degrees of soil erosion were considered (according to Turski et al. 1987) with respective average thickness reduction values assigned to them: 1) non-eroded soil (0 cm); 2) slightly eroded soil (-24 cm); 3) moderately eroded soil (-65 cm); 4) severely eroded soil (-97 cm); 5) very severely eroded soil (-135 cm); 6) deluvial soil (+60 cm).

The literature 8 works that were published in the yiers 1985-2004, including 1 laboratory study and 7 field ones. The works covered 33 years of field investigations (21 years of investigations carried out on different exposures and 12 years on the same one). Generally, erosion degree was assessed on the basis of attached figures of soil profiles. Only in two papers, a detailed description pedological was presented. The following crops were analyzed: wheat (both spring and winter) for a period of 15 years, spring barley for a period of 10 years, root plants (sugar beets, carrots) for a period of 5 years, maize for a period of 4 years, red clover for a period of 3 years, lucerne for a period of 2 years, spring rape for a period of 4 years as well as for oats for a period of 2 years. All yields crop were presented in relative values, assuming yield on non eroded soil as 100%.

The collected results were statistically analyzed and presented in a graphic form. Generally, analyzing field experiments, 17 % decrease in crops yield on the average corresponding to 135 cm of soil reduction was observed, whereas on colluvial soil, the crop decrease was assessed on 1% and results were characterized by a significant scatter of values. In the case of the experiments carried with the same topographic exposure, a scatter of relative yield variation was smaller and 28% decrease in crops was found at 135 cm of soil profile reduction, and an 18% decrease on colluvial soil. Results of laboratory studies (monolith samples) revealed a decrease in crops yield by approximately 12 % at 135 cm soil reduction and a crop increase by 5 % on colluvial soil.

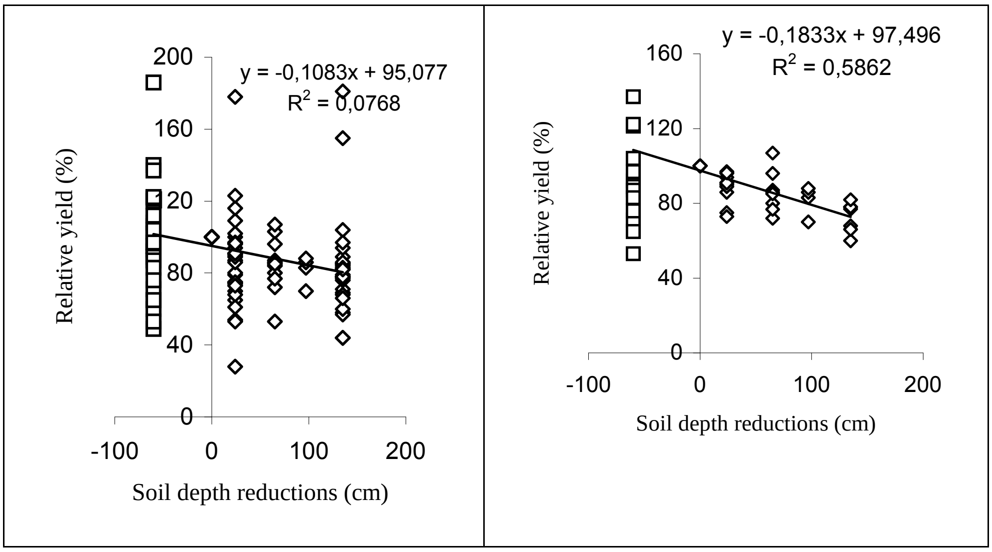

Fig. 1. Crop productivity with regard to soil erosion degree in areas with (a) different exposures and (b) the same exposure.

Results of the study showed that a location of plots at the same topographic exposure had a significant role in evaluation of the effect of soil erosion on crop productivity. Neglecting the influence of exposure, the analysis includes an addition error connected with variation of solar radiation. Within plots of the same exposure, a linear decrease of crop yield with intensification of erosion was observed with correlation coefficient (r^2) of 0.59.

INFLUENCE OF ULTRASONIC TREATMENT ON PRESSING PROCESS OF GRAPE JUICE

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Pressing process is common operation in juice technology. The raw material before pressing is subjected to preliminary treatment. In the operation different methods are used: heating, alkaline breakage, enzymatic treatment, pulsed electric field treatment, microwave heating and sonication. The goal of all the operations is to improve efficiency of pressing.

Power ultrasound can accelerate heat and mass transport in many food process operations for example: drying, mixing, filtration, crystallization, homogenization, extraction etc. Ultrasounds may enhance the degree of raw material plasmolysis and reduce viscosity of juice and this may contribute to enhance yield of pressing. But these effects are depended on frequently and acting time of ultrasounds. Therefore the aim of this study was to evaluate influence of ultrasonic treatment (for different frequencies and acting time) on yield of pressing. In addition it was tried to estimate the influence on unit energy consumption and changes in microstructure of fruit peels.

