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I AGRICULTURAL ENGINEERING

The environmental noise level in the rejuvenation pruning on centuries-old olive tree

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Abstract. In the Italian agricultural economy, olive cultivation plays a fundamental role, and this is especially true for the southern regions where almost all cultivation is spread. In Calabria, in particular, olive cultivation has seen over the last few decades significantly improve the quality of production also as a result of investments aimed at the creation of new mechanizable plants and/or the modernization of existing ones; today some areas have got both PDO and PGI certification. In the "Piana di Gioia Tauro", located north-west of the Reggio Calabria metropolitan area, olive growing extends over 20,000 hectares and the presence of centuries-old olive tree is still widespread. The olive varieties mainly belong to the local cultivars of 'Sinopolese' and 'Ottobratica', characterized by a remarkable rusticity and high development, perhaps unique in the world; they reach 20-25 meters high, forming what is called a 'forest of olive trees'. The pruning operations are carried out by means of chainsaws of different power and size whereby, in addition to the previously described difficulties, operators are exposed to prolonged periods of noise levels. The purpose of this study is precisely to assess the exposure of operators to this particular olive grove. The aim is to identify the acoustic levels generated by the two pruning and cross-cutting activities, the risk thresholds and the exposure to which the individual workers of the two work sites are subjected, giving indications on the appropriate safety distances to maintain (according to current regulations) compared to noise sources.

Key words: Mechanized pruning, chainsaw, safety, dB, phonometer.

Special tractor driving wheels with two modification of spikes inclination angle

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Abstract. The paper presents a research on an improvement of tractor drawbar properties using special driving wheels. Two modifications of the special driving wheels were designed and tested under field conditions. The results were compared with standard tyres. The special driving wheels consists of the tyres with a modified tyre-tread pattern and equips with the spike segments. The special driving wheels allow to activate or deactivate the spike segments to improve a drawbar pull at worse adhesive conditions of the ground or transport on roads with standard tyres. The first modification activates all 8 spike segments at spike inclination angle 90° and the second one 4 at angle 90° and 4 at 30°. The measurements were realised in October 2017 in an area of the Slovak Agricultural Museum in Nitra. The drawbar properties of the special driving wheels were evaluated based on drawbar pull of the test tractor Mini 070 type connected with a load tractor MT8-065 type. Using the test tractor in 1st and 2nd gear, the measurements were realized at 100% wheels slip and repeated 4 times. The results show the statistically significant differences in the drawbar pull of the test tractor with different driving wheels on a grass plot. The highest increase in drawbar pull reached the value 25.56% (2nd gear) and 19.98% (1st gear) in case of the special driving wheels with 4 spike segments at 90° and 4 at 30°. In case of the special driving wheels with 8 spike segments at 90°, increase in the drawbar pull reached the value 10.09% (1st gear) and 15.21% (2nd gear) in comparison with the standard tyres.

Key words: tyres, drawbar pull, force sensor, wheels slip.

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The efficiency of nitrogen fertilizer on the dry matter yield of tall fescue and festulolium grown as feedstock for combustion

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Abstract. Grass biomass grows during one vegetation season and can be cultivated and consumed at the place of breeding. Grass biomass can be used not only in traditional feed, but, recently, also for energy production (biogas, solid fuels). The most important economic indicator for any crop is its productivity. The study found that it is important to use nitrogen fertilizer to increase the productivity of tall fescue and festulolium. A significant increase ($p < 0.05$) in the yield of tall fescue was observed starting from the nitrogen norm of $60 \text{ kg ha}^{-1} \text{ N}$. Further increase in nitrogen fertilizer norm provides a significant increase in dry matter yield of tall fescue (reaching 8.64 t ha^{-1}) and festulolium (reaching 8.11 t ha^{-1}) at $180 \text{ kg ha}^{-1} \text{ N}$. The analysis of linear regression coefficients of polynomials showed that the highest nitrogen efficiency in the first year of the use of tall fescue was achieved at the norm of $180 \text{ kg ha}^{-1} \text{ N}$, but for festulolium – at the norm of $120 \text{ kg ha}^{-1} \text{ N}$. In the following years of tall fescue use, the highest efficiency of nitrogen norms differed: in the 2nd and 4th year of use – at $60 \text{ kg ha}^{-1} \text{ N}$, in the 3rd year of use – at $30 \text{ kg ha}^{-1} \text{ N}$, and in the 5th year of use – at $120 \text{ kg ha}^{-1} \text{ N}$. In contrast, for festulolium, in the 2nd year of use, the highest nitrogen efficiency was reached at the norm of $30 \text{ kg ha}^{-1} \text{ N}$, and in the 3rd–5th year of use – at the norm of $60 \text{ kg ha}^{-1} \text{ N}$.

Key words: Tall fescue, festulolium, nitrogen fertilizer, dry matter yield, solid fuels.

Effects of selected process parameters on the compaction of carob powder

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Abstract. The effects of important process parameters on mechanical response during the densification of an industrial food powder were investigated and important phenomena described using the power rule. The factors studied had highly significant effects on mechanical response. The effects of the models in predicting the behaviour of the system were also highly significant. The findings are of relevance to processing and handling of food powders.

Key words: applied pressure, strain, deformation, compressibility, bulk density.

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Review: Soil compaction and controlled traffic farming in arable and grass cropping systems

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Abstract. There is both circumstantial and direct evidence which demonstrates the significant productivity and sustainability benefits associated with adoption of controlled traffic farming (CTF). These benefits may be fully realised when CTF is jointly practiced with no-tillage and assisted by the range of precision agriculture (PA) technologies available. Important contributing factors are those associated with improved trafficability and timeliness of field operations. Adoption of CTF is therefore encouraged as a technically and economically viable option to improve productivity and resource-use efficiency in arable and grass cropping systems. Studies on the economics of CTF consistently show that it is a profitable technological innovation for both grassland and arable land-use. Despite these benefits, global adoption of CTF is still relatively low, with the exception of Australia where approximately 30% of the grain production systems are managed under CTF. The main barriers for adoption of CTF have been equipment incompatibilities and the need to modify machinery to suit a specific system design, often at the own farmers' risk of loss of product warranty. Other barriers include reliance on contracting operations, land tenure systems, and road transport regulations. However, some of the barriers to adoption can be overcome with forward planning when conversion to CTF is built into the machinery replacement programme, and organisations such as ACTFA in Australia and CTF Europe Ltd. in Central and Northern Europe have developed suitable schemes to assist farmers in such a process.

Key words: Axle load, Fertiliser use efficiency, Greenhouse gas emissions, Non-controlled traffic, No-tillage cropping, Traffic intensity.

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Finding Least Fragmented Holdings with Factor Analysis and a New Methodology: A Case Study of Kargılı Land Consolidation Project from Turkey

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Abstract. Land fragmentation (LF) is a problem restrain agricultural activities and decrease mechanization level, production. Land consolidation (LC) projects are done in the World as well as Turkey to solve LF issues. Researchers created indicators to measure land fragmentation which is important to see success level of LC projects. The use of these indicators is controversial or not accurate. The core aim of the present study is to find new land fragmentation index and to find least fragmented holding with factor analysis using the other indicators which are Simmons, Januszevski, number of parcels, Shmook and Igbozurike besides new land fragmentation index. Kargılı Village land consolidation project in Mersin, Turkey was chosen as a material. Cadastral data before land consolidation, was used to calculate value of indicators, where number of parcels was 932, total area was 1741.9 ha, the average parcel size was 1.9 ha, number of holdings was 542 and the average parcel size was village had 932 parcels. Data processing were performed with ArcMAP 10.6.1 and SPSS. A total of 18 holdings were identified randomly as sample size which were sufficient to carry out factor analysis including principle component to rank holdings ($P < 0.01$). As a result, new land fragmentation index found correlated with others ($P < 0.01$) and ranking according to new indicator performed better than ranking considering all indicators. In this context, it is possible to use new land fragmentation indicator to determine priority areas for land consolidation.

Key words: GIS, Factor analysis, Land consolidation, Land fragmentation indicators.

Measure of thermal transmittance of two different infill wall built with bamboo cultivated in Tuscany

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Abstract. Bamboo is used in different scenarios of application, its physical and mechanical characteristics guarantee a high flexibility of use especially in the buildings constructions. The experience gained in civil constructions demonstrates that bamboo can be considered a sustainable material able to replace wood in many constructive elements with structural functions. The applications of bamboo aimed at carrying out structural functions are thoroughly studied. For this reason the present research focuses on the thermal insulation performance. To ensure an approach focused on the sustainability of potential exploitation, the research examined only local material coming from three bamboo fields located in the Tuscany region (Italy). The material harvested and suitably treated was utilized for the realization of two different kind of wall, undergone later to experimental tests in compliance with the ISO 9869 standard for the calculation of the transmittance values. The measure of transmittance enabled to know the characteristics of thermal conduction of bamboo walls. The first wall was made of cut throw longitudinal axis bamboo culms; the second one was made of cut throw longitudinal axis bamboo culms coated in internal face with a sustainable mortar. The test was carried out using insulating thermal box with internal temperature under control. The calculation of the transmittance in place was compared with the images captured by thermal camera. Thermal image allowed to highlight the behaviour of the material subjected to a thermal stress induced by the experimental test.

Key words: bamboo, thermal transmittance, thermal conductivity, sustainable building material.

The impact of microclimate conditions during storage on quality of stored grain

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Abstract. Proper storage conditions, i.e. maintaining suitable microclimate inside the storage space, resp. inside the stored raw material, are the most significant factors in maintaining good quality of stored grain for small farmers. This article is aimed at evaluating the influence of outdoor climatic conditions on the storage conditions, respectively the temperature of stored grain in silo. The silo in question was a cylindrical container with a steel wire construction and textile shell with passive aeration. The tested material (spelt grain, *Triticum spelta*) was also stored simultaneously in FIBC big bags with capacity of 1 t for 24 months. The temperature within the stored grain was monitored and the quality of stored grains and the contamination of mycotoxins and other undesirable substances were periodically evaluated. The monitored outdoor environment parameters were temperature, dew point and relative humidity. The results show very strong dependence of the stored material temperature on the outside temperature in the case of big bags (correlation coefficient $r = 0.9628$). The dependence in the case of silo storage is weaker ($r = 0.7905$). The contents of the mycotoxins monitored were in both cases below the detection limit.

Key words: postharvest period, ochratoxin A, grain quality factors, storage conditions.

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Theoretical study on sieving of potato heap elements in spiral separator

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Abstract. One of the principal problems in the harvesting of potatoes is the cleaning of the lifted heap from soil and plant impurities. The low quality in the performance of this harvesting work process operation is the main cause of the withdrawal from fields of considerable amounts of fertile soil. In order to facilitate choosing the optimal parameters for the new design of the spiral potato heap cleaning unit, a mathematical model of sieving the soil impurities through its cleaning spirals has been developed. The obtained analytical expressions have been solved with the use of a PC and the results have been used for plotting the graphic relations between the parameters of the examined process of a variable-mass body's motion on the surface of a spiral, which have made it possible to select the optimal design and kinematic parameters of the spiral cleaning unit under consideration. The obtained graphic relations indicate that the rate of sieving in the spiral separator depends on many factors, including the initial mass, the design dimensions (spiral's radius, helix angle etc.), the frictional properties of the surface, the angular parameters of the position of the potato heap elements on the spiral's surface, and the angular velocity of the rotational motion of the spiral roll itself.

Key words: cleaning, digging, mathematical model, potato, spiral roll.

Numerical modelling of process of cleaning potatoes in spiral separator

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Abstract. Cleaning potato tubers from soil and plant residues after their digging from the soil is a topical problem in the industrial production of potatoes. Taking into account the fact that the cleaning spirals are positioned with overlapping and rotate in the same sense, the potato tuber that has landed on the surface of the spiral separator in the trough between two adjacent spirals will perform translational motion towards the output ends of the spirals. As a result of solving the said system of equations, the graphical relations between the values of the normal reactions and friction forces generated during the translation of the potato tuber along the mentioned spirals, on the one hand, and the design and kinematic parameters, on the other hand, based on the requirement of not damaging tubers when performing the said work process of transportation and cleaning, have been obtained. The limitations for the normal reactions and friction forces at the points of contact between the tuber and the surface of the cleaning spiral are set in accordance with the requirement that they do not exceed the force of scraping (damaging) the tuber's external surface permissible for potato tubers. That has provided an opportunity to obtain the rational values of the design and kinematic parameters of the separator's operating spirals, in particular, the value of the angular velocity of the rotating cleaning spirals as well as their radius and helix lead.

Key words: post-harvest processing, potato, rational parameters, surface of the spiral separator.

Theoretical investigation of the movement stability of agricultural machines and machine aggregates

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Abstract. The theory of the movement stability is of crucial practical importance for mobile agricultural machines and machine aggregates, since it determines how qualitative and stable their performance is in a particular technological process. It is especially urgent To ensure stable movement for operation at high speeds of contemporary agricultural aggregates. The aim of this investigation is detailed examination of criteria for the stability assessment of a mechanical system used in agriculture, enabling their wide application in order to study the performance of the system in the case when it is affected by random forces that were not taken into account in the original model. The considered calculation methods and examples of their application make it possible to evaluate the performance of complex dynamic systems without numerical solution of complicated differential equations of the movement in the presence of external disturbances. The considered example of the stability determination of the movement of a trailed cultivator showed that this research method can be successfully used for practical purposes. Besides, a differential equation of disturbed movement has been composed for an actually symmetrical trailed agricultural machine with a particular mass, which moves at a constant forward speed under the impact of summary resistance force running along the symmetry axis of the cultivator and is applied at its centre of gravity. Reduced to normal Cauchy form, this equation was solved on the PC, which made it possible to determine immediately the conditions for stable movement of the trailed cultivator.

Keywords: theory, stability, mechanical system, disturbed movement.

Development of symbiotic interactions in the faba bean (*Vicia faba* L.) roots

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Abstract. Double-inoculation of faba bean (*Vicia faba* L.) seeds before sowing is a well-known agronomic practice. It improves symbiotic nitrogen fixation and enhances legume supply with mineral elements and water. Effective symbiosis makes it possible to replace some of the required mineral fertilizer needed for the plant growth with symbiotically fixed. This ensures more environmentally friendly agricultural production. Formation of an effective symbiosis depends on a number of biotic and abiotic factors affecting the biochemical signals excreted by partners. The biochemical mediator for symbiosis formation is flavonoids. The aim of this experiment was to test effects of rhizobia and mycorrhiza fungi inoculum on symbiosis formation under different temperatures. Faba beans are an important source of protein for animal feed and human consumption, so the project EUROLEGUME tested several varieties. For this experiment four cultivars of faba beans were chosen - two *V. faba* var. *minor* Beck. - 'Fuego' and 'Lielplatone', and two *V. faba* var. *major* Harz. - 'Bartek' and 'Karmazyn'. Results demonstrated that combination of used microorganisms for seed inoculation influence frequency of root mycorrhization and abundance of arbuscules. The content of flavonoids in seed exudates correlated ($r = 0.93$) with germination temperatures. The use of mycorrhiza fungi alone or in combination with rhizobia reduced the amount of flavonoids in the bean seed exudate. In the vegetation pots experiment the amount and size of nodules significantly differed between cultivars. Use of mycorrhiza preparation mitigated the effect of inadequate germination temperature. Higher degree of mycorrhization and more intense formation of arbuscules formation was observed in the bean roots grown in vegetation pots in comparison with field ones. Local bred 'Lielplatone' had significantly better compatibility with microsymbionts in local agroclimatic conditions.

Key words: flavonoids; rhizobia; mycorrhiza; nodule; temperature, faba beans.

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Possibilities for the biological control of yellow rust (*Puccinia striiformis* f. sp. *tritici*) in winter wheat in Latvia in 2017–2018

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Abstract. Yellow rust, caused by *Puccinia striiformis* f. sp. *tritici*, is a significant wheat disease worldwide. In Latvia, the distribution of yellow rust has increased recently and new aggressive races have been identified. The aim of this research was to investigate the possibilities for the biological control of yellow rust in winter wheat. A field trial was established in a biological field of winter wheat in Latvia in 2017 and 2018. Biological products that contained *Bacillus* spp., *Pseudomonas aurantiaca*, *Brevibacillus* spp., *Acinetobacter* spp., and chitosan were used for treatments, and one variant was left untreated. The efficacy of products was evaluated by the AUDPC (area under the disease progress curve) comparison. Differences in the severity of yellow rust between the trial years were observed. In 2018, the severity of yellow rust was lower than in 2017. In untreated plots, on flag leaf, the severity varied from 10.9% to 32.5% in 2017 and from 1.4% to 6.5% in 2018. In 2017, the severity of yellow rust reached its maximum on 05.07. at wheat growth stage (GS) 79, and in 2018 – on 20.06. GS 79. Both in 2017 and 2018, no significant differences ($p > 0.05$) were found in AUDPC values among the variants. After two years of investigations, the results were not convincing; therefore, further research is needed.

Key words: disease severity, biological control, *Bacillus* spp.

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Conventional tropical fruit drying

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Abstract. Convection drying is the most commonly used technique for drying food. Drying is one of the oldest ways to protect agricultural products by reducing the moisture content. This preservation method adds added value to dried products. This study focused on the analysis of the drying process of banana, pineapple and manga. This fruit was dried at 40 °C in the oven. Measured data was analysed by computer software. Experimental curves for individual fruits were determined. A mathematical model was created and the model coefficients of the equation were determined.

Key words: food drying, mathematical model, banana, pineapple, mango.

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Effect of foliar fertilization of microelements on highbush blueberry (*Vaccinium corumbosum* L.) nutrient status and yield components in cutover peatlands

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Abstract. The commercial cultivation of highbush blueberry in Latvia was successfully started during the last 20 years. In 2018, there was an estimated 280 ha of highbush blueberries planted in Latvia with increasing annual hectareage. In general, blueberry is a highly specialized crop that has definite soil agrochemical and climatic requirements: it has low nutrient needs and is sensitive to excessive nutrient levels in the soil. However, balanced and precise mineral nutrition is essential for producing high and quality yield. The study was conducted in the producing planting of highbush blueberry, cultivar ‘Patriot’, during the vegetation season of 2018. The research was carried out to determine the effect of foliar fertilization with micronutrients (Fe, Zn, Cu, Mo, B) on the productivity, the content of mineral elements in leaves and photosynthesis of blueberries. Field experiment design included foliar fertilizer treatments 0 to 3 times per season. In general, our results revealed that foliar sprays with micronutrients had a positive effect on the berry yield, parameters of photosynthesis and microelement content in leaves of highbush blueberry. It was determined that the application of the foliar fertilizer 4 times per season provided the highest berry yield (134 % compared to control) and the highest photosynthetic activity of plants. Our study suggests that correct foliar fertilization can optimize the content of Fe, Zn and B in blueberry leaves.