Two varieties of grapes, namely Datal and Portugalskie Niebieskie were selected for pressing. The ultrasonic treatment was conducted with the help of two ultrasonic baths. The baths worked at two different frequencies: 25 and 40 kHz. In both cases the intensity of ultrasound were 2 $W*cm^{-2}$. The exposure time varied from 0 (control sample) to 90 minutes. The mash was pressed in the basket press integrated with an Instron Universal Testing Machine. The yield of pressing was calculated from equation:

$$Y_w = \frac{m_s}{m_m} *100 \ [\%]$$

where: m_s – mass of juice [kg], m_m – mass of mash [kg].
The unit energy consumption was calculated from equation:

$$N = \frac{E}{m} \quad [J/kg]$$

where: E – energy consumption [J], m_m – mass of mash [kg]

The pictures of fruit peels microstructure were taken by reflecting microscope. The results showed that sonication mash increases the yield of pressing, and this increase depends on frequency and acting time of ultrasounds. There was no influence sonication mash on unit energy consumption.

NITROGEN TRANSFORMATION IN AN ORGANIC SOIL IRRIGATED WITH MUNICIPAL WASTE-WATER

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Water and air are particularly responsible for migration of chemicals through different compartments of the environment. Clean water is essential for everyday life. Over last decade, biofiters have become popular system uses for cleaning of municipal wastewater. Biofilter medium usually consists of soil, peat, compost or combinations of those substances. As the wastewater pass through a biofilter, pollutants are removed by a combination of physical, chemical and biological processes.

The aim of the present work was to check the applicability of the redox potential to estimate a degree of changes in mineral forms of nitrogen in soils irrigated with communal wastewaters and estimation of a possibility of using organic soil and different plants for wastewater cleaning.

Experiments were carried out in Bystrzyca river valley in the area of about 8 ha, divided into 7 equal plots. The area of two plots was covered with willow (*Salix Americana*) (1) and grass (2). Every plot was divided into 3 subplots (a- control, b- with an optimal irrigation dose for the plant, c- with a double optimal dose). To evaluate ammonia, nitrates (III) and (V) nitrogen concentrations in soil solutions, ceramic drains for soil water sampling were installed at a depth of 10, 30, 50, 70 and 100cm on each subplot. Redox potential (Eh) at the above depths was measured with platinum electrodes.

The results showed marked effects of wastewater irrigation on the concentration of mineral forms of nitrogen in soil solution taken from various depths (10, 30, 50, 70, 100 cm) of the soil profile, as well as on the soil redox potential. Limiting values of selected contamination indexes and of soil aeration status were established. Significant relationships were shown between the redox potential and nitrogen transformations occurring in soil. The soil was proved to behave as a biological filter for the introduced contaminants.

The best aeration conditions were observed in the upper soil layer (Eh>350mV, development of nitrifiers); below the depth of 50 cm the lower redox potential permitted for the development of denitrifiers; at the depth of 100 cm the potential reached negative values, characteristic for methanogenesis and the formation of sulfides.

A negative effect of wastewaters on the redox potential was observed, especially in the case of double dosage, which lowered the redox potential below the value of +200 mV, corresponding to dissimilatory reduction of nitrates (V) to the forms of N_2O and N_2.

Beginning with the second year of irrigation, a distinct decrease of the redox potential (the soil began losing its buffering properties) occurred, being probably due to subsequent flooding-drying cycles and to a decrease in microbial activity. The decrease in the concentration of nitrates (V) in drainage waters suggested an intensification of the N- NO_3^- denitrification process in the object under study.

Nitrogen concentration in drainage waters increased with increasing wastewaters dose.

Higher concentration of N-NO_3^- and lower concentration of N-NH_4^+ were observed in the spring season (intensification of the process of nitrification). Therefore, in spring, the dosage of wastewater should be limited to prevent nitrates (V) against entering groundwaters.

In terms of suitability for N- NH_4^+ wastewaters purification, plants can be arranged in the following order: grasses, willow, and rape; in the case of the N-NO_3^- ion concentration, the corresponding plant order will be as follows: grasses, rape, and willow.

The distribution of nitrates (III) concentration, both in the soil profile and in the drainage waters was similar to that of the concentration of nitrates (V).

In each of the cases under discussion, the concentration of N- NO_3^- in the drainage waters did not exceed 15 g $N\cdot m^{-3}$, which meets the requirements of the European Union.

Application of wastewater in single irrigation dose may constitute a valuable source of nitrogen in the cultivation of plants for industrial purposes.

INFLUENCE OF TEMPERATURE AND HEATING DURATION ON WOOD MICROHARDNESS

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Mechanical properties of wood depend on different factors, especially on its temperature and moisture content. In the case of the influence of temperature is important not only the value of temperature, but also the influence time of this temperature on the wood sample.

This paper shows the influence of raised temperature (95°C) on the mechanical properties of four central european wood species – Norway spruce, Scotch pine, poplar and lime. Furthermore it is also shown the influence of heating duration at the constant temperature 95°C. The heating periods for all wood samples were 1, 7 and 21 days.

Modified penetration test method for every tests was used on the radial surface of the wood samples by the steel cylindrical indentor penetrated into the 3 mm of depth with the constant penetration speed 1 $mm.min^{-1}$.

ESTIMATION OF SOIL HYDROPHYSICAL CHARACTERISTICS

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Water retention curve and water conductivity coefficient in saturated and unsaturated zones are the most important hydrophysical soil characteristics. They have a huge effect on conditions of plants growth and development. The knowledge of the soil water hydrophysical characteristics is necessary for studying water availability for plants, plant water stress, infiltration, drainage, melioration, water and solutes movement in the soil. The spatial distribution of water characteristics in the soil is also an important factor in the investigations of plant cover and hydrological changes caused by climate change [1].