Keywords: field experiment, soil nutrient status, leaf nutrient status, parameters of chlorophyll fluorescence.

Ranking Irrigation Schemes based on Principle Component Analysis in the Arid Regions of Turkey

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Abstract. Water is a scarce resource and thus irrigation schemes in arid regions have become more important. The irrigation sector which uses most of the water resources has to cope with global warming, disasters and water scarcity around the world, particularly in the Mediterranean countries, including Turkey. Irrigation schemes, which were built by DSI (State Hydraulic Works) and whose operation and maintenance management was transferred to water user associations, play a crucial role in irrigated agriculture in Turkey. In order to improve the performance, weakness and strengths of irrigation schemes are determined by performance indicators (system operation, financial and production efficiency) which show the overall information about them. In the present study, seven irrigation schemes located in an arid region of central Anatolia were chosen to assess the irrigation performance using principal component, correlation and cluster analysis while quality index showed the rank of the irrigation schemes. We found that the average total annual volume of irrigation supply was 7648.58 m³ ha⁻¹ and the average relative water supply was 1.91 during the 11 years between 2006 and 2016. In this region, higher inverse correlations were due to using surface irrigation methods (51.3%). As of 2017, the irrigation schemes have weak water distribution systems, on an average, consisting of 55.5% open canals, 22.5% canalette and only 10% pipes. According to the quality index, financial and system operation indicators are more effective than that of production efficiency indicators. In conclusion, average irrigation ratio (55.68%) can be increased by improving the water distribution system, and the technology used on both management and farm levels.

Key words: Principal components analysis, irrigation performance indicators, irrigation schemes, quality index.

Assessment of Applied Microwave Power of Intermittent Microwave-Dried Carrot Powders from Colour and NIRS

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Abstract. Applied microwave (MW) power level is an essential factor on the quality of the dried agricultural products. Even if higher MW powers result in shorter drying times, they lead to quality degradations. It is almost impossible to know the applied MW power of a dried and powdered product by human vision. Thus, the aim of this study was to predict the applied MW power of carrot powders by using two different instruments, a chromameter and FT-NIRS. The experiments were carried out at nine different power levels (100-500 W) with three replications (N=27). The colour and NIR reflectance was measured using a chromameter and NIRS system. The data was analysed using PLS regression. The drying time of intermittent MW drying at the highest applied power of 500 W was 1.12-5.47 times shorter than those of other lower applied powers. Applied MW power was a crucial factor on all colour parameters of the powdered carrots. Brightness (L^*) decreased significantly with the increase of applied MW power resulting in darker product colours. Data analysis results showed that the NIRS system ($R^2=0.99$; SEP=16.1 W) can predict the microwave power of powdered carrots with significantly better performance than a chromameter ($R^2=0.95$; SEP=29.9 W). But, the chromameter is far more inexpensive when compared with the NIRS system and hence, it can also be used to predict the applied MW power from the colour data relatively well. Also, a mathematical model was developed to predict applied MW power from the colour parameters.

Key words: Microwave drying, applied power, carrot, reflectance, chromameter, FT-NIRS.

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Methodology of the stress determination in the tool module during the work of the agriculture machine

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Abstract. Machine construction is designed using by mathematical models. The frame is a fundamental part of an agricultural soil cultivation machine so that forces were transferred during transport and machine work to frame. The stress in the machine frame is important to know for the best frame design of the machine. The mathematical model included measured strain can able to design or detect deficiencies on the machine frame. Due to the transfer of forces from the tools, stress is created in the machine frame. High requirements are placed on the determination of boundary conditions for mathematical models in agricultural machinery. Various types, sizes and equipment of agricultural tools significantly affect the transfer of draught force to the machine. The direction and magnitude of the forces, that are caused by agricultural tools, it is important to find out. Ansys mechanical solver have been used to determination strain like response of frame from chisel module. The results can be used as a boundary condition for mathematical models.

Key words: agricultural machine, mathematical model, stress, simulation.

Evaluation of retention stresses of prestressing bars of a concrete ribbed panel from agricultural building after 20 years of service

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Abstract. In Estonian agricultural buildings there exist a lot of precast concrete load-bearing structures, which were manufactured in the 1970s and 80s. By now, some of these are rather near for reaching their designed service life. 20 years old prestressed concrete ribbed ceiling panels (type PNS-12) with the dimensions of 6 m (length) by 1.5 m (width) from an existing agricultural building (pigsty) are the subject of current study. The objective of current study was to evaluate the retention stress of prestressing bars (PSBs) of a ribbed panel PNS-12. In other words the purpose was to find out how much of the factory-issued initial prestress was left at the PSBs after 20 years of service. As a novel application in civil engineering strain gauges were applied in the evaluation of retention stress of PSBs in current study. The active strain gauges were glued to the opposite sides of PSBs at the middle-span of the ribbed panel, dummy gauges were glued to the unloaded steel slab. Strain gauges were connected to the half-bridge and measured with strain indicator and recorded. Retention stresses were calculated using the Hooke's law through the measured strains and elastic modulus of steel. Elastic modulus of PSBs was also measured using the universal testing machine Instron 3369 and software Bluehill 2, based on two standards. The results demonstrated about 20.8% and 10.0% of retention stress of PSBs, respectively. The possible errors created by different aspects in experiment are also discussed.

Keywords: retention stress, precast, prestressed, concrete, ribbed panel.

Half-cell potential mapping for corrosion risk evaluation of prestressed concrete ribbed panels from agricultural building after 20 years of service

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Abstract. Corrosion of steel is a significant problem in prestressed concrete structures as it decreases structural capacity and performance. In this research the 20-year-old prestressed concrete ribbed ceiling panels (of type PNS-12) with dimensions of 6 m (length) by 1.5 m (width) from an existing Estonian agricultural building (pigsty) are studied. The objective is to evaluate the corrosion risk of steel reinforcement of ribbed panels by means of an indirect (non-destructive) method and compare the results with a direct method. The methodology consists of a) non-destructive measurements of half-cell potential and b) comparison with actual condition of steel reinforcement after concrete removal (demolition). Non-destructive measurements were performed on the 10 longitudinal ribs of 5 ribbed panels, respectively. Steel half-cell potential maps were developed based on 900 measurement points recorded by half-cell (Great Dane). After destructive tests the ribbed panels including their longitudinal ribs were demolished and the concrete was carefully removed. The position and condition of steel details was photographed (direct method), which enabled the comparison with potential maps (indirect method). The results demonstrated that in general, half-cell potential maps give a rather good indication on the condition of corroding steel rebars with respect to intact details. Also, half-cell potential maps were found relatively useful in estimating the corrosion risk in the studied precast ribbed panels.

Key words: half-cell, potential mapping, corrosion risk, ribbed panels.

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Modular sensory hardware and data processing solution for implementation of the precision beekeeping

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Abstract. For successful implementation of the Precision Apiculture (Precision Beekeeping) approach, immense amount of bee colony data collection and processing using various hardware and software solutions is needed. This paper presents standalone wireless hardware system for bee colony main parameters monitoring (temperature, weight and sound). Monitoring system is based on Raspberry Pi 3 computer with connected sensors. Power supply is granted by the solar panel for reliable operation in places without constant source for power. For convenient data management cloud based data warehouse (DW) is proposed and developed for ease data storage and analysis. Proposed data warehouse is scalable and extendable and can be used for variety of other ready hardware solutions, using variety of data-in/data-out interfaces. The core of the data warehouse is designed to provide data processing flexibility and versatility, whereas data flow within the core is organized between data vaults in a controllable and reliable way. Our paper presents an approach for linking together hardware for bee colony real-time monitoring with cloud software for data processing and visualisation. Integrating specific algorithms and models to the system will help the beekeepers to remotely identify different states of their colonies, like swarming, brood rearing, death of the colony etc. and inform the beekeepers to make appropriate decisions/actions. This research work is carried out within the SAMS project, which is funded by the European Union within the H2020-ICT-39-2016-2017 call. To find out more visit the project website <https://sams-project.eu/>.

Keywords: Precision beekeeping, data warehouse, bee colony monitoring.

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Common and distinctive features of fen and raised bog peat humic acids for use in agriculture

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Abstract. Fen peat in present day is insufficiently used as a natural resource, but humic substances extracted from this type of peat can be noteworthy alternatives for the production of agricultural products. The main objective of this study was to analyse and evaluate features of fen peat humic acids and to compare them to raised bog peat humic acids, properties of which are well documented in the scientific literature, and to find common and distinctive features between them – thereby giving the scientific background of fen peat humic acids as equally good alternative in the production of environmentally friendly products that can be used in agriculture to improve soil fertility. Humic substances were extracted from fen peat as alkaline extracts. Whereas humic acids were precipitated on filter papers after acidification of humic substances. Properties of humic acids for this study were analysed and evaluated with FT-IR, EEM fluorescence, UV-Vis, TOC and elemental analysis. Results indicate that depending on the additional mineral matter 1 g of dry fen peat contains from 0.02 to 0.70 g of humic acid. The TOC content in 1 g of fen peat humic acids, depending on peat decomposition degree, varies from 20 to 300 mg. But IR spectra of fen peat humic acids show complex structure of degraded functional compounds due to high decomposition degree with lower transmittance than for raised bog peat humic acids. Despite the differences between the origin of raised bog and fen peat humic acids, overall results show rather similar properties between both types of humic acid.

Key words: fen peat, raised bog peat, humic substances, humic acids.

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Development of land use and land use change matrix using geospatial data of National forest inventory

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Abstract. Land use and land use change calculation matrix is one of the most important part of the national greenhouse gas (GHG) inventory in land use, land use change and forestry (LULUCF) sector providing information of an overall summary and changes in land use at a national level over a specified period of time. Information on land use and land use changes is further used to calculate other parameters important for determination of GHG emissions like stock changes of living and dead biomass, as well as basic information on applied management measures. Calculations of land use change can be carried out in partly automated process using GIS tools, which makes calculations easier to perform, reduces time consumption for this task and occasional mistakes due to manual operations. Aim of this study is to improve methodology for development of land use and land use change matrix in the national GHG inventory system using geospatial data information of National forest inventory (NFI) and auxiliary data sources. The developed system using geospatial NFI data and auxiliary information provided by the land parcel information system (LPIS) and stand-wise forest inventory improves accuracy and consistency of the land use and land use changes matrix providing ability to apply the same land use accounting method for the whole reporting period without significant increase of uncertainty. The developed method determines land use changes in a 5 years period by comparison of the site visit results from 3 NFI cycles having different weight in the estimate of the reported land use. Interpolation method is used to determine year-by-year transitions and extrapolation method is used for the subsequent years for which NFI data are not available. The land use change matrix elaborated within the study have similar trends of land use changes, if compared to the currently reported data in the National GHG inventory; however, elaboration of the matrix does not require time consuming manual sorting of changes in the NFI plot geometry, which are not associated with real land use changes. Partial automation of these calculations using tools available in GIS environments allows calculations to be made faster and more precise.

Key words: land use and land use changes, land use matrix, NFI, GHG inventory.

Discrete element simulation of rapeseed shear test

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Abstract: Suitable equipment are required for storage and transportation of rapeseed which are developed according to rules for bulk matters. It is one of reasons where bulk matter properties are important to the design. Bulk matter properties are important to known as angle of repose, internal friction, external friction, adhesivity force and other bulk properties. Experimental values of bulk properties are added to mathematical models. The model should be calibrated with adequate experiment. The shear test is one of popular calibration test for bulk matters so that be able done experiment and numerical model in one. The aim of this paper is simulation of rapeseed bulk properties during shear strain and flow and its evaluation and calibration with experimental tests. RockyDEM software was used for numerical simulation of rapeseed. Shear test, angle of repose, static and dynamic friction test were used to calibration of the numerical rapeseed model. Sensitivity of numerical model is discussed on the bulk properties.

Key words: oilseed, discrete element methods, angle of friction, shear test.

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Planting and tending productivity comparison in mounds and disc trenches using containerized and bare-root coniferous seedlings

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Abstract. In 2016 more than 40 300 ha of forest was regenerated in Latvia, where 13 000 ha were seeded or planted and 30 300 ha were left in natural regeneration. Before planting usually one of two soil preparation methods are used – mounding and disc trenching. In areas with optimal water regime trenching method is used, while in wet areas mounding is used. Tree planting is done manually by hand tools and after planting agrotechnical tending is done. The aim of the study was to compare planting and agrotechnical tending productivity in different soil preparation methods (mounding and trenching) by planting different planting material (containerized and bare-root seedlings). Planting time studies were done in 12 sites and agrotechnical tending time studies in 8 sites. In planting time studies different planting operations were measured and compared. In agrotechnical tending time studies GPS devices were used, where area, distance and working time (productive and rest) was counted from GPS data. Average planting time for containerized seedlings in disc trenches were 10.3 seconds, while in mounds 9.2 seconds per seedling, what is 11% faster. Average planting time for bare-root seedlings in mounds were 28.3 seconds, while in trenches – 18.2 seconds, what is 35% faster. Agrotechnical tending in trenches was done faster than in mounds. On average one hectare tending time in mounds was 8.4 hours, while in trenches 7.4 hours, what is 11% faster. Walked distance for 1 hectare tending in mounds was 5.4 km, while in trenches 5.0 km, what is 7% shortest distance. Factors that influence planting and tending productivity are soil preparation quality, logging residue amount in site and water level in site. Data from planting and agrotechnical tending time studies could be used for better work planning and suitable planting material selection in particular soil preparation method.

Key words: planting time studies, planting productivity, agrotechnical tending time studies, agrotechnical tending productivity, planting in mounds, planting in trenches.

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Measurement Robotic Arm (MRA) for the evaluation of localization sensors properties

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Abstract. The purpose of this longitudinal project is to verify the dynamic properties of the Real Time Kinematic receivers (“RTK”). For this purpose, a verification method using Measurement Robotic Arm (“MRA”) described in this paper has been developed. This device can be moved along a circular trajectory in a horizontal surface. Using the methodology described in this paper, the absolute position of the MRA trolley in absolute time can be defined with absolute accuracy and can serve as a reference for the verification of RTK receivers positioning. Its movement, including its breaking, can be controlled via a PC app and various sensor properties can be monitored. The position of the trolley is determined by the encoder. A Hall sensor indicates the absolute start position of one full turn. The absolute time marks of the measurement and the time synchronization of the microprocessor based on Pulse Per Second (“PPS”) were obtained from the standard GNSS receiver. This study provides information about a proposal solution of the MRA reference system in terms of the frame construction description, the design of electronic equipment and the design of a software solution for processing and logging of messages. This paper also presents the results of three tests performed to verify the functionality and reliability of the MRA system: PPS time accuracy verification, the quantity and correctness of sent messages according to the arm instantaneous speed, and a real RTK verification test. The MRA also can be used to verify the dynamic properties of other localization devices.

Key words: localization, accuracy, precision, dynamic properties, reference system, reference trajectory, time synchronization, PPS, RTK, GNSS, agriculture.

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Impacts of some cultivated crops on water erosion in the Central Bohemia Region

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Abstract. This paper aims at assessing the impact of crops on water erosion parameters. Water erosion is the most common cause of damaging agricultural land in the Czech Republic. This is due to the large average slope of land and the prevailing soil types. The field trial was based on a site with an average slope of 5.4 °. The primary objective was to assess the effect of the crop on the surface runoff and soil loss. The crops cultivated in the experiment were winter wheat, rape, potatoes, corn and oats (conventional tillage for all variants). Black fallow was used as the comparative variant (without vegetation). There is a light cambisol on the experimental field. To assess erosion, the method of microplots was used. The physical properties of the soil were also evaluated. The results show the risk of growing wide-rows crops (potatoes, corn). The soil loss in these crops was similar to the variant without vegetation.

Key words: water erosion, wide rows crops, surface runoff, erosion wash-out.

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Influence of the bentonite-containing acrylic humectant composite on the soil microflora

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Abstract. Acrylic derivative-based superabsorbents are widely used currently in agriculture as the soil conditioners, plant growth regulators, etc. Their usage has a positive effect on the growth and survival of the plants cultivated in the arid regions. However, the effects of hydrophilic acrylic polymers on the soil microbiocenosis still remain unknown. The influence of the moisture-absorbing acrylic acid-based hydrogels with different proportions of bentonite filler was studied on the soil microbiota. N,N-methylenebisacrylamide was used as a crosslinking agent. Acrylic hydrogels were synthesized by radical polymerization in an aqueous medium at a synthesis temperature of 45°C during 4 hours. The application of hydrogel of the certain concentrations (1.0, 1.5, and 2.5% wt) into the soil did not cause significant changes in the total abundance of heterotrophic bacteria and the length of the fungal mycelium. The CO₂ emission rates did not change after and during the application of the hydrogel), which indicated the same level of carbon mineralization in the soil with presence of acrylic bentonite-containing hydrogels. The nitrogen fixation rate decreased on the first day after hydrogel application; after 14 days, it was close to the control values. We assume the activity of nitrogen-fixing bacteria has though turned to the normal level.

Key words: acrylic hydrogels, bentonite, soil microflora.

Design and construction of a low-cost remotely piloted aircraft for precision agriculture applications

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Abstract: This study aimed to construct a low cost RPA capable of recording georeferenced images. For the construction of the prototype of a quadcopter type RPA, only essential materials were used to allow stable flight. A maximum total weight of 2 kg was stipulated, including frame weight, electronic components, motors and cameras. The aircraft was programmed using a low-cost microcontroller widely used in prototyping and automation research. An electronic circuit board is designed to facilitate the connection of the microcontroller with the other components of the design. Specific software was used for flight control. The prototype was built successfully, being able to lift stable and controllable flight. However, we still need to acquire equipment and programming components capable of enabling autonomous images and flights. The final cost of the RPA was on average \$ 427.00 on average 50% lower than the values found in the Brazilian ARP market (\$ 772.81 to \$ 1,288.00)

Keywords: arduino, prototype, drone, UAV.