The water retention curve (pF curve) is a relationship between soil water potential and soil water content. The soil water retention curve can be determined by using the following measurement methods: the tension plate assembly for achieving equilibrium between a soil sample with a known matric suction and the pressure plate apparatus for moisture characteristics measurement in the low and high-suction range (Richards chambers) [2].

Water conductivity coefficient can be measured using direct or indirect methods. The saturated hydraulic conductivity is measured by means of a device produced by Eijkelkamp-Agricultural Equipment, which is used as a standard [3]. To determinate the unsaturated hydraulic conductivity the following methods can be used: the Gardner's method, the infiltration methods, the Wind's method, constant evaporation method and instantaneous profile method (IPM) [3].

The determination of the soil water characteristics is time and labour consuming and it requires the use of the expensive specialist equipment. These were the reasons, that the intensive work has been done for over twenty years on creation of algorithms - models, which enable to determine the soil water characteristics on the base of other soil physical properties, routinely measured in laboratories. Most of them, called pedo-transfer functions, are the function to characterize these types of mostly empirical models (statistical models), which transform soil texture and other basic soil properties into soil hydraulic curves (Bouma 1989) [4].

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EFFECT OF VERTICAL STRESS ON PRESSURE RATIO OF GRAIN

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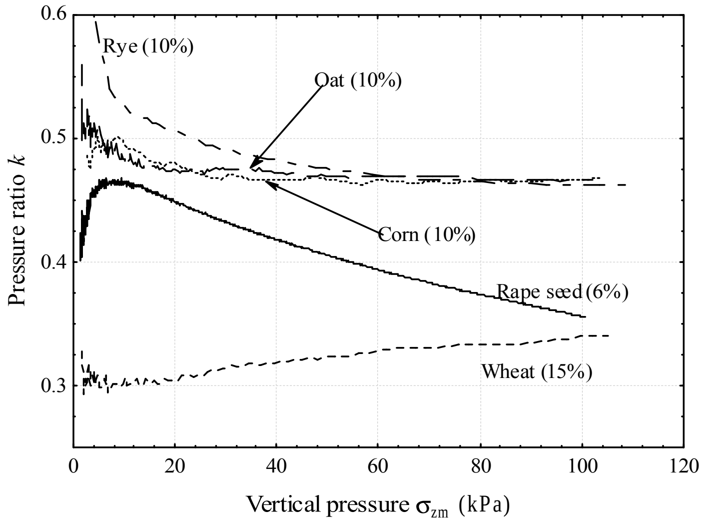
The ratio of horizontal to vertical pressure at any point in a granular material is defined as the pressure ratio *k* and was introduced by Janssen in 1895. This is one of the basic parameters required for calculation of stresses that a material exerts on the walls and floor of the silo. The pressure ratio *k* depends not only on type of grain, moisture content and bedding structure of the material formed during the filling process but also on level of vertical pressure. Usually pressure ratio is determined in a model silo or a tester, hardly ever in practical conditions of silo operation, when the level of vertical pressure is much higher. Reported project concerns effects of level of the vertical pressure on the pressure ratio *k* during cycles of loading of the bedding of granular material. The pressure ratio of cereal grain was determined in the uniaxial compression test according to the Eurocode 1 recommendations. Experimental results obtained in the uniaxial compression test were compared with results obtained in the model silo. Preliminary experiments were performed for samples of grain of different size and shape and typical storage moisture content. Extended range of moisture content was applied for tests performed for cereal grain (10-20%) (rye - variety Amilo, corn - variety Mieszko, wheat - variety Begra, oat - variety Borowiecki) and rape seeds variety Licosmos and Lirajet (6-15%).



The pressure ratio obtained in the uniaxial compression tests was found decreasing with the vertical pressure increase. The strongest decrease was obtained in the range of 0-20 kPa of the vertical pressure, followed be the stable value of the pressure ratio (0.48 – corn, oats and rye). Another course of changes were obtained for rape seeds: the maximum of the pressure ratio was obtained in the range of 0-10 kPa of the vertical pressure, followed by the continuous decrease (0.35).

Experimental values of the pressure ratio obtained in the uniaxial compression tests and in the model silo were similar only in range of 0-10 kPa of the vertical consolidation pressure. This confirms opinion that the range of the vertical pressure during the test should correspond to the pressure range in the full size silo.

METHODS OF PARTICLE SIZE MEASUREMENT

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People, who have never dealt with particle size measurement, can wonder why the knowledge of particle size is so important. All the surrounding nature is built from particles, which sizes decide about different features particular substances. The stability, chemical reactivity, opacity and material strength of many materials are affected by the size and characteristics of the particles within them [3].

In food industry the taste and feel of chocolate, the dissolution rates of milk and coffee and the viscosity of emulsions are all influenced by particle size. In environmental applications, particle size determines many aspects of strength and stability of soil, and properties related to transport and retention of water, heat and nutrients. In agrochemical industry, droplet size of pesticide sprays is very important. Droplets that are too large only moisten the top of the leaves and run off quickly. Droplets that are too small will drift into neighboring fields, creating a health hazard [2].

The suitable methods for measuring particle size were sought for many years. Nowadays, about 400 methods are known for measuring particle size distribution [7], but the easiest and the most popular method for size analysis is sieving [1]. It is important to be aware that each particle size characterization technique measures a different property of a particle (maximum length, minimum length, volume, surface area)[4].

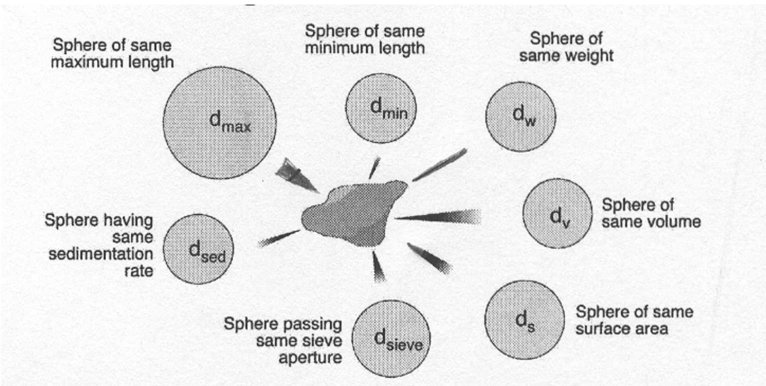

Fig.1. Different particle size measures for the same grain of sand [4]

If identical particles are measured by different techniques, they may appear to have a different diameters [6]. Methods, used for measuring particle size distribution, such as: sieving, pipette, sedimentation, microscopy and laser diffraction methods are based on different principles and assumptions, and use different approximations. Results from these methods cannot be directly compared. All the above mentioned methods are imperfect and time consuming. An alternative for measuring the particle size is the laser diffraction method.

The Institute of Agrophysics PAS disposes Malvern Mastersizer 2000, which measures particle size in a large range: 0.02–2000 μm (in liquid or air dispersion) on the base of laser diffraction method. The angle at which the light is scattered by a particle is inversely proportional to the size of the particle. The theory of Mie which describes an interaction between laser light and particles, is used to convert data from laser light diffraction to particle size distribution. We measured size of mineral and organic particles (for example: soil[5], starch, emulsions, pigments, sediments, dusts, gypsum, ceramics and food industry products).

Laser diffraction method has many advantages: short time of analysis, small sample required for measurement, analysis is independent of the particles density and results are presented at a continuous particle size distribution curves.

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SUSCEPTIBILITY TO MECHANICAL DAMAGE OF POTATOES CULTIVATED IN DIFFERENT ENVIRONMENTAL CONDITIONS

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Seven potato varieties were cultivated in 12 localities that can be classified into two characteristic regions: i) classical higher land region (cooler and more humid) and ii) lower land region (warmer and drier) in the years 1995-1997. Susceptibility to mechanical damage of the harvested tubers was studied extensively using the pendulum MIDAS 88 PP. The obtained parameter, so called “Pendulum index” (PI), represents percent part of the tubers not damaged in the test.

The obtained results show that season, region and variety significantly influence the pendulum index. PI of the tubers produced in the lower land region was significantly higher (~74 %) in comparison to the higher land region (~61 %). The season played the main role in the obtained PI-values: 87 % (1995), 53 % (1996) and 64 % (1997).

The analysis of weather conditions shows that tuber susceptibility to mechanical damage is reduced by slightly higher than normal rainfall during the entire growing period. This relation becomes even more evident with rainfall at the end of the vegetation period (total rainfall in August and September of about 150 mm) and, at the same time, under slightly higher than normal temperature at the end of vegetation period. In the drier weather of August and September, the PI grew with the increasing rainfall, and, on the contrary, in wet weather in the same period, PI dropped with increasing rainfall. The susceptibility to mechanical damage was increased mostly by a high level of rainfall, and, concurrently, by cold weather at the end of the vegetation period. Those two factors influenced negatively tuber maturity level. Neither did extremely dry weather have a positive influence. Weather variations and extremes have to lead to increasing potato damage.

The significantly higher PI was observed for medium-early varieties Korela, Rosella and Santé in comparison with early varieties Karin, Agria and very early variety Impala.

Keywords: potatoes, mechanical damage, pendulum index, locality, season

EFFECT OF LAND USE ON LEACHING OF ATRAZINE

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Because of low costs and ease of application atrazine (2-chloro-4-ethylamino-6-isopropylamino-1,2,3-triazine) is one of the most widely used pesticide in the world. It is used as selective pre- and post-emergent agent to control annual grasses and broad-leaved weeds in selected vegetable and cereal crops, vines, fruit orchards, citrus groves, sugar cane, grassland, and forestry. Its world consumption is estimated to be between 70,000 and 90,000 tons applied per year. Atrazine is applied in early spring when soils are at field capacity, because it is most effective in wet soils. Compared to other frequently used herbicides atrazine has a greater mobility in soil, is relatively persistent in soil and in aquatic environment may persist for many years.

Very small percentage of the amount applied herbicide coming in direct contact with target pests. The fate of atrazine in the soil environment depends on several mechanisms, which promote reduction of herbicide concentrations in soil. They include: sorption or binding by organic and mineral soil components, uptake by plants, transport via runoff and leaching into surface water or groundwater, biodegradation by soil microorganisms, photodegradation, volatilization into the air and chemical degradation (e.g. hydrolysis). The amount and persistence of atrazine bond to soil particles depend on soil type and structure, pH, organic matter content and clay content.