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Conversion of an industrial cutaway peatland to a *Betulacea* family tree species plantation

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Abstract. To evaluate the potential of establishing a deciduous tree plantation on an industrial cutaway peatland over an 8 ha large experimental site was established in the central part of Latvia and silver birch (*Betula pendula* Roth) and black alder (*Alnus glutinosa* (L.) Gaertn.) tree species were planted. As it is a harsh and unfavorable environment wood ash, otherwise a waste product, was used as a fertiliser and liming material in three applications (5, 10 and 15 t ha⁻¹). In comparison with control, fertilised soils had higher Ca, Mg, P amounts, whilst the most substantial difference was seen in the amount of K. Application of wood ash also considerably increased soil pH from 3.5 (Control) to 5.9 (15 t ha⁻¹). Even though showing reduced growth in unfertilised soil both alder and birch seedling survival rate was higher than 80%. The highest survival rate for birch was under wood ash treatment, while alder under 10 t ha⁻¹ wood ash fertiliser treatment showed the lowest survival rate i.e. 81%. In total, more than 60 naturally occurring vegetation species were observed in the first and the second year of sites establishment after fertilisation. Species as *Betula pendula*, *Betula pubescens*, *Populus tremula*, *Pinus sylvestris*, *Salix* spp. often occurred from natural vegetation regeneration. Already after one year of vegetation succession increase in tree and shrub species cover was observed, suggesting perhaps such areas can be naturally afforested thus creating a more heterogeneous forest stand. In such a way sustaining economic use of land resources after peat extraction while providing other ecosystem services.

Key words: afforestation, drained peatland, wood ash fertilization.

ACKNOWLEDGEMENTS. Study was conducted as a part of project MAGIC – Marginal Lands for Growing Industrial Crops: Turning a burden into an opportunity (Horizon2020 - Grant agreement ID: 727698) and the experimental plot was established as a part of LIFE REstore, LIFE14 CCM/LV/001103.

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Development of intelligent system of mobile robot movement planning in unknown dynamic environment by means of multi-agent system

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Abstract. Through the ages the world has conceived the projects which are aimed at creating diverse models of robots that would be beneficial for exploration of different dangerous surfaces where human participation is excluded. Therefore, the main task of the study of this article is to develop the researches, the object of which is mobile robot movement in unfamiliar environment, based on multi agent apparatus system and neural networks. The aim of the research is to develop methods for creating intellectual systems for planning mobile robot movement in unfamiliar environment applying the methods of multi agent apparatus and neural networks ensuring the robot executes the planned and adjusted on the way safe trajectory in an environment with unknown obstacles. Accordingly, the entire study of the article is based on a two-stage process. The first stage involves determination of distance between the robot and the obstacles in its operating area as well as classification of the possible location of obstacles, based on the information received from distance sensors, using the model of multilayer neural networks. During the second stage bypassing obstacles, wall tracking, movement-to-destination as well as speed management agents are developed. As the result of the study, a method was suggested for creating neural network model for classification of environment into agents and their consistent switching, which, according to the classification table compiled, involves all the possible locations of obstacles occurring on the robot's movement trajectory and allows reducing the number of unfamiliar environment situations that are necessary to identify.

Key words: multi-agent system, unknown environment, neural network, dynamic obstacles, planned track.

Robotic electromechanical object control by means of variable structure system

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Abstract. The practical purpose of robot design is to transfer types of complex human activities that require much effort, are monotonous and harmful. The robotic systems differ from traditional automation measures in terms of their universality and the possibility to reconstruct them quickly which enables them to create flexible automation production measures on the basis of universal equipment. Therefore, the subject matter of the present article is constituted by manipulator robot control system methods (semi-continuous control method, coordinator parameter control method and adaptive control method etc.) and the aim of the present study is to cover the said manipulator robot control system methods in order to assess the problems relating to their application and to provide the potential solutions. In analysing studies by other authors and assessing the results based on them, the following results of the present article were obtained: having regard to the peculiarities of control object model, due to their universality, theoretical methods of systems with semi-continuous control are the most attractive. The approach of other studies is also improper as it is claimed that the dynamics of electric executive equipment may be neglected and control moments can be formed in the same way as breakage functions and the problem which occurred may partly be solved, by using the advantages of the system with semi-continuous control in the pre-limiting situation which occurs by approximating semi-continuous control by means of continuous functions. The fundamental gap of the majority of electromechanical object control studies is, first of all, related with the fact that the phase variables are considered measurable, so the necessity arises to note that the entire complex of measurement equipment may lead to a significantly more expensive control system; moreover, measurement equipment adds additional dynamics to the control system and makes the synthesis procedure even more complex.

Key words: manipulative robot chains, slip mode, coordinate parametric control, adaptive control, approximating semi-continuous control.

Surface water runoff of different tillage technologies for maize

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Abstract. The present paper is focused on the evaluation of efficiency of soil-conservation technologies to reduce surface water runoff in Central Bohemia Region. In the last years, there has been an increase in maize planting on hillslope plots due to the construction of many biogas plants in conditions of Czech Republic. It enhances the risk of water erosion because the occurrence of sloping lands in the Czech Republic is high. To evaluate the technologies of stand establishment a field trial was laid out with four treatments of maize planting. The trial was laid out on a plot with light soil and slope of around 12%. It was a multi-year trial. To measure erosion parameters a rainfall simulator was used (measurement of surface runoff). The values obtained in two seasons show a positive effect of the soil surface cover by organic matter when reduced soil tillage was used. Soil loss also decreased at the same time compared to treatments with conventional soil tillage. It was found up to six-fold reduction in surface runoff by appropriate soil tillage technology during two seasons of measurement.

Key words: water erosion, soil tillage, organic matter on surface.

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Effects of drip irrigation on the yield of strawberry plants grown under arable conditions

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Abstract. The study investigated the effects of drip irrigation on the yield of ‘Honeoye’ strawberry plants for commercial purposes grown under arable conditions throughout the harvest season. The plants were irrigated at irregular intervals depending on natural precipitation. Crop yields and fruit parameters (diameter, length, individual weight, count per plant) were compared on several harvest dates. Statistical analysis has shown that irrigation has a significant impact on yield and fruit parameters. The irrigated plants yielded more strawberries, which also had a larger diameter, length, and individual weight.

Key words: strawberry, drip irrigation, fruit crop.

Challenges of mechanisation of smallholders in Sub-Saharan Africa

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Abstract. The main challenges hampering agricultural mechanisation in sub-Saharan Africa (SSA) are affordability, availability, lack of farmer skills and constraints within the private sector (Sims et al. 2016). Most of the farmers in SSA are smallholders who control the majority of total farmland. Specifically in Zambia, there are 1.5 million small and medium-scale farmers (Sitko et al. 2015) – 15.3% of them are subsistence farmers farming 2 ha or less by hand and typically with a family of five to six members, and 57.8% are emerging farmers (261,590) with larger parcels of land (over 5 ha) and some mechanisation tools. Smallholders have a restricted purchasing power and cannot afford to invest in agricultural machinery. Low yields (ca 1 t/ha), poor marketing facilities, low market prices and high transport costs result in a low ability of farmers to access financing, as their contribution to supply chains is very limited. The availability of tractors and agricultural machinery is limited because the distribution networks of machines, spare parts, service, fuel, lubricants, advice and training are underdeveloped, and due to the low demand in the countryside, suppliers are only found in capital cities or larger towns. This work will report on the challenges of trialling mechanisation in smallholder sector in Zambia. The results will contribute to the overall goal of making recommendations and developing a model for sustainable agricultural intensification (e.g conservation agriculture (Bymolt and Zaal, 2015 and FAO, 2011)) and affordable financing of well-suited mechanisation.

Key words: Mechanisation, smallholders, Sub-Saharan Africa.

Effect of rotors on the parameters of hop drying in belt dryers

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Abstract. This article contains a design and verification for a technical solution aimed at optimising the hop drying process in belt dryer. Above the first belt of our belt dryer two evenly distributed double-arm rotors were installed and tested in operation to improve the permeability of the drying air through a flattened hop layer, as well as to improve the speed of drying. The measurements carried out in operation and comparing the drying process with the rotors switched on and off concluded that by inclusion of rotors the hop layer becomes more permeable, and when switched on, the rotors have a positive effect on faster reduction of the relative humidity and on increase of the drying air temperature. With rotors switched on, the percentage drop in the drying air relative humidity at the third inspection window of the first belt, compared to the first inspection window, was 41% on average (values obtained from data loggers and fixed sensors), the drying air temperature increased by 29%, and the hop moisture content decreased by 12%. Whereas with rotors switched off, the drop in the drying air relative humidity was only by 26% on average, the drying air temperature increased only by 14%, and the hop moisture content decreased by 12%. Based on long-term monitoring of fuel consumption during the whole harvesting season starting 2011 until 2017 inclusive, the average annual consumption of LFO (2011–2014) results in 494 l t⁻¹ operating without rotors, and 431 l t⁻¹ when operating with rotors (2015–2017). This implies that due to the implementation of rotors, the fuel saving being 13% is significant.

Key words: hop cones; hop drying; belt dryer; quality of hops.

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Effect of strip tillage on the energy, environmental and agronomical indicators of faba beans cultivation

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Abstract. Strip tillage combines the positive aspects of no tillage and full-tillage technologies. The main objective of this work was to determine the influence of the technological parameters of strip tillage machines on agronomical aspects of faba beans (*Vicia faba* L.) cultivation, on energy consumption and CO₂ emissions. Tests of strip tillage machine's technological parameters was carried out in 2013–2014 at the Experimental Station of Aleksandras Stulginskis University (ASU), and experimental field research in 2016–2018 at the farmer's farm, situated in Kaunas District. Tests in ASU was carried out by changing the row cleaner disc rake angle from 10.0o to 22.5o, the working depth from 0 to 200 mm, and the working speed from 1.4 to 3.1 m s⁻¹. The results indicate that increasing the working depth from 0 to 200 mm increases the hourly tractor fuel consumption from 10.3 to 24.3% depending on the working speed. An analysis of the experiments indicates that the lowest fuel consumption and CO₂ emissions per hectare were achieved at a working speed of 2.5 m s⁻¹. CO₂ emissions from tractors increased approximately 20% on average with a working depth increase from 0 up to 200 mm. Application of strip tillage technology at the farmer's farm resulted an average faba beans yield of 4.4 t ha⁻¹ or 0.2 t ha⁻¹ higher than that of conventional tillage. A comparison of studies investigating different soil tillage technologies demonstrates that strip tillage is environmentally friendly. The assessment of the results showed that the technology of strip tillage uses up to 2 times less fuel, and CO₂ emission are 13–20% lower than in conventional tillage.

Key words: Strip tillage, faba beans, depth, speed, CO₂, fuel consumption

Single cell oil production from waste biomass: review of applicable agricultural by-products

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Abstract. Single cell oil (SCO) is an attractive alternative source of oils, since it can be used as feedstock in biofuel production and also have been recognized as viable option in production of essential fatty acids suitable for either human nutrition or as supplementary in animal feeds. However, the usability of SCO is limited due to the high price of raw materials used in the fermentation process. This problem can be tackled by using low-cost agro-industrial residues which are applicable for SCO production. Use of these by-products as the main carbon source in fermentations not only significantly reduces the overall production costs of SCO, but also enables treatment of generated waste streams, thus reducing the negative impact on environment. Since various biodegradable agro-industrial by-products can be used in microbial fermentations, this review aims to categorize and compare applicable agricultural residues by their availability, necessary pre-fermentation treatments, SCO yields and current usability in other competing sectors.

Key words: microbial oil, oleaginous microorganisms, low-cost substrate, agricultural residues, animal feed, biodiesel.

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Role of humic substances in agriculture and variability of their content in freshwater lake sapropel

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Abstract. The term ‘humic substances’ (HS) refers to a general category of naturally occurring, biogenic, heterogeneous organic substances. They create the most widespread natural organic matter found in sediments, soils and waters. Organic carbon in soil (up to 70%) and peat (up to 90%) usually occurs in the form of HS. HS influence the formation process of fossil fuels, as well as they are involved in the plant nutrition process, have an influence on availability and toxicity of metallic and other elements. Furthermore, HS play a significant role in the global carbon geochemical cycle. Properties and application efficiency of humus depend on the source of HS. Freshwater sapropel is a huge reservoir of HS with superior biological activity, although their total content is lower than in peat. The aim of this paper, firstly, was to present the information about the options of HS in agriculture and their main effects on plant growth. Secondly, determination and characterization of HS content in freshwater lake sapropel was performed as sapropel nowadays becomes a popular natural organic-mineral fertilizer and soil conditioner. Sapropel samples were derived from Lake Pilvelis, Lake Pilcines, Lake Vevers, Lake Liducis and Lake Padelis situated in Eastern Latvia. Investigation of HS content in sapropel is significant for the Baltic States and Northern Europe due to wide distribution and availability of sapropel in freshwater bodies. That promotes a search for new ways of extraction methods and bioeconomically effective utilization of this natural resource, obtainable in economically significant amounts, with high opportunities of its use especially in agriculture. Contemporary agriculture strongly desiderates in new products of high effectivity enhancing soil and crop productivity and quality hand in hand with sustainable development and careful attitude to the nature and surrounding environment, thus, one of the ways how it can be achieved is understanding how, where and how much HS preparations can be applied.

Key words: humic substances, freshwater sapropel, organic fertilizer, bio-stimulant, soil conditioner.

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Influence of organic and inorganic fertilization on soil properties and water infiltration

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Abstract. Soil aggregate stability (SAS) belongs to the most important parameters determining the quality of soil and fertilizer influence on soil aggregation. We evaluated the relationship between SAS, hydro-physical soil properties and infiltration rates in three long-term field experiments founded in 1956 on different soils. Soil properties under three fertilization regimes—no fertilization, farmyard manure, farmyard manure and mineral fertilization—were evaluated at silty loam Chernozem, silty loam Phaeozem and sandy loam-loam Cambisol. A significant impact of fertilization on SAS was found, even though the differences in SAS were rather low. The lowest SAS was recorded at plots with manure and mineral fertilization (25.1%) compared with plots without fertilization (28.7%) and plots with manure-only fertilization (28.2%). The highest SAS (36.5%) and the highest semi-capillary porosity (SP; 11%) were observed at sandy loam-loam soil. Hydro-physical soil properties were more favourable at fertilized plots (SP 9.6% and bulk density ρ_b 1.31 g cm⁻³) compared with unfertilized ones (SP 8.8% and ρ_b 1.35 g cm⁻³). The lowest SP (8.32%) and the highest ρ_b (1.37 g cm⁻³) were recorded at Phaeozem, which corresponded with the lowest SAS (19.4%). Chernozem had similar soil texture to Phaeozem, but SAS (24.7%), SP (9%) and ρ_b (1.27 g cm⁻³) were more favourable. Despite the low level of statistical significance due to the large variation of infiltration measurements, a higher infiltration rate was recorded at fertilized plots (45 mm hour⁻¹) compared to unfertilized ones (35 mm hour⁻¹).

Key words: soil quality, soil aggregate stability, infiltration, porosity, long-term field trial.

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Modelling of operator's focusing scheme along working hours: harvesting operation

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Abstract. In consistent with the growing research activities regarding the Farm 4.0 concept, it is valuable to consider each possible chance of enhancement which is expected to contribute positively to the productivity and the safety of planned operations. Human centred design concept is becoming essential for the multitasking vehicles market, which promotes the research experiments aiming to understand the human behaviour inside the vehicle cabins to proceed with upgrading the design, planning and production procedures based on validated inputs leading to introducing reliable solutions for more productive and safety conduct of operations. The accurate and deep analysis of the operator behaviour inside the cabin will lead to a better understanding for the problems and issues need to be resolved in new designs in addition to providing the production planning (i.e. manpower planning and working shift period) with the necessary data to ensure achieving the maximum efficiency and effectiveness. In this research, the operator's glance behaviour inside the tractor cabin is studied during the harvesting operation to develop a model for the change of operator's focusing scheme along working hours.

Key words: off-road vehicle, operator's behaviour, eye tracking, focusing scheme, passive fatigue, precision farming.

The effect of sowing date on cover crop biomass and nitrogen accumulation

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Abstract. Cover crops are important tools for reducing nitrogen (N) leaching from the soil and improving the nutrition of cash crops. In northern regions with short autumns it is important to maximise the growing season of cover crops to achieve sufficient biomass and N accumulation. The objective of the study was to evaluate the biomass and N accumulation of cover crops at different sowing dates in August.

Field experiment at Estonian Crop Research Institute was conducted in 2017 and 2018 with white mustard (*Sinapis alba* L.), phacelia (*Phacelia tanacetifolia* Benth), buckwheat (*Fagopyrum esculentum* Moench), berseem clover (*Trifolium alexandrinum* L.), field pea (*Pisum sativum* L.) and faba bean (*Vicia faba* L.). Cover crops were sown on August 3, 8, 14 and 18 in 2017 and August 3, 8, 13, 17 and 23 in 2018. The two year experiment showed that biomass and N accumulation of cover crops were reduced with delayed sowings, but the reduction mainly depended on cover crop species. White mustard, field pea and faba bean accumulated significantly higher amount of biomass and N than phacelia, buckwheat and berseem clover at all sowing dates in both years. Because of a rapid decrease in biomass, the optimum sowing time for phacelia and buckwheat should not be later than middle of August. In both year berseem clover produced the modest amount of biomass and therefore more suited as spring sown cover crop in Estonian conditions.

Key words: biomass, cover crops, nitrogen accumulation, sowing date.

ACKNOWLEDGEMENTS. The research was supported by Estonian Ministry of Rural Affairs' project „Varieties suitable for organic cultivation in Estonia“ (10.1-2/430 p.4; PA1-RUP-026) and by „Designing of an agrotechnical system including evaluation of suitable catch crop species, their seed mixtures and their cultivation methods“ (T170143PKTM).

Determining external friction angle of barley malt and malt crush

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Abstract. This paper deals with determining the amount of external friction angle of barley malt and malt crush depending on the load size. Barley malt is a basic raw material for production of the traditional Czech Pilsner type of beer. The angle of internal and external friction is one of the basic parameters of bulk materials. Friction among individual grains of material, i.e. a connection with the forces, applied between individual material particles, includes the internal friction angle. Conversely, the external friction angle is the angle in which the bulk material begins to move on the other material (steel). A two-roll mill (or disc mill and hammer mill) was used for the malt crush manufacture, which is used in the traditional malt processing in beer production. During crushing on this machine, we used the passage of the milled material through a gap between two counter-rotating cylinders. The results of barley malt and malt crush external friction angle, depending on the load size of the barley malt and the malt crush on mobile prototype device, are from 8 to 22°. The mobile prototype device is based on the following principle: a square chamber filled with a loaded material moves on the pad (steel).

Key words: barley malt, external friction angle, food industry, particulate matter.

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II AGRICULTURAL ECONOMICS

Potential social lifecycle impact analysis of bioenergy from household and market wastes in African cities

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Abstract. Bioenergy is touted as a viable source of stable and affordable energy in a number of remote sub-urban centres. This study evaluates the potential social lifecycle impacts of bioenergy production from household wastes and agri-wastes in some African cities. The assessment considered the use of rotten and unsold fruits, vegetables and other related agri-wastes from central open markets in Lagos and Johannesburg as case studies. The 2009 UNEP/SETAC's social lifecycle assessment (sLCA) guidelines and the associated sLCA methodological sheets are used to evaluate the potential social impacts of bioenergy production from agri-waste on operators/workers, the consumers, the value chain, and the local community. Preliminary results showed that it will provide a lot of benefits such as alternative employment opportunities, improved profits for small businesses, waste minimization, cleaner environment and improved communal health. It will also lead to improvement in energy supply, and alleviation of poverty. However, care has to be taken to protect the bio-digestion facility's neighborhood from unpleasant odour, rodents and other organisms that may attempt to feed on the rotting agri-waste. The outcome of this study provides an insight to the necessity for the development of appropriate bioenergy policy/regulation and for the need to take preemptive steps to eliminate/minimize potential negative consequences of bioenergy production on the stakeholders.

Key words: bioenergy, household wastes, market wastes, social impact assessment, social lifecycle assessment (sLCA)

Benchmarking the GHG Emissions Intensities of Crop and Livestock– derived Agricultural Commodities Produced in Latvia

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Abstract. With the production of grain and livestock–derived agricultural commodities increasing, the agricultural sector has become one of the main sources of greenhouse gas emissions (GHG) in Latvia. In 2016, the agricultural sector contributed to 23.6% of the total GHG emissions originated in Latvia (266.4 kt CO₂eq), and therefore the mitigation of the emissions is important. Considering the new indicative target, Latvia must reduce its GHG emissions in the non-ETS sectors by 2030 (Regulation 2018/842) so that the emissions do not exceed the 2005 level. The research aims to estimate the emissions intensities (EI) of grain and livestock-derived commodities produced in Latvia and benchmark the EI against those for other countries. The GHG EI were analysed per kilogram of product (kg CO₂eq. kg⁻¹) and per hectare currently in use agricultural land (kg CO₂eq. ha⁻¹). The main part of the GHG emissions of crop production originated from fertilizer application (direct N₂O emissions) and soil liming (direct CO₂ emissions). The main part of the GHG emissions of livestock–derived production originated from livestock enteric fermentation (direct CH₄ emissions) and from manure management systems (direct CH₄ and N₂O emissions). The EI per hectare of industrial crops and grain were 550.5 and 438.4 kg CO₂eq. ha⁻¹, respectively. The yield and fertilizer application had a strong impact on the EI per kilogram of product. Pulses had a lower EI (0.003 kg CO₂eq. kg⁻¹), while industrial crops (0.17 kg CO₂eq. kg⁻¹) and grain (0.09 kg CO₂eq. kg⁻¹) had the highest EI. A comparison of the GHG EI of crop and livestock–derived agricultural commodities per kilogram of product between Latvia and other EU Member States showed: Latvia had the lowest grain EI (0.09 kg CO₂eq. kg⁻¹), but one of the highest cattle meat EI (25.18 kg CO₂eq. kg⁻¹) and milk EI (0.64 kg CO₂eq. kg⁻¹).

Key words: GHG, emissions intensity, commodities, benchmarking.

Estonian dairy farms' technical efficiency and factors predicting it

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Abstract. Milk production is a complex process whose efficiency depends directly on the input-output ratio and indirectly on the decisions made at farm and animal level. Decisions made about farm hygiene, dairy cows' milk yield, cows' age at first calving etc. affect farms' efficiency. The aim of this study is to provide an understanding of the factors that affect dairy farms' technical efficiency. A two-stage approach was used in this study, consisting of a data envelopment analysis (DEA) in the first stage, and classification and regression tree (CART) in the second stage. DEA determined technical efficiency scores (TE), and CART enabled to detect the main factors that influenced efficiency in dairy farms. The analysis studied at the Estonian national level FADN dataset and Estonian Livestock Performance Recording data. 147 Estonian dairy farms were included in this analysis, all of which are specialized in dairy production. DEA results demonstrated that more than half of the farms (55%) were operating efficiently or rather efficiently ($TE \geq 0.900$). CART results revealed that the main variables determining efficiency are milk yield per cow's lifetime (kg day^{-1}), feed costs (€ kg milk^{-1}), and somatic cell count (SCC; 10^3 ml^{-1}). Milk yield per cow's lifetime is a complicated factor as it is influenced by a lot of components (e.g. milk yield, number of lactations, age at first calving, and calving interval), but if it is known at farm level, it is also a useful variable for predicting efficiency. Feed costs per milk kg is an economic variable, i.e. lower costs are related with higher efficiency. Better hygiene (lower SCC) is also related with higher efficiency. The analysis showed that integrating farm accounts data, herd-level genetic information, and milk quality attributes enables to use more specific factors to explain the variation of TE between dairy farms.

Key words: data envelopment analysis, classification and regression tree, dairy farms' efficiency.

Cost-effectiveness of ammonia emissions' reduction measures in dairy farms: Latvia's case

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Abstract. The targets of ammonia emissions had been established by the revised Gothenburg protocol and European Union (EU) Directive (2016/2284) on the reduction of national emissions of certain atmospheric pollutants. According to the Directive the reduction target of ammonia emissions for Latvia should be one per cent for any year since 2020 to 2029; and one per cent from any year from 2030, compared with a 2005 baseline. Nevertheless, ammonia emissions have increased substantially from 2005 to 2015 by 20.1 per cent. Taking into account that the agricultural sector remains the major source of ammonia emissions in Latvia (above 80 per cent), the huge effort should be made by agriculture sector to achieve ammonia mitigation targets. Similarly, other EU countries the main share - 45.6 per cent of total ammonia emissions were originated by the livestock sector. Moreover, the dairy cattle generate about half of these emissions. The aim of the paper is to provide most promising options for reduction and mitigation of ammonia emissions in the dairy cattle sector in Latvia. The principal materials used in the studies are as follows: different sources of literature; as well as guidelines and recommendations of both international institutions (EMEP, UN) and EU (European Commission, EEA); and also published and unpublished data from the Central Statistical Bureau of Latvia (CSB) and the Agricultural Data Centre, data from Eurostat database. The literature review was conducted, in which systematic review approach was applied, and the descriptive and comparative methods were used. The quantitative estimation and analysis of dairy cattle productivity, profitability, as well as evaluating the feeding strategies' impact on ammonia emissions was performed using data analysis methods and case studies. High milk urea nitrogen (MUN) concentrations have been recognized as an indicator of inefficient utilization of feed, particularly crude protein, by dairy cows. At the same time the values of MUN can be successfully used as an indicator showing the potential of ammonia emissions. The previous research indicated that MUN values have been indicated that the high proportion of dairy cows have received feed, in which the content of crude protein is higher than necessary. The results of studies show that the most promising and cost-effective ammonia emission reduction measure in Latvia could be the balanced feeding strategies for dairy cows. The feeding strategies could be aimed to balance feeding with the production levels, physiologic stage and breeds of dairy cows. The balanced feeding could be realized by providing the optimal content of crude protein in dairy cows' diet or ration.

Key words: ammonia emission, dairy cattle, productivity, feeding, crude protein, efficiency.

A systematic approach to exploring the role of primary sector in the development of Estonian bioeconomy

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Abstract. The aim of this paper is to provide a systematic overview of biomass production and the use of biomass for the production of key products, as well as to map businesses operating in the field of bioeconomy in Estonia. The importance of primary sector in Estonian economy has decreased over the last decade. At the same time, the competitiveness of primary sector has increased, which will, in the future, contribute towards a stable production of biomass. Therefore, bioeconomy and respective business models are some of the key ways of coping with climate change. Innovative ways to transform the use of natural resources in a conscious manner are being mapped in Estonia as well as in other member states of the European Union. Comprehending the current use of biomass is essential for finding new sustainable management solutions. Acknowledging these aspects, the study explores biomass production in Estonia. One of the aspects observed during the period 2014–2017 is the proportion of the primary sector in total gross value added and the use of biomass in the food and feed industry. The results of the paper are presented in the form of Sankey diagrams, which illustrate noteworthy connections.

Key words: bioeconomy, primary sector, biomass production, regional development, innovation.

ACKNOWLEDGEMENTS. This study is a part of the research project “Maximising added value and efficient use of raw materials in bioeconomy and its sectors in Estonia”, financed under the “Strengthening of sectoral R&D (RITA)” project by the Estonian Research Council (ETAg) and the European Regional Development Fund. We would also like to thank the Government of the Republic of Estonia for continuously fuelling our hopes about raising research funding to 1% of GDP.

Bioenergy in Agricultural Companies: Financial Performance Assessment

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Abstract. The target of increasing the use of renewable energy in rural areas has initiated the investments in bioenergy. The purpose of this paper is to assess the financial performance of Estonian agricultural companies that have invested in bioenergy solutions. An investment in bioenergy is attractive to the company if the results obtained by it enable benefits to the investors. In the context of the study of financial performance of agricultural companies that have undertaken bioenergy investments, the key performance indicators based on DuPont identity are analysed from the perspective of formulating and implementing a company's financial decisions. The data of financial statements of the analysed companies are from Estonian Agricultural Registers and Information Board (ARIB) and Commercial Register. The study reports the financial performance results of Estonian agricultural companies using renewable resources and producing bioenergy: whether they achieved higher efficiency and profitability or change in financial structure. The Estonian agricultural companies that have invested in bioenergy solutions may need to control their financial performance by improving profitability and controlling financial leverage.

Key words: agricultural companies' performance, bioenergy investment, DuPont identity, renewable energy.

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Digitalization as an Essential Growth Factor Contributing in SME Development (experience of Latvia and Romania)

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Abstract. In today's global economy, entrepreneurship is an important economic growth engine for the European Union. Small and medium-sized enterprises (SMEs) are the backbone of Europe's economy, providing 85 % of all new jobs. The European Commission aims to promote entrepreneurship and improve the business environment for SMEs, to allow them to realise their full potential in today's global economy (EC.2015. COSME). The expansion of SMEs in today's environment is increasingly influenced by the use of digital networks. The present research focuses on the characteristics of digital environment use by SMEs in two EU Member States – Romania and Latvia. Groups of entrepreneurs that produced both goods and services and differed in number of the employed and geographical location were surveyed in each country. The information acquired revealed the technological and economic characteristics of the digitalization process in each country, highlighting both similarities and differences. An analysis of the data gives an opportunity to identify main priorities to enhance SME digitalization processes in the future. The first of them is the accessibility of competent workers in digitization and digitalization.

Keywords: SMEs, digitalization, economic benefits, rural viability.

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III BIOENERGY

Contribution to the energy situation in Tajikistan by using residual apricot branches after pruning as an alternative fuel

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Abstract. Lack to the energy access in the rural areas of Tajikistan during the winter is one of the current problems of the country. Growing global awareness on the negative environmental impact associated with burning of fossil fuel has launched the expansion of solid biofuels made of different biomass as an alternative to conventional fuels in many countries. The possibility of producing briquettes and pellets from diverse agriculture wastes or mixtures of raw materials are the advantages of renewable biofuels. Tajikistan's goal is to reach energy independency, and the main prospects for the country's energy sector, which is relied on energy imports during the long heating periods, are: higher exploitations of hydropower and development of other renewables, mainly biofuels. Tajikistan is highly agrarian country, where agriculture is the dominant source of income for majority of the population, especially in rural areas, and provides food and employments for the rural community. According to the FAOSTAT in 2016 Tajikistan was between the top 25 apricot producing countries in the world and 11,788 ha of apricot has been harvested. However, TAJSTAT (2017) reported in total 61,617 ha including small-scale orchards. By the Institute of Horticulture in Tajikistan about 156 trees are growing in one hectare and every year approximately 15–20 kg of branches after pruning each tree are available for utilization as biomass, which is however usually improperly wasted. Thus, the main focus of the present research was to investigate the properties (physical, chemical and mechanical) of densified/briquettes and pellets from the residual apricot tree branches through the laboratory measurements and to calculate the energy yield and potential of this material for Tajikistan, where similar study has not been conducted yet.

Key words: briquettes, energy yield, pellets, properties, waste biomass.

ACKNOWLEDGEMENTS. The research was supported by the Internal Grant Agency of the Faculty of Tropical AgriSciences, Czech University of Life Sciences Prague – grant number 20185011.

Wheat straw and lipids: UV-mutagenized *Yarrowia lipolytica* for the conversion of wheat straw hydrolysate into lipids

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Abstract: Due to the rising energy demand of our modern society and the finite amounts of petroleum-based fuels, renewable forms of energy have become extremely important. Bio-based fuels like bioethanol and biodiesel represent an already applied and accepted alternative. Biodiesel is currently mainly produced from plant oils. A new and promising alternative, which avoids the use of food crops, is the cultivation of the oleaginous yeast *Yarrowia lipolytica*, which possesses the capacity to accumulate up to 40% of its biomass in form of lipids. Moreover, this non-conventional yeast is able to metabolize a broad range of carbon-sources, presenting a sustainable alternative to reutilize a wide spectrum of waste substrates. This makes it an auspicious candidate for the generation of non-edible oils for biodiesel production. In this work, we aimed to generate a *Y. lipolytica* mutant strain with enhanced lipid production when grown on wheat straw hydrolysate as sole carbon source. Therefore, UV mutagenesis was applied and mutants with a high-lipid content were selected by their ability to grow in the presence of the fatty acid inhibitor cerulenin. Further, growth of the mutants on wheat straw hydrolysate was evaluated. The fatty acid composition was analysed by GC-FID and the calculated total lipid content revealed an up to 33% increase compared to the wild type strain. Fermentation optimisation and the combination of various waste substrates as carbon sources are expected to further increase the total lipid yield by the *Y. lipolytica* mutant strain and serve as initial point for its industrial scale evaluation.

Key words: biodiesel; UV-mutagenesis; wheat straw hydrolysate; *Yarrowia lipolytica*.

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The potential of energy recovery from by-products of small agricultural farms in Nigeria

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Abstract. Agricultural by-products are renewable energy sources from which essential amount of energy can be recovered, which can be used to replace the use of conventional fossil fuel, reduces the potential of greenhouse gas (GHG) emission and at the same time reduces deforestation, especially in rural areas. Energy values of biomass from small Agricultural farms, in particular waste generated from different tropical crops, viz; Maize, Millet, Rice, Sorghum and Groundnut were determined, to ascertain their potentials as alternative fuel sources for rural use. The materials were found to be of importance judging by their combustion potentials in all the forms investigated. The Energy values of the by-products considered ranged between 11.68 MJkg⁻¹ to 17.48 MJkg⁻¹ with Groundnut pods and millet husk having the highest and least respectively. Moisture and ash had effect on the energy values of these biomass. Our results are relevant to the problems posed by the management of farm residues in developing countries.

Key words: By-products, Energy, Tropical biomass.

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Concept of technology for management subsidiary product of methane fermentation extended of energetic aspects

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Abstract. The aim of the study was to determine the minimum content of organic carbon in the by- product of methane fermentation, i.e. a biogas digestate which would enable its rational utilization for energy purposes. The main scientific problem related to the topic discussed is to determine the characteristics of changes in the energy efficiency of the use of fermentation, together with changes in the organic carbon content of the mixture. The problem presented in this way was a premise for the formulation of a research problem aimed at determining the effect of physic-chemical composition of the ferment on its energy value. The achievement of the set scientific and utilitarian goals was carried out in several stages - for this purpose both the elementary laboratory analysis technique was used as well as advanced methods of numerical analysis were implemented.

Key words: biogas digestate, biogas plant, pellet, economics, energy balance.

Particle size and shape characterization of feedstock material for biofuel production

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Abstract. Particle size and shape are key factors influencing the properties of particulate and agglomerated materials, and having an impact on a quality as well as utilization of a final product. In case of plant biomass particle morphology is greatly irregular. Large errors at most determinations of biomass particle sizes are caused by simplification on a single parameter of size, assuming particle sphericity or circularity. Thus, the aim of a present research was to determine the particle size in a complex way. Pine sawdust as an experimental material and typical biofuel feedstock was ground by a hammer mill to a fraction size of 12 mm. The dimensional features of such ground sawdust particles were identified for all particles individually via photo-optical analysis, a method based on a digital image processing that is sensitive to irregular particles' shapes. The particles were described mainly by variables of length, max width, equivalent diameter, max and min feret diameter, sphericity, roundness, circularity together with length/width ratio and aspect ratio. Data were analysed by descriptive statistics, i.e. by arithmetic means, medians, minimum and maximum values, variance and standard deviation. The obtained results may contribute to a better knowledge of material properties needed for designing an optimal technology for the production of quality biofuels.

Key words: particle morphology, size variable, pine sawdust, photo-optical analysis.

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Physicochemical properties and agglomeration parameters of biogas digestate with addition of calcium carbonate

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Abstract. The aim of the work was to determine the physical properties of digestate from biogas production - either with or without the addition of calcium carbonate and to determine the parameters of its compaction. The material for research was obtained from an agricultural biogas plant specialized in processing cattle manure, vegetable pomace, chicken manure and maize silage. The parameters of compaction of digestate were experimentally determined and its net calorific value was calculated based on the gross calorific value. Physical properties were determined according to standards. The moisture content of liquid digestate was 96%. Mechanical separation allowed to decrease the water content by 19% and addition of 20% of calcium carbonate by 30%. It was found that digestate with addition of calcium carbonate is not suitable to use for energy purposes, because of its low net calorific value (5,2–5,9 MJ·kg⁻¹), however it can be used for fertilizer purposes in relation to its chemical composition. Without additives, the net calorific value was 14.9 MJ·kg⁻¹, but due to the high moisture content of the raw material it is unprofitable to dry it and burn. On the other hand, it was proved that it is possible to obtain pellets of appropriate density out of the digestate using 40 mm of the die height and 0.3 g of single portion of the material.

Key words: digestate, binder, pellets, fertilizer, energy.