Herbicide pollution of groundwater is mainly caused by leaching. Soil tillage and land use change the physical and hydraulic properties at the soil and consequently amounts of water and chemicals (in the solution) moving through the soil profile. Continuous no-tillage management practice causes improvement of soil structure and amount of macropores (cracks and biopores such as earthworm burrows or root channels) increases. However tillage system disrupts continuity of macropores. Macropores may act as preferential flow paths for rapid movement of water and herbicides contained in it.

Atrazine has harmful impact on environment including human health (as potential human carcinogen). For European Community the maximal allowable concentration atrazine in water supply is 100 ng/L.

The aim of our investigation was to examine leaching of atrazine under four tillage systems, namely: conventional tillage, reduced tillage, 15 years orchard and 35 years orchard. Laboratory studies were carried out on undisturbed soil cores (20 cm in diameter and 20 cm in height) from the upper soil layer. Three replicates were collected from each type of land use. The soil is silty loam (Orthic Luvisol) from Felin, Poland. All cores were saturated with water in order to obtain field water capacity before atrazine application and then 28.5 mg atrazine suspensed in 6.5 ml of destillated water was uniformly surface-applied onto each core. 48 h later all cores were subjected to spray irrigation at an amount of 1100 ml destillated water per each core in 100 ml doses. Leachate in 50 ml increments was collected until 650 ml cumulative amount of leachate was received from each core. The time of each increment was recorded. 1 ml sample of leachate from each increment was analyzed for atrazine by means of liquid chromatography Waters with detector UW-VIS.

Amount of atrazine recovery in cumulative leachate amounts to 1.78% of atrazine applied for conventional tillage and 1.40%, 1.27%, 1.0% for reduced tillage, 35 years and 15 years orchards, respectively. The lowest rate of leaching was recorded in conventional tillage (it takes 722 min to obtain 650 ml of leachate) compared to other type of land use (150 min, 101 min and 67 min for reduced tillage, 35 years and 15 years orchards, respectively).

PARTICLE DISTRIBUTION, COMPRESSIBILITY AND FLOWABILITY OF WHEAT MEAL

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Knowledge of mechanical properties of food powders is essential for design of industrial equipment, efficient and reliable material processing as well as for assessment of quality of raw material. The flowability of powders and their shear behaviour under pressure are important in handling and processing operations such as: storage in hoppers and silos, transportation, mixing, compaction and packaging.

The objective of reported work was determination of influence of size distribution of wheat meal on its flowability. Tests were performed in 60mm in diameter shear tester in a low range of consolidation stress varying from σ_r=4 kPa to σ_r =10kPa, for speed of shearing V=2 mm·min^{-1}. Procedure recommended by Eurocode 1 was applied.

Six materials were tested of different particle size distributions. Samples were produced by adding 0, 5, 10, 15, 20 and 25% of fine fraction of wheat meal (dimensions from 0.1–0.2 mm) to initial material.

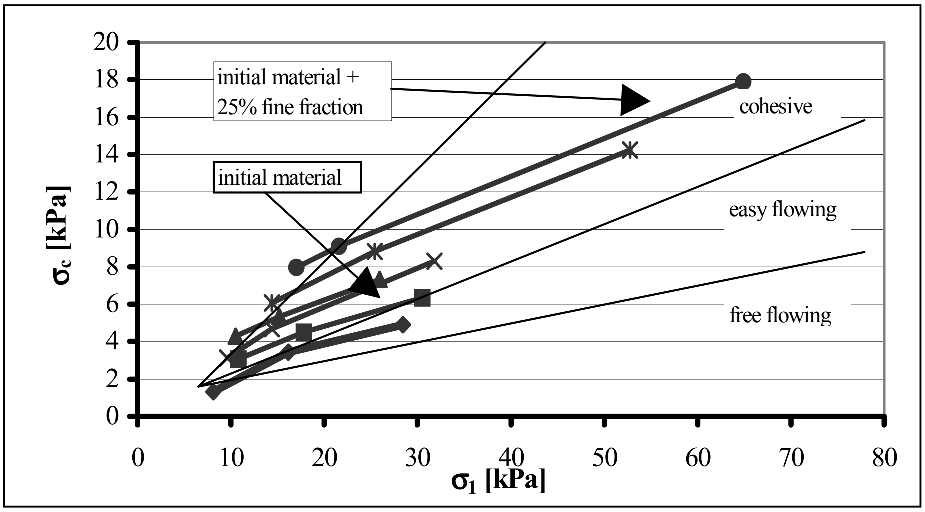

Fig. 1. Flow functions of experimental materials

Values of flow functions, *FF*, of all materials took values characteristic for easy flowing and cohesive materials. Highest values of *FF* characteristic for cohesive materials, were obtained for sample with 25% addition of fine fraction of wheat meal. Lowest values of *FF* (characteristic for easy flowing materials) were obtained for initial material with no addition of fine fraction (Fig.1). Differences in compressibility of samples of different particle size distributions were observed. Maximum values of strain ε_z for vertical stress σ_z=10kPa were obtained for initial material, while minimum ε_z was found for material with 25% of addition of fine fraction.

DISCRETE ELEMENT METHOD IN GRANULAR MATERIALS

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Understanding of behaviour of granular assemblies is nowadays in vital interest of industrial practice. Numerous industrial and agricultural processes involve granular media. They are essential materials in chemical, food and pharmaceutical industries. Behaviour of materials may be examined experimentally but these methods are often too expensive or time-consuming to be applied. Sometimes easier solution is using the simulation methods to examine phenomena occurring in granular systems. One of promising numerical techniques- Distinct Element Method (DEM) is based on Newton's second low. The method developed by Cundall and Strack [1] describes behaviour of granular system as a effect of equilibrium of individual granules.

Distributions of velocity and force was analized for 500 spheres of 1mm in diameter filling Jenike's shear box (50mm×40mm) (Fig 1). 2D simulations were performed using C.R.Wassgren's [2] software. Contacts between particles were described by Cundall- Strack contact model, i.e. the normal contact model consisted of spring linear and damping element whilst spring linear and sliding element constituted tangential interaction.

It was observed that displacement of lower box of Jenike's tester caused changes in distribution of particles' velocities. The largest increase in velocity was found around the border between upper and lower part of shear box (Fig 2).

Searching for set of simulation parameters ensuring stability of the system turned out to be the most essential and time-consuming problem.

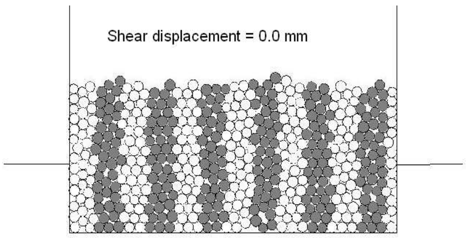

Fig 1. Jenike's shear box.

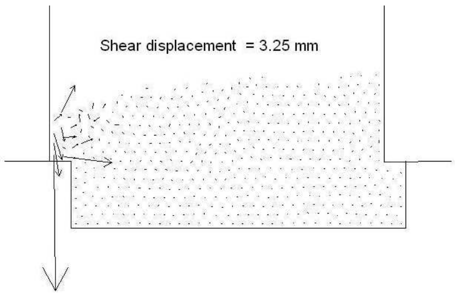

Fig 2. Distribution of velocity.

The analysis of contact force distribution showed that the largest forces occurred in lower box almost during whole simulation (Fig 3A). Directly before failure marked increase in contact forces near the left side wall of the upper part of shear box was observed (Fig 3B).

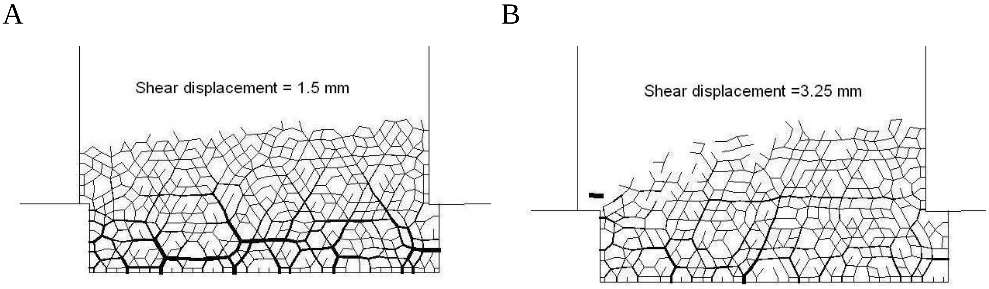

Fig 3. Distribution of contact force: A- at shear displacement 1.5 mm and B- at shear displacement 3.25 mm.

Results of our simulation showed close agreement with earlier results reported by Sakaguchi and Favier [3].

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VARIATION OF INITIAL DENITRIFICATION IN POLISH MINERAL SOILS

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Denitrification is the main source of nitrous oxide (N_2O) emission, which is one of the dangerous greenhouse gases, which can also destroy ozone layer. Further, production of N_2O and N_2 from nitrate fertilizers causes losses of nitrogen in the soil.

Agricultural soils are considered the most important anthropogenic source of N_2O. Denitrification process can occur in the soil when oxygen availability is limited, then nitrate is used like alternative electron acceptors in microbial respiration process.

Decrease of oxygen content resulted in falls of Eh potential. When Eh potential drops to the value of 400 mV it is possible that process of denitrification is active and nitrate are changed into N_2O and N_2. This soil feature reflecting it's redox buffering capacity. Time t_{400} is defined as a time during which the soil redox potential under flood conditions, at a definite temperature, drops to the values of 400 mV- coresponding to the nitrate decomposition.

We examined 59 soils from Bank of Mineral Soils. Time t_{400} for almost all of investigated soils was below 2 days. It means that denitrification process can start between 0- 2 days after flooding. We want to measure the initial stages of denitrification to define how many N_2O is produced at the beginning of this process.

The 10 g portions of air-dried soil were placed in 38 ml glass jars, and then 10 ml of deionized water with NO_3^- solution was added. The soils were incubated anaerobically (N_2 atmosphere with 2% C_2H_2) at 20°C for 2 days. Nitrous oxide evolution was measured with gas chromatography.