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Use of ethanol production and stillage processing residues for biogas production

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Abstract. In Latvia, ethanol is produced mainly from wheat grains. The production process involves the formation of the by-products of wheat bran, grains residues and stillage. By-products from production of alcohol distilling dregs (stillage) contain much organic matter therefore could be useful for the production of the biogas. The product with high protein content usable for feed can be produced from the stillage too. A liquid residue is formed during the production process. Purpose of study is the assessment of the methane volume obtainable from the stillage processing residue mixed with wheat brans and grains residues in anaerobic fermentation process and from wheat brans and grains residues mixed only with inoculum. Investigation was provided in 16 bioreactors operated in batch mode at 38°C. Stillage processing residues mixed with the wheat brans and inoculum were filled into 4 bioreactors, mixed with grains residues were filled into 4 bioreactors and only inoculum was filled into two bioreactors for control. Wheat brans with inoculum were filled into 3 bioreactors. Into others 3 bioreactors were filled grains residues with inoculum. The yield of biogas from wheat brans was 1.151 L g⁻¹_{DOM} and methane 0.593 L g⁻¹_{DOM} after 30 days of anaerobic digestion. The yield of biogas from wheat brans with stillage processing residue was 1.098 L g⁻¹_{DOM} and methane 0.600 L g⁻¹_{DOM}. The yield of biogas from grains residues was 0.915 L g⁻¹_{DOM} and methane 0.451 L g⁻¹_{DOM}. The yield of biogas from grains residues with stillage processing residue was 1.01 L g⁻¹_{DOM} and methane 0.523 L g⁻¹_{DOM}. The study demonstrates that the investigated products are very good raw material for the production of methane. Stillage processing residue acted as a catalyst for the process.

Key words: methane; stillage, anaerobic digestion, wheat brans, grains residues, stillage processing residue.

The production of methane from the straw pellets by adding enzymes

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Abstract. Biogas production requires much cheaper raw materials. The use of straw, as not always the full use of agricultural residues, increases the methane yield in pelletised form compared to non-pelletised straw. Lack is the high ratio of carbon to nitrogen content of straw, which leads to a slow and incomplete breakdown of the matter, and less producing substances from which bacteria produce methane. Variety of additives can be used to improve anaerobic digestion process. This article shows the results of the study, where the enzymes alpha amylase and xylanase and catalysts Metaferm and Melafen mixture are used for the digestion process enhancement. Investigation was provided in 16 bioreactors operated in batch mode at 38°C. Additives were filled into 14 bioreactors and only inoculum were filled into two bioreactors for control. The yield of biogas from straw pellets without additives was 0.655 L g⁻¹_{DOM} and methane 0.301 L g⁻¹_{DOM} after 34 days of anaerobic digestion. The yield of biogas from straw pellets with added alpha amylase was 0.652 L g⁻¹_{DOM} and methane 0.318 L g⁻¹_{DOM}. The yield of biogas from straw pellets with added xylanase was 0.689 L g⁻¹_{DOM} and methane 0.347 L g⁻¹_{DOM}. The yield of biogas from straw pellets with added Metaferm and Melafen mixture was 0.638 L g⁻¹_{DOM} and methane 0.254 L g⁻¹_{DOM}. The study demonstrates that the adding of enzymes increases the production of methane.

Key words: anaerobic digestion, straw pellets, methane, alpha amylase, xylanase.

Review: Evaluation of new genetic toolkits and their role for ethanol production in cyanobacteria

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Abstract. Since the public awareness for climate change has risen, increasing scientific effort has been made to find and develop alternative resources and production processes to reduce the dependency on petrol-based fuels and chemicals of our society. Among others, the biotechnological fuel production, as for example fermenting sugar-rich crops to ethanol, is one of the main strategies. For this purpose, various classical production systems like *Escherichia coli* or *Saccharomyces cerevisiae* are used and have been optimized via genetic modifications. However, despite the progress made, this strategy competes for nutritional resources and agricultural land. To overcome this problem, various attempts were made in recent years with different microalgal species including cyanobacteria to directly synthesize ethanol out of CO₂ via the use of solar energy by photosynthesis. Those different approaches and studies led to several ethanol producing strains and an improved knowledge about carbon metabolism. However, compared to existing platforms, the development of cyanobacteria as photoautotrophic cell factories has just started, and accordingly, the ethanol yield of established production systems is still unreachd. On the one hand, this is mainly attributed to low ethanol tolerance levels of cyanobacteria and on the other hand, there is still potential for optimizing the cyanobacteria towards alternative gene expression systems. Meanwhile, several improvements were made by establishing new toolboxes for synthetic biology offering new possibilities for advanced genetic modifications of cyanobacteria. Here, current achievements and innovations of those new molecular tools are discussed.

Key words: biofuel, synthetic biology, expression system, *Synechocystis* sp. PCC6803.

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Properties of biofuel fly ash and capabilities of its use for agricultural needs

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Abstract. The use of various types of biomass for energy production provides great prospects for reducing the consumption of fossil fuels and the negative impact on the environment. However, the use of biomass, in particular agromass for this purpose, results in relatively large amounts of bottom ashes and fly ashes, the composition and properties of which also raise a number of additional environmental problems. The composition and properties of fly ash are investigated in the paper, taking into account the possibilities of utilizing them for soil fertilization and other applications. Fly ash samples were collected from bunkers of flue gas cleaning equipment (electrostatic precipitator and cyclones) installed after water heating boilers, which are firing wood chips and chuffed straw. The composition of fly ash was determined using Inductively Coupled Plasma Optical Emission Spectrometry (ICP-OES) and Scanning Electron Microscopy with Energy Dispersive Spectroscopy (SEM/EDS) while particle size distribution was obtained using scattered-light aerosol spectrometer. Electrical Low Pressure Impactor (ELPI) was used to separate fly ash into 14 groups by particle diameter, and the analysis of their composition showed differences in the composition of the fly ash collected in cyclones and Electrostatic Precipitators (ESP). An analysis of the composition of samples in regard to the existing heavy metals norms and considering concentrations of elements beneficial to the growth of plants, enables to prepare recommendations for fertilization. The determined alkalinity of fly ash pH 13 confirms the possibility of their use for reducing soil acidity. The analysis of fly ash composition has shown that they contain elements, important for plant growth (Ca, Mg, K, P, N, S), and their concentrations determine the further use for soil quality improvement because the amount of these elements in the acid soils is reduced.

Key words: agromass, biofuel, fly ash, chemical and physical properties.

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Study of co-culture for bioethanol production

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Abstract. Combustion of fossil fuels has become an important cause of environmental pollution as a result of greenhouse gas emission. In this regard, bioethanol production using lignocellulosic biomass has gained substantial attention for the past few decades because of its easy availability, high fermentable sugars content, and renewability along with eco-friendly nature. Despite these advantages, lignocellulosic bioethanol is not fully explored due to the lack of suitable microorganism and efficient fermentation process. *Saccharomyces cerevisiae* is used for ethanol production from hexose only while *Pichia stipitis* utilizes both sugar molecules (hexose and pentose) which exist in lignocellulosic biomass. However, *Pichia stipitis* is not preferably used due to its intolerance to ethanol and inhibitors. To overcome drawbacks associated with these microorganisms, a co-culture fermentation technology for the production of ethanol using lignocellulose has been developed as an alternative route with significant product yield. At high concentration of glucose in sugars mixture, co-culture does not work efficiently because the microorganism which consumes pentose became retarded in the presence of hexose fermenting yeast and due to intolerance to ethanol. Therefore, the concept of sequential co-culture is introduced to utilize both sugars to get improved product yield. The present study deals with the improvement in ethanol yield using sequential co-culture of *Saccharomyces cerevisiae* and *Pichia stipitis* by slightly modifying the operating condition. Firstly, the sequential co-culture was operated only under microaerobic condition throughout the fermentation. Secondly, a combination of anaerobic and microaerobic condition was used. The mixture of sugar containing 40 g/L glucose and 20 g/L xylose was used in both experiments (simultaneous co-culture and sequential co-culture). In the simultaneous co-culture, *Saccharomyces cerevisiae* and *Pichia stipitis* both were added at the same time in the reactor whereas, in sequential co-culture, *Saccharomyces cerevisiae* was added at the beginning of the fermentation for glucose utilization. After almost utilization of glucose, *Pichia stipitis* was added for xylose conversion. The obtained ethanol yield from simultaneous co-culture, sequential co-culture using microaerobic condition and sequential co-culture using anaerobic and microaerobic condition was found to be 0.344 g/g, 0.351 g/g, and 0.403 g/g, respectively. Based on the significant yield of bioethanol under a modified operating condition, a sequential co-culture with a combination of anaerobic and microaerobic condition could be effectively used to maximize ethanol production yield.

Key words: Bioethanol production, Co-culture, Sequential co-culture.

The impact of substrate – enzyme proportion for efficient hydrolysis of hay

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Abstract. Lignocellulosic substrate loading is one of the factors that directly influences overall alcohol production yields. Most of the studies that demonstrate biomass conversion technologies use low substrate loadings (< 5% solids, w/w) to ensure good wetting, enzyme accessibility and minimize any inhibitory effect of the hydrolysis products. Over the last years high-solid loadings (> 20 wt%) have been evaluated on their efficiency and applicability in conversion of various lignocellulosic substrates, especially materials that are linked with low productivity, e.g., grassland biomass. At the same time these resources do not compete with food production. The aim of this study was to evaluate the impact of substrate loading on enzymatic hydrolysis of hay with non-commercial enzyme products obtained from fungi. Increase in hay loading (1–10 wt%) had a significantly negative effect on the hydrolysis efficacy of the commercial enzyme, however, non-commercial enzyme products from fungi had no negative effect irrespective of substrate loading (> 10 wt%), thus, demonstrating the potential of these products in high loading hydrolysis technologies. Assessment of enzyme concentration demonstrated that 0.2 FPU ml⁻¹ is sufficient for the fungal enzyme mixes when biomass loading rates from 1 – 10 wt% are used and higher concentrations do not result in any significant conversion increase. Mixing impact was observed only in substrate loading > 10 wt%. The apparently positive features of the non-commercial enzyme mixes give rise to their future use. Upgrade in the technology, e.g., efficient pre-treatment, membrane purification and concentration and efficient product recovery will result in even more efficient results.

Key words: lignocellulose, enzymatic hydrolysis, white-rot fungi.

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Trace metals in anaerobic biomass digestate

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Abstract. One of the most abundant sources for alternative energy is biomass. Energy can be produced either by direct biomass combustion or alternatively using anaerobic biogas production technologies. Digestate – a by-product of anaerobic digestion can be used in agriculture or forestry as an organic fertiliser. However, due to the elevated concentrations of trace metals on-land application of the digestate can be restricted. Furthermore, the fate, chemical speciation as well as transport of trace metals in environments - often agricultural lands – is far from being understood. Metal species are formed exclusively in the extremely reducing, organic and metal rich conditions in anaerobic bioreactors. After anaerobic digestion trace metals are released into the environment via different routes of entry either suspended/dissolved in effluents or in a form of a solid biomass product. Once outside the reducing conditions of anaerobic fermenters, they will face oxidizing conditions that will influence their transformation to other thermodynamically stable species. This work aims to understand trace metal chemical speciation, redox-stability, sorption, mobility as well as bioavailability both in anaerobic technologies and in the soil environment. The total metal concentration, the conditions during digestion such as pH and redox potential, and the kinetics of reduction, precipitation, complexation, and adsorption are expected to play a key role influencing the chemical speciation of microelements in the digestate. To realize this aim, trace metal fractionation experiment was performed. Trace metal concentration and speciation was dependent upon the type of biomass used in the biogas reactor. The increasing pH decreased solubility of metals in the matrix. There were found significant differences in trace metal speciation between anaerobic environment and oxidising conditions.

Key words: anaerobic digestate, trace metals, fractionation.

Evaluation of Giant Knotweed and Bulrush as Perspective Non-Traditional Herbaceous Energy Plants and Quality Assessment of Biofuel Produced from These Plants

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Abstract. As the consumption and demand of biofuels in the Central Europe increases, Lithuania is in need to find more types of biomass that can not only be grown locally, but also produce effective results. In this study, two non-traditional herbaceous energy plants, giant knotweed (*Fallopia sachalinensis*) and bulrush (*Typha*), were chosen and the important biofuel properties of these plants, such as life cycle assessment, were investigated. Giant knotweed was chosen because it is not demanding for soil quality and is considered to be one the most effective crops in the Central Europe according to biomass yield. Likewise, bulrush is a very common plant in the region, growing on lake shores. For the study, giant knotweed and bulrush biomass was cut, chopped, milled and granulated with a small capacity granulator (250 – 300 kg h⁻¹), then the technical means of plant preparation and use for energy purposes were investigated and applied. To assess biofuel quality, the compositions of plant ash and milling fractions were determined and the granule quality indicators were measured – moisture content, density, compressive strength as well as elemental composition, ash content and calorific value. Moisture content reached 22.3 ± 0.07 % in giant knotweed pellets and 15.3 ± 0.07 % in bulrush pellets, pellet density was respectively 1057.5 ± 73.6 kg m⁻³ and 1050.0 ± 34.1 kg m⁻³, pressing force of degradation of both plant pellets reached 569.4-642.2 N. Ash content was 4.3 ± 0.01 % in giant knotweed pellets and 5.88 ± 0.06 % in bulrush pellets, net calorific value was respectively 18.96 ± 0.28 MJ kg⁻¹ and 17.43 ± 0.39 MJ kg⁻¹. These parameters meet high quality requirements for solid biofuels; biomass of both plants can be compared to wooden briquettes and pellets because of their similar mechanical and thermal properties. The production and use of giant knotweed and bulrush pellets for energy needs can be recommended to farmers and individual homeowners, in addition to commonly used pressed biofuel, such as wood waste. In order for this product to appear in the Lithuanian market, the government's attention would be needed.

Key words: knotweed, bulrush, pellets, properties, density, life cycle.

Hydrothermal carbonization and torrefaction of cabbage waste

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Abstract. In recent years, waste biomass has been increasingly becoming an energy source. The utilization of biomass includes a number of potential treatments: thermochemical, physicochemical and biochemical. In the food industry, significant amounts of biodegradable wastes are produced which have to be quickly treated to not pose an environmental problem. In this work cabbage waste (*Brassica oleracea var. capitata*) was treated by hydrothermal carbonization and torrefaction. Hydrothermal carbonization experiments were carried out in a pressure reactor vessel Berghof BR-300 (inner volume 400 ml, temperature regulation by Berghof BTC 3000). The carbonization took place at target temperatures 180°C and 225°C. Torrefaction tests were carried out in a thermogravimetric programmable oven LECO TGA701 under nitrogen atmosphere at temperatures 225°C, 250°C and 275°C. The residence time was 30 min for both processes. Proximate and elemental composition, as well as calorific value was analysed in all samples. To express the influence of the treatments on combustion behaviour, stoichiometric combustion calculations were performed. The analyses show a positive effect of both torrefaction and hydrothermal carbonization on fuel properties in the samples. Most obvious is the reduction in oxygen content which depends on the process temperature. After hydrothermal carbonization at 225°C the oxygen content was lowered by 46.7%. The net calorific value increased proportionally with temperature in both processes. After hydrothermal carbonization at 225°C the net calorific value increased on average by 3 MJ kg⁻¹ to 20.89 MJ kg⁻¹. Both tested processes significantly increased the fuel value of this biodegradable waste.

Key words: biomass, biochar, elemental analysis, energy properties

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Torrefaction – the process for biofuels production by using different biomasses

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Abstract. Torrefaction process is a mild pyrolysis, where biomass material is converted into solid fuel with higher heating value. The results of torrefaction at different temperatures in a range from 220 to 400°C for three varied materials, oak wood, mixed wood and dehydrated, granulated sewage sludge are presented. The torrefaction process started with warm up stage, which took place for 30 minutes, after that sample was torrefied for 2 hours at constant temperature. The process continued with cool down stage. The energy demands were covered by electric power, while the flue gasses were not integrated in the process. The influence of the operating temperatures are analysed in order to determine optimal operation parameters to get the torrefied biomass with highest calorific value. Furthermore, the optimal operation time according to the largest increase in calorific value for each material is evaluated. The results of calorific value, mass drop and chemical compositions such as elemental analyses are also presented. Results show that heating values increase with raising temperature for both wood samples. The heating values for sewage sludge increases to approximately 320°C, after that temperature are unchangeable. Torrefied oak wood samples were more fragile at higher temperatures in comparison to raw or torrefied oak wood samples at lower temperatures. At torrefied sewage sludge samples the changes in fragility are not detected due to pre-prepared granulates of sludge.

Key words: solid fuel, torrefaction, oak and mixed wood, sewage sludge, biomass, energetic evaluation.

IV ERGONOMICS

An analysis of influences of blinds and solar radiation on microclimate in office rooms during summer days: a pilot study

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Abstract. Windows are the only part of a building that can directly penetrate the solar radiation into the occupied space and thus the shading devices are needed to control the solar penetration. In the office buildings, they usually use external blinds and internal blinds to reduce heat gains during summer caused by sunlight as well as solar radiation. Therefore, these blinds are main part to maintain thermal comfort for office workers. The aim of this paper is to present results of measurements in four big office rooms in different situations of blinds application. Then, the influence of the internal and external blinds on the internal microclimate conditions inside the large offices during the hot summer days with high solar radiation will be evaluate. The offices floor area is from 43.3 m² to 59.5 m² and height 2.8 m. The experiments in this research were focused on measurement and evaluation of globe temperature, indoor air temperature and relative humidity at level of working place during several hot summer days. Comparison of the results of short-term measurements in a room with open blinds and closed blinds has shown the influence of the blinds on the reduction of indoor temperature. More significant was the effect of external aluminium blinds. Solar energies passing through the windows into the interior were 3,476 W without blind and 305 W in case of aluminium venetian external blinds. When the maximum outside temperature was 29.9°C and office workers used blinds with natural ventilation, the maximum air temperatures in four rooms were from 27.2°C to 28.5°C, which exceeded maximum recommended temperature (28°C). The external aluminium venetian blinds and internal fabric vertical blinds did not maintain thermal comfort inside the offices during all summer days, but it can help in reduction of energy consumption for air-conditioning.

Key words: air-temperature, glazed window, globe temperature, measurement.