Figure 1 shows the production N_2O in all type of soils. Nitrous oxide amount was more than twice higher in the second day then in the first one. The hihest N2O emission was observed in black earth, in the rest type of soil denitrification process was comparable.

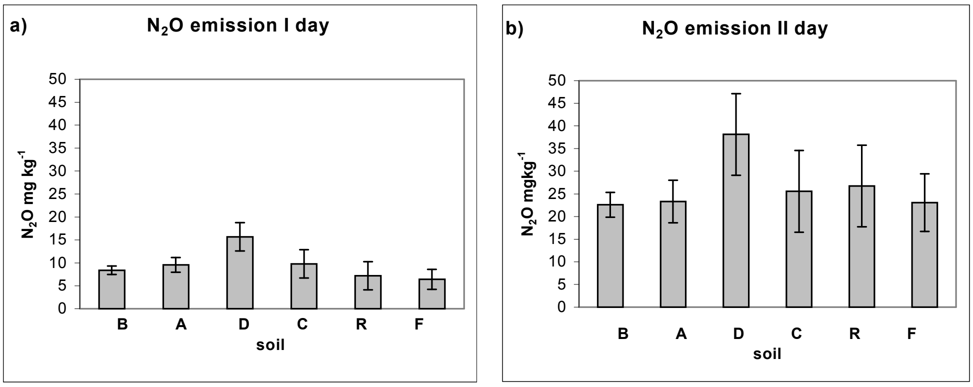

Fig. 1.. Level of nitrous oxide emission from investigated soils after first (a) and second (b) day (B- brown soil, A- podzolic soil, D- black earth, C- chernozem, R- rendzina, F- alluvial soil)

RESPONSES OF SOYBEAN PLANTS TO NICKEL SULPHATE AND UV-B RADIATION

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The effect and possible interaction of two stresses, UV-B radiation and nickel ions, applied simultaneously, was investigated in the plants of soybean cv. Augusto. The plants were grown in greenhouse (average PPFD 600 µmol·m^{2}·s^{-1}) from 6th May to 14th July 2004. One group of plants (H_{UV}) was subjected to high intensity of UV-B radiation (biologically effective daily dose was 4.8 kJ·m^{-2}·d^{-1}), and the second group (L_{UV}) – to 25% of this dose. Each group of the plants was divided on three subgroups with different concentration of nickel sulphate, what correspond to 0, 8 and 40 mg Ni/kg dry mass of soil, respectively. After ten weeks the plants were harvested and measurements of dry mass of shoots and roots, intensity of CO_2 assimilation and H_2O transpiration, content of flavonoids in the leaves were done in 5 – 15 replications.

Table 1. The effect of UV-B radiation and nickel ions on the measured features of the plants

Measured feature	Low UV-B (L_{UV})			High UV-B (H_{UV})		
	Concentration [mg Ni/kg d.m. of soil]			Concentration [mg Ni/kg d.m. of soil]		
	0	8	40	0	8	40
Dry mass of shoots [g]	2.90	3.14	3.31	2.92	3.10	3.21
Dry mass of roots [g]	1.49	1.22	0.97	0.99	0.95	0.88
Flavonoid content [A_{305}·g^{-1}]	110^{d}	167^{e}	216^{a}	225^{ab}	317^{c}	271^{bc}
CO_2 assimilation [µmol·m^{-2}·s^{-1}]	5.44^{d}	4.85^{cd}	2.85^{ab}	4.16^{bcd}	3.24^{abc}	1.88^{a}
H_2O transpiration intensity [mmol·m^{-2}·s^{-1}]	0.67^{b}	0.63^{b}	0.33^{a}	0.33^{a}	0.29^{a}	0.23^{a}

a, b, c, d – averages marked by the same letter (in the row) do not differ significantly (p<0.05).

The obtained results indicate both nickel ions and UV-B radiation effected on the measured features. Dry mass of H_{UV} plants was lower than L_{UV} ones (Table 1). The plants grown in soil with nickel had higher dry mass of shoot and lower mass of roots compared to those without nickel. Both stress factors had a disadvantageous influence on the intensity of CO_2 assimilation and H_2O transpiration of the leaves. As expected the content of flavonoids in the H_{UV} plants was higher than in the L_{UV} ones. It was found that this value increased as the concentration of nickel increased.

Keywords: flavonoids, *Glycine max* (L.), nickel sulphate, UV-B radiation

APPLICATION OF MODIFIED ATMOSPHERE IN STORAGE SEEDS

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Nowadays consumers demand for more natural and high quality products. The supplying high quality products can be achieved by using an appropriate harvest technology and, most of all, the suitable technology of storage. A major cause of stored products degradation and deterioration are insect pest and microorganisms. Many studies have shown that modified atmosphere of elevated carbon dioxide and depleted oxygen is effective method against insect and microorganisms attacks seeds in storage. Modified atmosphere storage is one of the seeds, food preservation methods that maintains the natural quality of food products in addition to extending the storage life. Modified atmosphere (MA) reduces the respiration rate of seeds and activity of insects or microorganisms in seeds. The MA can be achieved in several ways: (i) by adding gaseous or solid CO_2, (ii) by adding a gas of low O_2 content or (iii) by allowing metabolic processes within an airtight storage to remove O_2, usually with associated release of CO_2 (Jayas el. al. 2002).

The most important component in MA is carbon dioxide which is a non-flame, colorless, odorless gas, about 1,5 times as heavy as air. Carbon dioxide can be supply from an external source to a silo using either gas producer from a liquid supplied in pressurized cylinders or from solid “dry ice”. Solid “dry ice” is useful source of CO_2 because changes directly form solid to a gas. Its can be supplied as blocks, crushed ice or pellets. Block are useful to make up gas loss during treatment due to their slower release. Crushed ice or pellets rapidly change to a gas and are best for initial gas addition (Graver 2004). Jayas et al. (2002) reported that there are some different methods of introducing CO_2 as “dry ice” in the seeds mass in silo: (i) introducing of dry ice under the perforate floor or in the perforated duct, (ii) introducing of dry ice on the top surface of the seeds covered with a carbon dioxide impermeable sheet, (iii) introduction of equal amounts of dry ice on the top surface under the sheet and in the perforated duct, (iv) introducing of dry ice through a 10cm – diameter perforated tube installed vertically in the center of the seeds bulk, (v) introduction of one-quarter of the dry ice on the top surface under the sheet and the remaining three-quarter in an insulated box placed under the sheet. The fourth method gave the most uniform CO_2 concentration in the seeds mass and used the least amount of carbon dioxide to maintain the desired CO_2 concentration. However installation of

10cm – diameter perforated tube would be very difficult, therefore the last method was recommended for practical use (Alagusundaram et al. 1995a).

The effectiveness of modified atmosphere for controlling various stored-products pests depends on the temperature and moisture content of the seeds, species and life storage of pests, gaseous composition, uniformity of gas distribution and exposure time of the MA treatment (Łukasiewicz et. al. 1999).

There are many research involving prediction of insects and microorganisms in storage seeds, e.g. Bera et. al. (2004) reported that complete control of Rhyzopertha dominica and Corcyra cephalonica in storage seeds was achieved with 20% concentration of CO_2. The 5 and 10% CO_2 concentration also reduced the insect population growth and seeds damage as compared to ambient storage. This researches also have shown no adverse effect on germinability and vigour of seeds. There was no change in the dehydrogenase activity and malondialdehyde as well.

MA storage preservation microorganisms, pest and mould growth preserves seeds quality and maintains high level of germination in the storage seeds. In spite of these benefits, major limitation appears to be the high initial cost of airtight storage structures and sealing the exiting structures to the desired airtightness (Jayas et. al. 2002). Research in these fields is reviewed and should be continuous in future investigation.

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OPEN-ENDED COAX METHOD FOR DETERMINATION OF DIELECTRIC PERMITIVITTY OF POROUS MATERIALS

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Real-time and non-invasive monitoring of physical and chemical properties of agrophysical objects, i.e. food products and agricultural materials, as well as the environment of their growth, storage and transportation is necessary to improve quality as well as quantity of agricultural production and to minimize the loss. The development of technology in the recent years has increased the number of methods and decreased the price of monitoring tools for application in Agriculture. Data transmission facilities, accurate and battery operated converters of physical and chemical properties into electrical signals and measurements in high frequency range are a few examples of the observed progress.

The important parameter for soil monitoring is its water content because water directly influences the other physical and chemical parameters of soil as a porous body. The indirect measurement of moisture using its dielectrical properties seems to be the right direction for the researchers.

The objectives of the study are:

a) description of the main features of two methods of determination of ε^*: Open-Ended Coax Probe and a three-rod Time Domain Reflectometry (TDR) methods,
b) comparison of real and imaginary parts of ε^* determined from the measurement of three mineral soils using the discussed measurement methods,
c) discussion of the hardware differences of the meters working in the frequency domain (Open-Ended Coax Probe) and time domain (TDR).
d) long term objective is to design and build a prototype of a portable and not expensive meter for the measurement of ε^* of porous materials working in the frequency domain.

The presented methods of the determination of the complex dielectric permittivity of materials are applications of dielectric spectroscopy, the branch of science aimed to identify relationships between dielectric properties of materials and their important quality characteristics and to develop scientific principles for measuring these characteristics through interaction of radio frequency and microwave electromagnetic fields with the agricultural materials and products.

Dielectric spectroscopy has some advantages over other physicochemical measurements: sample preparation is relatively simple, varieties of sample size and shapes can be measured, measurement conditions can be varied under a wide range of temperatures, humidity, pressure, etc., the technique is extremely broad band (mHz - GHz) thus enabling the investigation of diverse processes, over wide ranges of time and scale. Moreover the construction of a not expensive and reliable meter working in the frequency range adjusted to the material under study can be a significant step towards the standardization of the measurement of the dielectric properties of agricultural materials and products.

The measurements were performed using a TDR system working with the 20 ps rise-time step pulse and a Vector Network Analyzer (VNA) operating in the frequency range from 20 kHz to 8 GHz. The sensors were calibrated on liquids of known dielectrical properties and were used to measure the complex permittivity of three types of soil at various moistures. The real part of the complex permittivity calculated from S_{11} parameters measured by VNA for frequencies near 1 GHz is in agreement with the values measured by TDR method using three-rod probes. The values of the imaginary part of the complex permittivity of the soil samples measured by the applied probes show also good correlation. The comparison of the hardware differences between the systems for the measurement of the complex permittivity of porous materials working in time and frequency domains is also discussed.

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