Dynamics of WA incidence by severity, gender and lost workdays in Estonian agricultural sector and sub-sectors in 2008–2017

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Abstract. The risk of dying in a work-related accident is greatest for those employed in agricultural sector. The aim of this study is to analyse the dynamics of work accidents (WA) incidence by severity, gender and sick leave in Estonian agriculture in 2008-2017. Method: The database of accidents in agriculture (2008–2017) has obtained from the Estonian Labour Inspectorate (ELI). Work accidents statistics is based on official reports of employers. Results: In total 1683 non-fatal work accidents (NFWA) was registered in the past decade, from which 1235 (79.3%) were minor and 448 (20.7%) severe. In total 13 fatal work accidents (FWA) have occurred, which accounts 0.8% of all the WAs (n = 1696). Although the dynamics of minor and severe WA cases showed steady increase, the number of FWA has remained low. A major part WAs (74%) was registered in farming and horticulture, with prevalence of minor accidents. A severe WA is likely to occur in forestry or very likely in fishery. The proportion of injured male and female was 51.8% and 48.2%, accordingly. In the farming and horticulture sector there were more accidents among women - of all the minor accidents (n = 1235) 52.1% occurred to women. Of all the severe WAs (n = 448) 61.2% and all the fatal work accidents happened to male workers. About 2/3 of severe WAs caused sick leave 31-90 days and more. Conclusion: The statistics of WAs in Estonian agricultural sector show steady increase of cases in the past decade. A major part of accidents is minor and mostly occurred in farming and horticulture, and more often for females. Severe and FWAs more often occurred in forestry and fishery. Mostly the severe WAs cause long sick leave - a month or more. When to increase work accidents' severity level by one step (from minor to severe), the sick leave is increasing significantly.

Keywords: agriculture, injury, gender, occupational accident, severity, sick leave, work-related.

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Reliability of parking assistants depending on the material of detected obstacles

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Abstract. Today's modern vehicles are equipped with a range of assistance systems to enhance road safety. The standard equipment of most cars are parking assistants. It turns out that not always sensors can reliably detect the obstacle on the travel path of the vehicle. The aim of the paper is to determine the reliability of the parking sensors depending on the material of the obstacle detected. The original parking assistants of Škoda Rapid, Škoda Octavia II, and Škoda Superb have been tested in laboratory conditions using obstacles made of various materials (glass, mirror, plastic, metal, cardboard ...) located at distance of 100 cm from the vehicle. Distance values of the original sets of parking assistants were measured during the measurement from on-board diagnostic vehicle using diagnostic kit VAG-COM. The real distance was checked using a calibrated gauge. The results of the research show, that original sets of parking assistants achieve significantly more accurate results with a wider coverage of the space being scanned. Material composition of obstacles has a great influence on the reliability of parking systems. Not every material can respond properly to parking sensors.

Key words: parking sensors, assistance systems, reliability, materials.

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Work Posture Load Evaluation in Medium Size Metal Processing Enterprise in Latvia

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Abstract. The aim of this study was to evaluate the exposure of individual workers to ergonomic risk factors associated with upper, lower extremities and trunk WRMSDs and to assess entire body posture for risk of WRMSDs. The company that produces finished metal products (ironing boards) was chosen for the research. Rapid Entire Body Assessment (REBA) was used to assess the entire body posture for risk of WRMSDs. Rapid Upper Limb Assessment (RULA) method was used for ironing boards employees to evaluate exposure of the neck, trunk, arms and legs in relation to physical load. Our study proved that employees are subjected to WRMSDs due to the load on certain body parts during the work: shoulder and neck area, lower back, legs and arms. Forced work postures are an essential risk factor at work. Assemblers and packers are subduced to high risk level, but inspectors – to medium risk level, which corresponds to evaluation with RULA and REBA methods.

Key words: ergonomics, RULA, REBA, work posture, physical load

Determining the influence of factors on retroreflective properties of traffic signs

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Abstract. One of the distinguishing features of future autonomous cars is the ability to take into account and communicate with traffic infrastructure. Thereby detection and recognition of vertical traffic signing is an obvious requirement. Automatic recognition of traffic signs allows to check driver's reaction time, if it is necessary to react, and in that way to contribute to and increase the road safety. It is especially important in the darkness when the retroreflective sheeting materials on the traffic signs help to increase visibility. Unfortunately, environmental conditions around the traffic signs exert considerable influence on the sign's surface and alter their retroreflective properties. Many scientists explored different impacts on retroreflective properties of signs. Some impacts attracted more attention (such as detection distances and deterioration with age), some impacts were studied by several scientists only (such as dew and frost) and some factors were even omitted at all (e.g. the temperature during measurements of in-service signs). The paper is focused on the impact analysis of insufficiently explored factors influencing retroreflective properties of traffic signs. The findings of this research can support the development of further experimental research and could become a basis of reliable traffic signs usage on modern and smart roads.

Key words: autonomous cars, traffic safety, meteorological conditions, quality of signing.

Hygrothermal analysis of masonry wall with wool glass interior insulation

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Abstract. When the external appearance of the building is fixed due to heritage requirements the interior thermal insulation is the only possible solution for thermal upgrade of the building envelope. Applying internal insulation to existing buildings is known to pose a challenge in relation to hygrothermal risks, as this can lead to high relative humidity levels, condensation and ultimately, mould growth and decay. The case study building is under historical preservation and therefore this is not allowed to be insulated from outside. The paper describes the hygrothermal assessment of applying internal glass wool insulation and vapour barrier in masonry wall with air gap. In addition to the calculations the condition investigation was also performed. Data loggers measuring temperature and RH were applied during the period of 31.01.2013 – 16.02.2013. The conclusions were based to theoretical calculations (case study and DIN 4108-3) and practical measurement results based on the data logger values obtained. The calculations showed that glass wool and vapour barrier insulated system were in risk on condensation but the condensed water dries out during summer time. Due to the fact that logger measurements were recorded during the time when inside plastering was still in progress the relative humidity in the room was very high. As a result of calculations it is possible to build this type of wall effectively, but in this case it was not the most reliable way because of ongoing interior fitting.

Keywords: interior insulation, hygrothermal performance, energy efficiency.

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Use of Qualimetry Method in Production Labour Estimation

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Abstract. Every work process of production organization involves employees and employer interaction with each other by “agreement”. Such agreement is contracted based on the implementation of concrete types of work processes in particular workplaces. The general the total number of workplaces are continuous interaction areas of people to transform substance, energy and information. The solution of the assigned tasks requires the methodology for designing product quality, analyzing market consumer needs, forecasting potential prices and detecting effectiveness in order to present the strategic objectives in digital values. This study is part of a larger investigation which involves principles of economic metrology and qualimetry of work. The purpose of the research is to demonstrate use of qualimetry in the production organization, based on experience of several years in many industry organisations by focusing on engineering.

Key words: work, qualimetry, ergonomics, quantitative, manufacturing.

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Farm Health and Safety Adoption through Engineering and Behaviour Change

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Abstract. The agriculture sector is one of the most hazardous occupations worldwide. The EU farming population is predominantly self-employed, who are largely outside the scope of EU occupational safety and health (OSH) legislation. Utilising effective communications approaches to transmit clear messages is a possible way of motivating farmer OSH adoption. The Public Health Model (PHM) of accident causation conceptualises an accident as occurring due to multiple interacting physical and human factors while the Social-Ecologic Framework enhances the PHM by defining various levels of the social environment which are influential on persons' OSH actions. A knowledge gap exists in how farmers conceptualise accident causation. The aim of this study is to report findings of a Score Card exercise conducted among Irish farmers (n= 1151) to reveal knowledge on farmers' conceptualisation of accident causation where farmers ranked in order of importance up to five causes of farm accidents. First ranked items related to 'machinery/ vehicles', 'organisational' and 'livestock' as accident causation factors (92%). Overall rankings for up to five ranked causes identified six causes: 'machinery/ vehicles', 'organisational', 'livestock', 'slurry related', 'trips, falls, buildings-related' and 'electrical' (96.5%). The study data indicated that farmers' perceptions of accident causes were inaccurate when compared with objective fatal farm accident data. The study concluded that communicating accurate and contemporary OSH messages to farmers has potential to assist with farm accident prevention. Based on the multiple and interacting risk factors arising in agriculture it is suggested that more elaborate study of farm accident prevention is warranted.

Keywords: Agriculture, Accident, OSH, Causation, Communications, Hazard.

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Reduction of moisture and thermal conductivity of wet walls by special plaster

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Abstract. This paper is focused on the problems of moisture reduction in old buildings. Wet walls are very common problem of old buildings, but it can appear also in new buildings as well. The moisture in the wall influence the insulation quality; bigger heat losses continuously cause problems of worse heat balance, higher consumption of energy for heating and it can result in not sufficient indoor conditions in such a room or building. Old rural residential buildings and also agricultural buildings for housing of animals, storage of different materials, workshops etc. could be repaired and reconstructed by the use of some special methods. The application of special plaster can reduce the walls moisture as well as improve the thermal properties of the buildings by reduction of thermal conductivity. This paper includes the results of laboratory experiments focused on research of plaster properties (temperature, moisture and thermal conductivity) and tests provided in the real building. Different measuring principles, enabling mutual comparison of results were used for this research. The measurement results showed a significant effect of high wall moisture on the heat losses. Differences between the walls improved by new tested plaster and old untreated walls are discussed in this paper. Obtained results from this measurements and findings may be useful for further research in this issue as well as for the practical solutions for similar problems in many old buildings.

Key words: heat losses, measurement, natural material, rural buildings.

V LIVESTOCK ENGINEERING

Model for ammonia emissions' assessment and comparison of various dairy cattle farming systems and technologies

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Abstract. A dairy cattle farming is an important source of ammonia emissions, particularly in Latvia. Models using a wide range in level of detail have been developed to represent or predict these emissions. Besides, models are useful for improving the understanding of various farm processes and their interacting effects on ammonia emissions. The model for ammonia emissions' assessing or representing, predicting and comparing for manure management chain of dairy cattle was created. The model provides a tool for evaluating mitigation and management strategies, abatement measures and techniques to reduce of ammonia emissions and improve the sustainability of dairy production systems both on the dairy farm and at the national level. It could be used as a supplement tool for officials and experts. The model estimates those ammonia abatement measures and techniques that have the highest emission reduction potential and opportunities for implementation on Latvia's dairy farms. The simulation model assesses the ammonia emissions into each stage of the farming: animal housing, manure management - manure handling and storage, and manure application. An important stage in reducing ammonia emissions is manure storage. It should be noted that the main task of the model was to compare the impact of the ammonia emission reduction options. When entering the number of animals, the average nitrogen quantity per animal, the percentage distribution of manure quantities, the first three levels of the program can be used to estimate the amount of nitrogen to be incorporated into the soil and, as the difference; and the amount of ammonia emissions.

Key words: model, ammonia emissions, mitigation, dairy cattle.

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Effect of concentrate supplementation on fattening performance and carcass composition of finished meat-goat kids

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Abstract. A study on the effective usage of the concentrated feed supplement to Boer meat goat kids was carried out within the framework of the project "Zootechnical and economic efficiency of feeding of fodder pulses to ruminant's meat production". Since the Boer goat breed in Latvia is still very rare, there is a lack of experience in the feeding and production of meat goat for better carcass traits and meat quality. This study was arranged in autumn period, using the Boer cross breed male kids born in 2018. In control group (OG) four kids were kept together with mothers till finishing and were fed by oats as concentrated feed supplement. In research group (BG) four goat kids were weaned from mothers and placed in shed to explain influence of mix of 85% of oats and 15% of fodder beans as protein supplement to the fattening outcomes. In the trial kids were weighed at the starting and ending of the trial. Carcass quality is assessed according to the European standard for the classification of carcasses of sheep, where EUROP letter designations have been used to denote musculature development, and the fat deposition level is indicated by numbers 1 - 5. The length of the carcass and the circumference of the hips were measured using the tape measure. The carcasses were analyzed by type of tissue: muscle, bone, fat. The fastest growing rate during the fattening period of 72 days was given to BG kids with a mean daily live weight gain of 72 g, while the OG kids achieved 69 g. After slaughter, the carcass yield of OG kids was from 42.5% to 51.4%, but for BG kids was 38.5% to 42.5%. The quality of the obtained carcasses was an average, and score for musculature was from R to P class, but the average score for fat deposition was from 2.25 to 2.75 points and higher fat cover was observed in BG kids. Higher proportion of lean meat (59.1%) and fat tissues (16.3%) were observed to OG kids, but higher proportion of bone (25.9%) was in BG kid's carcasses. The consumption of concentrated feed for 1 kg of live weight gain indicates the conversion of feed nutrients. The consumption of oats per kilogram of live weight gain was 3.21 kg for OG kids, but the consumption of the feed mix of oats and beans for BG kids was 2.83 kg. Based on physical parameters of goat kid carcass and high level of lean meat, fattening of Boer cross breed goat kids by using of oats or feed mix can be an ideal choice for farmers, which try to find new products and free market for consumers.

Key words: kids; carcass characteristics; meat quality.

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Effect of environmental temperature during the of brooding period on growing period of pullets viscera and tibia

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Abstract. Poultry production in subtropical and tropical regions faces many problems, one of which is the high air temperature causing thermal stress, particularly dangerous in high-producing birds. Thus, the negative effects caused by heat stress (HS) must be managed. The objective of this study was to evaluate the effects of four different levels of HS in viscera and tibia of pullets. A total of 648 chicks (Lohmann LSL Lite) were used in this study in two different phases. The pre-experimental phase (PEP) was from day 1 through 6 weeks of age. The birds were reared with three different environmental temperatures: thermal comfort, hot and cold. The experimental phase (EP) was conducted from the 7th to the 17th week. Pullets from each thermal environment of the PEP were submitted to: 20°C, 25°C, 30°C, 35°C. At the end of the 17th week of age 120 pullets were euthanatized and the organs, heart, liver, spleen and gizzard were weighed, as also their tibias. Effects of PEP, and its interaction with EP, were not significant ($P < 0.05$) for viscera and tibia weight. However, a significant increase ($P < 0.05$) in heart weight with the decrease of the environmental temperature was observed, being the pullets subject to 20°C and 25°C with the heaviest weights. For the liver, pullets subject to the 35°C had the lowest weight and were different ($P < 0.05$) from the other three treatments. For gizzard, the difference ($P < 0.05$) was between the treatments 20°C and 35°C. These results indicate that brooding temperatures tested during the first 6 weeks of life did not affect the viscera and bone weight during the growing phase.

Key words: heat stress, poultry, pullet, thermoregulation, viscera.

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Temperature of Japanese quail submitted at different temperatures

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Abstract. Thermography has been gaining more space in analyzes of the superficial thermal profile of birds since it is a non-invasive way of evaluating thermal comfort. This study aims to evaluate the influence of different air temperatures (t_{air}) from 20 ° C to 32 ° C on the maximum, average and minimum surface temperature (ST_{max} , $ST_{average}$ and ST_{min}) of Japanese laying quails. The experiment was performed in four wind tunnels, where the continuous air temperature within each tunnel, 20 ° C, 22 ° C, 24 ° C, 26 ° C, 28 ° C, 30 ° C and 32 ° C represented treatment, with 20 ° C being the control treatment. Two experiments, of 21 days each, were carried out. For each experiment, we used four replicates and eight quails in each repetition, in a completely randomized design. Thermographic images of each repetition were made weekly through the Fluke Ti55 camera and analyzed using SmartView[®] software. The ST_{max} , $ST_{average}$ and ST_{min} of each repetition were obtained by delimiting the area of the quails within the cages. Significant differences were observed between ST as the room temperature increased. The ST of quails behaved similarly from 28 ° C on. Both head and feet had higher temperatures. It was possible to verify that air temperatures above 22 ° C promoted an increase in the maximum, average and minimum surface temperatures. The highest surface temperatures are found in the head and foot region.

Key words: thermal comfort, quail farming, thermal image.

Thermal comfort of pigs housed in different installations

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Abstract. In an intensive production system, the environment directly influences the comfort and welfare of pigs. Animals under heat stress may exhibit behavioural changes and changes in physiological parameters, such as increased body temperature, respiratory and cardiac movements. The aim of this study was to evaluate the thermal comfort of growing and finishing pigs housed in facilities with different construction typologies. The evaluated pens were: pen with water depth (WDP) and pen with partially slatted floor (SLF). Data on the ambient thermal environment in the pens and in the outside were collected automatically using Hobo dataloggers, model U12-013. This equipment recorded the air temperature, relative humidity of the air and black globe temperature in intervals of five minutes. Subsequently the variables were used in the calculation of the temperature index of the globe and humidity. The physiological responses of the animals were collected: Surface Temperature (ST) and Respiratory Rate (RF). When analyzing the parameters: ST and RF, it was observed that the WDP pen presented a significant difference in all the observed hours, with an increase observed throughout the day, and the SLF pen presented a difference at 9:00 a.m. presenting a lower value than the other schedules evaluated. The BGHI inside the pens showed average values in the hottest period of the day slightly above what is recommended for adult pigs. Both facilities during the hottest time of the day demonstrated a similar trend in relation to the evaluated variables, so it was concluded that both pens provided the same conditions of thermal comfort for the animals.

Key words: rural buildings, pigs, house design.

Spatial distribution of thermal variables, acoustics and lighting in compost dairy barn with climate control system

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Abstract. The main objective of this research was to evaluate the spatial distribution of the thermal variables, acoustics and lighting in climate controlled compost dairy barn. The experiment was conducted in October 2017, in a farm located in the west of Minas Gerais state, Brazil. For the study, the interior of the animal facility was divided into 120 meshes equidistant points, in which air temperature (t_{db}), relative humidity (RH), noise, illuminance, and air speed (V_{air}) were manually collected. The technique of geostatistics was used to evaluate the distribution and spatial dependence of variables. Spatial distribution maps showed the occurrence of high variability of attributes and content within the animal facility. Thermal environment variables showed alert situations throughout practically the entire facility. The noise and luminance levels were within the recommended values.

Key words: animal welfare, dairy cattle, geostatistics.

ACKNOWLEDGEMENTS. The authors are thankful to the Federal University of Lavras for this great opportunity; the Brazilian State Government Agency, FAPEMIG; the National Counsel of Technological and Scientific Development (CNPq - Brazil); Federal agency, CAPES, for their financial support.

Spatial variability of litter temperature, relative air humidity and skin temperature of chicks in a commercial broiler house

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Abstract. The thermal environment inside a broiler house has a great influence on animal welfare and productivity during the production phase. Among the importance of the chicken litter is the function of absorbing moisture, provide thermal insulation and provide a soft surface for broilers. The skin temperature is an important physiological parameter to quantify the thermal comfort of animals, its variations may occur as a function of thermal variables. So, the aim of this work was to analyse the magnitude and spatial variability of chicken litter temperature and relative humidity of the air and to correlate them with the spatial distribution of chicks' skin surface temperature throughout the broiler house during the 7th, 14th and 21st days of the chicks' life, using geostatistical techniques. The experiment was performed in a commercial broiler house located in the western mesoregion of Minas Gerais, Brazil, where 28,000 male Cobb chicks were housed. The heating system consisted of an industrial indirect-fired biomass furnace. The heated air was inflated by an AC motor, 2206 W of power, 1725 RPM. Geostatistical techniques were used through semivariogram analysis and isochore maps were generated through data interpolation by kriging. The semivariogram was fitted by the restricted maximum likelihood method. The used mathematical model was the spherical one. After fitting the semivariograms, the data were interpolated by ordinary kriging. The semivariograms along with the isochore maps allowed identifying the non-uniformity of spatial distribution of the broiler litter temperature throughout the broiler house for 3 days of chicks' life. It was observed that skin surface presented a positive correlation with the litter temperature and a negative correlation with the air humidity. The semivariograms along with the isochore maps allowed identifying the non-uniformity of spatial distribution of the litter temperature, air humidity and skin temperature of chicks throughout the broiler aviary for the three days. In addition, the use of geostatistics and distribution maps made possible to identify different environmental conditions in regions inside the broiler house that may harm the development of chicks.

Key words: environment; geostatistics; thermal comfort; physiological responses.

ACKNOWLEDGEMENTS. The authors thank the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES), the National Council for Scientific and Technological Development (CNPq), and the Minas Gerais Research Foundation (FAPEMIG) for funding the project.

Behavioural and physiological responses of rabbits

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Abstract: The profitability of a rabbit farming system must consider the thermal environment that the animal will be exposed during the productive period. The goal of this study was to evaluate the physiological responses and behaviours of 26 New Zealand rabbits during seven days of their lives at three times a day. The experiment was carried out in rabbit house in the Federal University of Lavras at Lavras, Brazil. To characterize the thermal environment sensors were used to measure the dry bulb temperature and relative humidity at 48 points inside the rabbit house, at 6:00 a.m., 12:00 a.m. and 6:00 p.m. In addition, the temperature and humidity index (THI) was calculated. The respiratory rate and the superficial temperature of the rabbits' ears were measured. Behaviour evaluations were monitored in punctual record, with duration of two min/cage. Later an ethogram was made with the main behaviours identified. Similar data of behaviour and data of physiological responses were identified by using Ward's method of cluster analysis. It was observed the period of 6 a.m. showed more comfortable conditions of THI values than the others analysed. Besides, physiological responses presented better values at 6:00 a.m. in comparison to 12:00 and 6:00 p.m. Furthermore, in general, a similar behaviour was observed in the rabbits at 12:00 and 6:00 p.m., while at 6:00 a.m. was different. But rabbits demonstrated to be more comfortable at 6 a.m. maybe because at this time environment conditions were better than the rest of the day. Besides, it can be observed that rabbits were more active in sunrise and sunset than in the rest of the day.

Key words: thermal environment, dendrogram, grouping of data, animal welfare.

Dairy farm equipped with AMS and milking parlour: Are any differences in housing conditions for dairy cows ?

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Abstract. In many dairy farms there is possible to find practical solutions, which show gradually introduced technical progress in milking area. Such farm, where one group of dairy cows is operated by automatic milking system (AMS) and the second part of cow herd is milked in herringbone milking parlour was investigated. For the investigated French dairy farm the following research problem have been put: Are any differences in housing conditions for two independent group of cows operated by two various milking systems in the same farm ? Another way it is the question about cow welfare / comfort in the farm, where two group of animals are milked by two independent milking systems. Some measurements were made in the farm including own methodology to assess housing conditions as well as other aspects deciding about cow comfort. No statistically significant differences in sizes of lying stalls for group of cows operated by AMS and milking parlour were found. In the pen with cows milked by AMS there was possible to find higher range of measured data for stalls located inside and outermost the particular rows with lying stalls. Two indices, i.e. index of pen dispersion and index of milking centre location were proposed as a contribution to analyses on cow comfort in dairy production system.

Key words: AMS, barn, cow, milking parlour, housing conditions.

Measurements of wireless detectors used to monitor animal movements in livestock farms

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Abstract. At present, there is a great interest in monitoring and automating farm animals and livestock farming. There are many systems and methods to check the movement of animals in certain areas. One option is to use motion detectors. However, some installations are so specific that they require the use of wireless motion detectors. They not only have to fulfill their functional part but also have a sufficiently strong signal that should not interfere outside the defined ISM bands. Due to the frequent deployment of different types of these detectors, research has been carried out to monitor shortcomings in frequently used types of wireless detectors. This research defines which tested detectors are fully usable according to the standards and which need to be modified by the manufacturer. Also, based on measurements, the basic risks and recommendations for the use of individual types of tested detectors are defined.

Key words: livestock, measurement, wireless, ISM band, detector.

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The course of drying and colour changes of alfalfa under different drying conditions

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Abstract. One of the conditions for successful livestock breeding and efficient livestock production is to ensure quality feed. High quality feed for livestock is alfalfa, which has a very high nutritional value and its cultivation is also important for crop production in terms of improving the soil structure and nitrogen enrichment. The aim of this paper is to inform about the experimental investigations of alfalfa drying and colour changes under different drying conditions. The results of natural convection at 27.5°C and 40% relative air humidity are compared with forced convection at 1.2 m s⁻¹ air flow velocity at the same air temperature and with results of drying by natural convection at 50°C. The dry matter content was measured gravimetrically after drying in a hot air dryer at 105°C. Higher drying rates shorten the time required for drying and earlier preservation and storage in the hayloft or in the hay bales. This reduces the risk of wetting of feed such by rain and degradation by fungi, etc. A shorter drying time is also important in terms of energy savings. The precise knowledge of the drying process and drying curves allows also to determine the appropriate time for storage and conservation for production of another type of fodder e.g. haylage or silage. The measurement results show a positive effect of higher drying speeds as well as increased air temperature. Higher drying air temperature during convection led to the partial lightening and greater yellowing of the feed.

Key words: forced drying, natural drying, moisture, spectrophotometer, temperature.

Effect of two housing systems on performance and longevity of dairy cows in Northern Italy

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Abstract. The objective of the current study was to evaluate and compare performance of dairy cows housed in compost-bedded pack barns (CBP) and free stall barns, with a focus on longevity-related parameters. Study included 30 commercial dairy farms located in the Po Valley, Italy. Twenty farms had free stall barns, among which 10 used rubber mattresses (FSM) and 10 used deep straw bedding (FSS). The remaining 10 farms had CBP. Monthly dairy herd records were obtained from the Italian DHI association for each farm included in the study over a period of one year. All farms were visited to measure characteristics and dimensions of housing facilities. Linear mixed models were used to evaluate the association between housing system and the outcome variables. In CBP total available area was larger than both in FSM and FSS. However, space per cow over the bedded pack area in CBP ($6.8 \pm 2.4 \text{ m}^2 \text{ cow}^{-1}$) was relatively low for this housing system. Milk production was similar among housing systems but somatic cell count and mastitis infection prevalence resulted to be higher in CBP than in FSM and FSS. Calving interval was lower in FSS compared with both FSM and CBP while no differences were found in number of services per pregnancy. Cows housed in CBP were older and had higher parities than those in FSM and FSS while no significant differences in herd turnover rate were detected among housing systems. Results confirm that CBP housing system may improve longevity of dairy cows, which is reported to be one of the most important motivations for building this kind of housing. Nevertheless, CBP housing can pose some challenges in achieving adequate udder health and high milk quality, especially with low space per cow.

Key words: compost-bedded pack barns, freestall, cows, animal welfare, longevity.

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Investigation of fly larvae *Lucilia Caesar* application in pet feed composition

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Abstract. Internationally, the biomass of insect larvae is widely used as a valuable raw material for the pharmaceutical, microbiological, cosmetic industry and feeding production, also in the food industry. There is certain complex technology for processing biomass of insect larvae, which affords to isolate many physiologically active substances - chitin, antimicrobial peptides, fatty acids mixture, organic forms of mineral substances, hormones, etc. In Russia, the company New Biotechnology (Lipetsk) has developed a technical process for producing a dry product (commercial name is Zooprotein) based on the fly of the species *Lucilia Caesar*. The utilization of food waste as a substrate, unpretentiousness to cultivating environment and high protein content are capable of considering insects of this species as a promising object of cultivation and a reliable, cheap and replenishable source of nutrients for resource-saving feeds. Currently, on the basis of ITMO University, investigation is being conducted on the qualitative composition of the Zooprotein and the possibility of pet feed application. Cats are the most demanding animals to the quantitative and qualitative composition of protein fractions of feed. In this research an evidence-based calculation of the balance of the Zooprotein composition is presented as a feed component for adult cats. Additionally, the functional and technological properties of Zooprotein were assessed in comparison with other commonly used ingredients in the feed industry. Accordingly, the unique chemical composition of the development product based on fly larvae *Lucilia Caesar* makes possible to maintain that it is a promising functional ingredient for feeding rations for various animal species.

Key words: fly larvae; *Lucilia Caesar*; pet feed; water holding capacity; fat holding capacity; nutrients; feed additive; microbial quality.

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Geostatistics applied to evaluation of thermal conditions and noise in compost dairy barns with different ventilation systems

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Abstract. The objective of this work was to evaluate the spatial distribution of thermal conditions and bed variables in compost dairy barns with different ventilation systems, through the technique of geostatistics. The experiment was conducted in April 2017, in farms located in Madre de Deus, Minas Gerais, Brazil. Three facilities were evaluated with different ventilation systems: natural (NV); mechanical of low volume and high speed (LVHS); and mechanical of high volume and low speed (HVLS). The interior of the premises was divided into 40 meshes equidistant points, in which air temperature, relative humidity and air speed were manually collected. Geostatistics technique was used to assess the spatial dependence of the variables. The results showed the occurrence of dependence and spatial variability of the variables evaluated. Based on thermal comfort indexes, it was concluded that dairy cows were under stress conditions during the hottest hours of the day in the three animal facilities evaluated. The results obtained allow us to understand that the thermal environment is more influenced by the ventilation system adopted.

Key words: animal welfare, dairy cattle, compost barns, geostatistics.

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Most appropriate measures for reducing ammonia emissions in Latvia's pig and poultry housing

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Abstract. New goals of ammonia emissions reduction for each of EU Member State, including Latvia, were approved by the EU Directive 2016/2284/EU ‘on the reduction of national emissions of certain atmospheric pollutants’. Agriculture sector, particularly livestock farming, is the main source of these emissions. Besides, the implementation of modern or intensive animal rearing/breeding technologies causes the increase of emissions in Latvia. Therefore, more effective ammonia abatement measures or techniques should be chosen for implementation in Latvia to reach the objectives. The description and benefits of such measures are provided in the guidelines and recommendations developed and approved by the United Nations Economic Commission for Europe (UNECE) and the European Commission. However, all of these recommendations are not applicable in Latvia. Therefore, the aim of research was to find most appropriate ammonia emissions abatement measures for pig and poultry farming in Latvia. The study was focused on the intensive pig and poultry farming, particularly animal housing. Evaluation or assessment of most appropriate ammonia emissions’ reduction measures was conducted using an expert method. The results of the study indicate that it is possible to ensure reduction of ammonia emissions by comparatively simple and less expensive options that could be more or less easy implemented (e.g. ensuring cleanness in the livestock building, periodical removal of manure, covering of poultry litter or solid manure stockpiles with plastic sheeting, etc.). Even more effective reduction of ammonia emissions can be achieved by implementation of measures, which require significant investments, as well as additional operating costs.

Key words: ammonia, abatement measures, survey, housing.

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Enrichment of the grains from rye wort after shock-activator-disintegrating processing

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Abstract. In this study, the mode of obtaining grains (pellets) from wort prepared from rye processed by the shock-activator-disintegrator (SAD), has been developed. Additionally, the enrichment of the grains by proteins using the strain of yeast producing proteins was carried out. For cultivation of a pure culture of a strain of yeasts producing proteins, grains with a concentration of 43.00 g 100 g⁻¹ reducing substances and 62.71 mg g⁻¹ of the total amount of amino acid were used. Different concentrations (10%, 20%, 30% and 40% by weight of the grains) of filtrate 24.90% dry matter, 21.00 g 100 g⁻¹ reducing substances and 10.82 mg g⁻¹ of the total amount of free amino acid was added to the grains. As nitrogen and phosphorus-containing mineral feed, diammonium phosphate was added to the nutrient medium. To obtain a pure culture of *Candida tropicalis*, SK-4 yeast strain was isolated. The content of crude protein and the concentration of amino acids were determined. The morphological state of the cells was assessed. The results of this study show that to prepare the nutrient medium for a pure culture of a strain of protein microorganisms-producers and its cultivation, it is necessary to add 30% of the filtrate to the grains, while the proportion of crude protein in the protein-containing additive reaches more than 40%. The resulting protein-enriched product has a balanced amino acid composition, which is of interest as a protein-containing feed additive and its fine particle size distribution allows its use for feeding farm animals

Keywords: shock-activator-disintegrator (SAD), rye filtrate and grains (pellets), proteolytic enzyme complex, *Candida tropicalis*, protein-enriched product.

Possibilities of Monitoring Cattle via GSM and A-GPS

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Abstract. Nowadays, people and things can be localized using GNSS (Global Navigation Satellite System) or GSM technology. Devices using Differential Global Positioning Systems may not be suitable for their computing and energy intensity. The GSM and A-GPS systems have certain limitations and disadvantages. They are different in accuracy, energy intensity and therefore they are suitable for different applications. Trackers can't be effectively used to locate animals, monitor their movements, and observe their behaviour. They can also be used to search for stolen pets and farm animals. Unguarded herds of cattle are often the target of thieves. For reasons of crime, localization was tested by devices using GSM and A-GPS technology. Specifically, the quality of these localization methods has been tested. Has been addressed above all, accuracy, reliability, speed and consistency of individual methods. In addition, further measurements were made. Localization has been tested in different well-defined environments. This makes it possible to judge the quality of individual localization technology and to suggest the best use of individual technologies and their link.

Key words: localization, tracking, cattle care.

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A software to estimate heat stress impact on dairy cattle productive performance

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Abstract. The aim of this study is to develop a computational tool, based on the Temperature and Humidity Index value, to characterize the thermal environment in dairy cattle barns and to evaluate the impact of thermal stress on productive performance. The software for the thermal environment prediction, and determination of the influence of heat stress on dairy cow productivity (Ambi + Leite) was developed using the C# programming language in the Microsoft Visual C# 2010 Express Integrated Development Environment. The following scenario was considered for the program test: air temperature 32°C, relative air humidity 70% and milk production potential in thermoneutrality condition 20 kg cow⁻¹ day⁻¹. The prediction of the thermal environment based on the simulated situations indicates that the animals are submitted to a moderate heat stress condition with THI equal to 82.81. In this condition a decrease of approximately 26% in milk production and a reduction of 4 kg cow⁻¹ day⁻¹ in food intake was calculated. In conclusion, the developed software can be a practical tool to assist the producer in making-decision processes.

Key words: Thermal environment, THI, dairy cows, software.

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Assessment of selected parameters of automatic and conventional equipment used in cattle feeding

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Abstract. A cattle farming is a very important sector of agriculture. In the Czech Republic, both breeds with “combined useful” as well as “meat cattle” are breeding, but especially “dairy cattle” breeds. Providing feed at the right time, in required quantity and quality is the basis of successful breeding, especially in breeding dairy cows. Automatic systems are present in almost all sectors of human activity, and livestock production is no exception. Fully automatic feeding systems for pigs or poultry are already in use. The process of milking cattle using automated milking systems is also sufficiently mastered. An interesting trend is the installation of automated feeding systems for cattle feeding. They are stationary lines that perform the following operations: they dose the individual components of the feed mixture, mix the feed mixture and distribute it to the relevant feed places. All these activities are usually done without the presence of a person. The automated feeding system Lely Vector and the conventional feeding system using feeding wagon Cernin were compared. The number of automated feed wagon runs has been monitored and then the feed consumption was compared while using automatic and conventional equipment. The aim of this paper is to evaluate the benefits of an automatic feed system with regard to the conventional feed system through a mobile feed car.

Key words: cattle, feed, silage, feeding, conventional feeding system, automated feeding system.

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Computational fluids dynamics (CFD) in the spatial distribution of air velocity in prototype designed for animal experimentation in controlled environments

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Abstract. Maintaining a comfortable and productive thermal environment is one of the major challenges of poultry farming in tropical and hot climates. The thermal environment encompasses a number of factors that interact with each other and reflect the actual thermal sensation of the animals. These factors characterize the microclimate inside the facilities and influence the behaviour, performance and well-being of the birds. Thus, the objective of this study is to propose and validate a computational model of fluid dynamics to evaluate the spatial distribution of air velocity and the performance of a system designed to control air velocity variation for use in experiments with birds in controlled environment. The performance of the experimental ventilation prototype was evaluated based on air velocity distribution profiles in cages. Each prototype consisted of two fans coupled to a PVC pipe 25 cm in diameter, one at each end of the pipe, with airflow directed along the entire feeder installed in front of the cages. The contour conditions considered for the simulation of airflow inside the cage were air temperature of 35°C at the entrance and exit of the cage; air velocity equal to 2.3 m.s⁻¹ at the entrance of the cage; pressure of 0 Pa. The model proposed in this study was representative when compared to the experimental measurements, and it can be used in the study of air flow behaviour and distribution for the improvement of the prototype design for later studies.

Key words: Computational Fluids Dynamics, air velocity, ventilation, poultry farming.

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PIGSYS – improving pig system performance through a whole system approach

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Abstract. Current European Union pig production sector has suboptimal resource utilisation, resulting in unnecessarily high emissions and wastes. This has much to do with outdated building standards, climate control systems and barn management approaches. At the same time animal welfare is of increasing concern, farmers are struggling to maintain economic competitiveness and the public image of the sector is poor. Whilst there are many approaches for the improvement of individual aspects of the system, none provide effective whole system consideration. PigSys is an ERA-NET (European Research Area Network) SUSAN (Sustainable Animal Production) funded project that is addressing these issues by the adoption of a multi-disciplinary, system level approach to pig production systems. A system model of mass and energy flows and Decision Support System, as well as novel building climate control systems, are under development to underpin a sustainable improvement in system performance. By taking a cross-scale, multi-disciplinary approach, the project will ensure that all aspects relevant for the development of sustainable, socially acceptable and economically viable pig production systems are adequately addressed. The geographical and climatic balance, with partners from different European regions, and including France, Germany and Denmark as three of the five biggest European pig producers, will ensure the relevance of the project across the EU and beyond. PigSys will provide the sector with (a) a whole system model of energy and mass flows and decision support system (DSS); (b) measurement and control devices for improved barn climate control and animal welfare; (c) “big data” to support barn and control system design; (d) sound LCA and LCCA; (e) increased animal welfare and performance; (f) increased sustainability of production through increased resource efficiency; (g) reduced emissions, waste and carbon footprint; (h) improved public perception of the sector and decreased product prices; (i) increased competitiveness of the sector. Latvian partner of the PigSys project is responsible for development of a unified data warehouse for a cloud-based data storage and processing with the option of data analysis and support by decision support system (DSS), as well as to provide a scalable platform for distributed and flexible processing of different livestock object data.

Key words: integrated pig production system, decision support system, image based climate control and early warning system, animal performance and welfare.

Alternative form to obtain the black globe temperature from environmental variables

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Abstract. Reaching thermal comfort conditions of animals is essential to improve well-being and to obtain good productive performance. For that reason, farmers require tools to monitor the microclimatic situation inside the barn. Black Globe-Humidity Index (BGHI) acts as a producer management tool, assisting in the management of the thermal environment and in decision making how protect animals from heat stress. The objective of this work was to develop a mathematical model to estimate the black globe temperature starting from air temperature, relative humidity and air velocity. To reach this goal, data of air temperature and humidity were collected, with the aid of recording sensors. The black globe temperature was measured with a black copper globe thermometer and the air velocity was monitored with a hot wire anemometer. Data were analysed using a regression model to predict the black globe temperature as a function of the other variables monitored. The model was evaluated, based on the significance of the regression and the regression parameters, and the coefficient of determination (R^2). The model proved to be adequate for the estimation of the black globe temperature with $R^2 = 0.9166$ and the regression and its parameters being significant ($p < 0.05$). The percentage error of the model was low (approximately 2.2%). In conclusion, a high relation between the data estimated by the model with the data obtained by the standard black globe thermometer was demonstrated.

Key words: thermal comfort, black globe temperature, Black Globe-Humidity Index, animal housing.

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VI PRECISION AGRICULTURE

Comparison of lycopene and β -carotene content in tomatoes determined with chemical and non-destructive methods

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Abstract. Tomatoes are one of the most popular vegetables due of their wide use as food. Tomatoes are not only tasty fruit, but one of its benefits - high carotenoids content is well-known. Non-destructive analyses methods are used more and more in different industries. It is cheaper, faster and environmentally friendly way of analyse than traditional chemical methods. But these methods need references to the traditional ones. The aim of this study was to find the correlation between lycopene and β -carotene content in tomatoes determined with reflectance spectrometer and extraction of pigments. Content of two carotenoids (lycopene and β -carotene) was determined in 27 varieties of tomatoes. Red, pink, orange, yellow and brown fruits were included in experiment. Reflectance spectrums of tomatoes fruits were obtained with remote sensing portable spectroradiometer RS-3500 (Ltd.Spectral Evolution). Tetrahydrofuran was used for extraction of pigments. Absorption spectra of extract were obtained by spectrophotometer UV-Vis -1800 (Ltd. Shimadzu). Linear regression analyses were performed to correlate spectral data with lycopene and β -carotene concentrations measured by pigment extraction. The best reflectance region for lycopene spectral detection was 570 ± 5 nm, but for β -carotene 487 ± 5 nm. Reflectance indexes for both pigments were worked out. High linear correlation ($R^2 > 0.9$) between spectral parameters and lycopene concentration was detected. Correlation between results obtained with methods used for β -carotene determination was lower and depended of colour of tomatoes fruits.

Key words: *Lycopersicon esculentum*, , reflectance spectrum, reflectance index.

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RGB vegetation indices applied to grass monitoring: a qualitative analysis

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Abstract: In developing countries such as Brazil, research on low-cost remote sensing and computational techniques become essential for the development of precision agriculture (PA), and improving the quality of the agricultural products. Faced with the scenario of increasing production of emerald grass (*Zoysia Japônica*) in Brazil, and the value added the quality of this agricultural product, The objective of this work was to evaluate the performance of RGB (IV) vegetation indices in the identification of exposed soil and vegetation.. The study was developed in an irrigated area of 58 ha cultivated with emerald grass at Bom Sucesso, Minas Gerais, Brazil. The images were obtained by a RGB digital camera coupled to an remotely piloted aircraft. The flight plan was setup to take overlapping images of 70% and the aircraft speed was 10 m s⁻¹. Six RGB Vegetation index (MGVRI, GLI, RGBVI, MPRI, VEG, ExG) were evaluated in a mosaic resulting from the images of the study area. All of the VIs evaluated were affected by the variability of lighting conditions in the area but MPRI and MGVRI were the ones that presented the best results in a qualitative evaluation regarding the discrimination of vegetation and soil.

Key words: ARP; emerald grass; index vegetation RGB.

ACKNOWLEDGMENTS. We thank Itograss Agrícola, the Brazilian Federal Agency for Support and Evaluation of Graduate Education (CAPES), the National Council for Scientific and Technological Development (CNPQ), the Federal University of Lavras (UFLA), and the UFLA Office of Graduate Studies (PPGEA-UFLA) for their support in the development and presentation of this study.

Principal components in the study of soil and plant properties in precision coffee farming

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Abstract. In this work, a principal component analysis was performed to evaluate the possibility of discarding obsolete soil and plant variables in a coffee field to eliminate redundant and difficult-to-measure information in precision coffee farming. This work was conducted at Brejão Farm in Três Pontas, Minas Gerais, Brazil, in a coffee field planted with 22 ha of Topázio cultivar. The evaluated variables were the yield, plant height, crown diameter, fruit maturation index, degree of fruit maturation, leafing, soil pH, available phosphorus (P), remaining phosphorus (Prem), available potassium (K), exchangeable calcium (Ca²⁺), exchangeable magnesium (Mg²⁺), exchangeable acidity (Al³⁺), potential acidity (H + Al), aluminium saturation (N_(Al)), potential CEC (CECp), actual CEC (CECa), sum of bases (SB), base saturation (BS) and organic matter (OM). The data were evaluated by a principal component analysis, which generated 20 components. Of these, 7 representing 88.98% of the data variation were chosen. The variables were discarded based on the preservation of the variables with the greatest coefficients in absolute values corresponding to the first component, followed by the variable with the second highest absolute value corresponding to the second principal component. Based on the results, the variables V, OM, fruit maturity index, plant height, yield, leafing and P were selected. The other variables were discarded.

Key words: Multivariate analysis, coffee plant, precision agriculture, fertility, management.

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Spatial variability of soil fertility attributes and productivity in a coffee crop farm

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Abstract. Coffee cultivation is of great importance to Brazilian agribusiness, as coffee occupies extensive production areas and is one of the most exported Brazilian products. To maintain coffee production numbers, productive techniques must be adopted that optimize productive system use. The objective of this work was to apply geostatistical techniques in the evaluation of soil fertility attributes to construct maps of variability in soil fertility parameters and the productivity of a coffee crop in the municipality of Monte Carmelo, Minas Gerais (MG), Brazil. The work was developed with coffee of the cultivar Mundo Novo 379/19, and 19 sample points were georeferenced in Universal Transverse Mercator coordinates. Spatial dependence of the fertility and productivity parameters was analysed via classic semivariogram fitting and interpolation by ordinary kriging using the statistical computer system, R. All parameters evaluated showed high degrees of spatial dependence. The attribute values varied along the sampling points, except for the sodium (Na) contents, which had similar values in all samplings. The studied parameters ranged from 80 to 200 metres. It is conclusion, the use of productivity maps linked to soil chemical attributes can be useful for determining the occurrence of variable productivity rates throughout the area, allowing the adoption of corrective practices for subsequent crops and thus making the maps very useful tools for producers.

Key words: Precision coffee cultivation, Geostatistics, Spatial maps, Semivariograms.

Morphological variability of *Botrytis cinerea* – causal agent of Japanese quince grey mould

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Abstract. *Botrytis cinerea* is a causal agent of grey mould that damages many species of plants including Japanese quince (*Chaenomeles japonica* (Thumb.) Lindley ex Spach). Grey mould has been found on *Chaenomeles spp.* flowers, fruits in all stages as well as on twigs. Morphological variability within *Botrytis* species has been previously reported in the literature but no research information is available about similar studies in *B. cinerea* isolated from *Chaenomeles spp.* The aim of this study was to determine the occurrence of *Botrytis sp.* among isolates of fungi obtained from samples collected in commercial plantations of Japanese quince in Latvia and to clarify their morphological variability. Samples of plant parts with fungal disease symptoms were collected in eight commercial plantations of Japanese quince during vegetation seasons of 2017 and 2018. Totally 292 isolates of fungi were isolated from damaged shoots, inflorescences, leaves and fruits of Japanese quince plants, using Potato dextrose agar. Isolate identification was done based on the morphological characteristics of the colony and using a microscope. *B. cinerea* was found on shoots, leaves and fruits but not observed on inflorescences. During the investigation, 19.9% of all isolates were identified as *B. cinerea*. The largest proportion of *B. cinerea*. (32.6%) has been detected between isolates obtained from damaged shoots. The isolates of *B. cinerea* were classified into distinct morphological types depending on characteristics of mycelia, sclerotia, reverse side of media and presence or absence of sporulation. The research was financed by the ERDF project “Environment-friendly cultivation of emerging commercial fruit crop Japanese quince (*Chaenomeles japonica*) and waste-free methods of its processing”.

Key words: *Chaenomeles spp.*, grey mold, occurrence, morphological type, sclerotia.

Assessment of production zones modelling accuracy based on satellite imaging and yield measurement of selected agriculture plot

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Abstract. Currently, remote sensing or yield monitor equipment offer possibilities how to estimate productivity of the agriculture field. That is why the main aim of this study is to assess how the latest satellite images from vegetation season and final yield data from combine harvester can be used to predict yield and to assess site-specific zones productivity. The study is focused on the accuracy of these systems for the field productivity estimation. The 24.7 ha experimental field is located near to Vendolí village (the Czech Republic) and it is cultivated by conventional agricultural practices with emphasis on typical agricultural crops growing in the Czech Republic (winter wheat, spring barley and winter rape). The results showed that both methods of estimation can be used for yield prediction. Nevertheless, each of them need specific processing and has typical limitations.

Key words: Spectral indices, yield data, growth stages, geoinformatics.

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Controlled traffic farming delivers better crop yield of winter bean as a result of improved root development

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Abstract. This paper reports on the continuation of a long-term experiment on the effects of alternative field traffic systems (STP-random traffic with standard tyre inflation pressure, LTP-random traffic with low tyre inflation pressure and CTF-controlled traffic farming) on soil conditions and crop development as influenced by different tillage depths (DEEP-250mm, SHALLOW-100mm and ZERO-tillage), in a randomised 3x3 factorial design in 4 replicates launched by Harper Adams University in Edgmond, UK, in 2011. The results from season 2017/2018 revealed that CTF delivered 8% higher crop yield of winter field bean (*Vicia faba*) cv. *Tundra* comparing to STP ($p=0.005$), i.e. 4.13 vs 3.82 tonnes ha⁻¹ respectively (at 14% moisture content). The ZERO-tillage plots featured significantly lower plant establishment percentage comparing to shallow and deep tillage: 79% vs 83% and 83% respectively ($p=0.012$). The research showed that roots traits differed significantly between contrasting traffic at depths greater than 50mm with $p<0.05$ of: tap root biomass, number of lateral roots, biomass of lateral roots as well as total root biomass (tap+lateral roots), delivering significantly greater values of those before mentioned parameters on CTF comparing to STP. Tap root length significantly differed between traffic systems ($p<0.001$) giving significantly greater results on CTF comparing to LTP and STP (17.7, 13.4 and 12.6 mm respectively). Significant differences in tap root diameter were found only at the depth of 100mm ($p<0.001$) where again CTF delivered significantly higher root diameter than the remaining 2 traffic systems.

In the shallow layer of soil (0-50mm) a significant difference was found only for tap root biomass, for interactions, where STP ZERO gave significantly higher results than STP SHALLOW and CTF SHALLOW (1.430, 0.733 and 0.716 g respectively).

Key words: Soil compaction, random and controlled traffic farming (CTF), standard and low tyre inflation pressure, *Vicia faba*, root morphology.

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Properties of soil and peat humic substances from Latvia

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Abstract. The acidity, elemental, functional and spectral (UV, fluorescence, IR spectra) characteristics of humic substances isolated from soils of different origin and peat in Latvia are described and compared with values common for humic substances of different origin, to evaluate the character of processes during humification. Substantial dependence of properties of humic substances on the humification conditions are found.

Key words: humic substances; soil; peat.

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A research on models of the photosynthetic light response curves on the example of evergreen types of plants

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Abstract. The peculiarities of CO₂ exchange in the leaves of ornamental evergreen plant species that are common in the Southern coast of Crimea were studied: *Nerium oleander* L., *Laurus nobilis* L., *Aucuba japonica* Thunb., and *Melissa officinalis* L. The results of approximation of the most commonly used four models of P_N/I curves with the measured data were compared. The values of the parameters P_{gmax} , $\phi_{(I_{comp})}$, R_D , I_{max} , which were calculated from the modified Michaelis-Menten model in comparison with the measured values were higher by 5–15%, and those that were calculated by the hyperbolic tangent model – lower by 3–13 %. The use of a modified rectangular hyperbola model, which is capable of describing the photoinhibition by the nonrectangular hyperbola and the modified nonrectangular hyperbola model, showed a high degree of adequacy of the proposed models for describing the true dependence between the rate of photosynthesis and the light intensity for *Nerium oleander* L., *Laurus nobilis* L., *Aucuba japonica* Thunb. and *Melissa officinalis* L. Measurements of CO₂ exchange in leaves under similar environmental conditions showed significant differences in the parameters of the P_N/I curves: the light compensation point, the rate of photosynthesis and dark respiration, light saturation, and quantum yield. The highest values of photosynthesis efficiency were observed in *Nerium oleander*, the lowest values in *Aucuba japonica* – the light saturation was noted at a very low photosynthetically active radiation. The lower values of the light compensation point and the saturation constants in *Laurus nobilis* and *Aucuba japonica* indicate their effective use of the photosynthetically active radiation, which allows them to survive in conditions of durable shade.

Keywords: evergreen species, CO₂ gas exchange, photosynthetic light response curves, fitting, nonlinear regression.

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Effect of Nitrogen Rate and Forecrop on Nitrogen Use Efficiency in Winter Wheat (*Triticum aestivum*)

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Abstract. Application of plant nutrient is one of the most important measures increasing grain yield and yield quality. Excessive application of nitrogen fertilizers leads to nitrogen leaching and it affects the quality of groundwater and surface water. The objective of this research was to evaluate the effect of nitrogen fertilizer rate on nitrogen use efficiency in winter wheat after two forecrops. The experiment was conducted at the Research and Study farm ‘Pēterlauki’ of Latvia University of Life Sciences and Technologies (56° 30.658’ N and 23° 41.580’ E) in four growing seasons: 2014/2015, 2015/2016, 2016/2017 and 2017/2018. Researched factors were crop rotation (wheat/wheat and oilseed rape (*Brassica napus* ssp. *oleifera*)/wheat) and five nitrogen fertilizer rates (kg ha⁻¹): N0 or control, N60, N120(90+30), N180(90+60+30) and N240(120+60+60). Nitrogen fertilizer affected winter wheat grain yield significantly ($P < 0.001$) and average grain yield increased significantly ($P < 0.049$) until nitrogen rate N180. But analyzing it after each forecrop separately, yield increased significantly ($P < 0.05$) until N120 after both forecrops. Nitrogen fertilizer affected nitrogen use efficiency (NUE), nitrogen uptake efficiency (NUpE), nitrogen utilization efficiency (NUtE) and protein content significantly ($P < 0.001$). When increasing nitrogen fertilizer rate NUE, NUpE and NUtE decreased, and higher results were observed at the lowest nitrogen rates. Increased nitrogen fertilizer rate also increased crude protein content in grain, and for bread baking suitable grain was obtained only with the highest N rate: N 240. Forecrop did not affect winter wheat grain yield, however, it affected NUtE ($P < 0.01$), NUE ($P < 0.001$) and nitrogen harvesting index ($P < 0.001$) significantly; higher results were observed when wheat was grown after wheat.

Key words: forecrop, nitrogen fertilizer, winter wheat, nitrogen use.

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The efficiency of humic growth stimulators in pre-sowing seed treatment and foliar additional fertilizing of sown areas of grain and industrial crops

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Abstract. The aim of the research was to establish the effectiveness of preparations, made on the basis of humic and fulvic acids on the yields of crops in case of different methods and amounts used. The experiments were held with varieties and hybrids of winter wheat, soya, corn, and sunflower. Based on the obtained results of investigation during the period of 2015-2017, the positive impact of foliar additional fertilizing with 4R Foliar Concentrate growth stimulator on the basis of humic and fulvic acids on the formation of productivity of the main crops sown areas was established. Proceeding from the results of the research, the using of growth stimulators based on humic and fulvic acids, which contain high concentrations of these substances, can be recommended as an expedient and efficient measure of raising the productivity and improving qualitative indicators of corn, sunflower, soya, and winter wheat yields.

Key words: fertilizing, humic substances, plant development, seed treatment.

Influence of the assimilation apparatus and productivity of white lupine plants

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Abstract. Artificial regulation of the growth and development of cultivated plants aimed to increase biological productivity and improve the quality of eco-friendly products is an important goal of modern agricultural production. Application of the natural growth stimulators and bacterial agents is quite relevant and effective. The field research was conducted on the basis of the research farm “Agronomichne” of Vinnytsia National Agrarian University, village Agronomichne, Vinnytsa district, Vinnytsia region, Ukraine. Features of the growth and development of white lupine (*Lupinus albus L.*) plants are examined. There has been established a positive effect of the combination of inoculation with the bacterial agent and growth stimulator on the productivity of white lupine, which is important for the formation of high and stable yields. The papers presents the results of studies on the effect of pre-sowing seed treatment and foliar nutrition under conditions of the right-bank Forest-Steppe of Ukraine on the assimilation apparatus of white lupine plants. It has been established that bacterial agents and growth stimulators increase white lupine productivity due to optimization of the studied technological methods of cultivation. The optimal leaf surface area that provided maximum grain yield has been determined. The research has established a positive effect of pre-sowing seed treatment with the bacterial agent Rhizohumin and the growth stimulator Emistym C and foliar nutrition with Emistym C on the chlorophyll content in the white lupine leaves. The influence of the investigated technological methods on the formation of the assimilation surface area and chlorophyll synthesis in the leaves of white lupine has been proved. The preparations studied induce intensive development of the photosynthetic apparatus, yield increase, improvement of the yield structure and they improve grain quality under conditions of right-bank Forest-Steppe of Ukraine. The issue of seed bacterization and application of growth stimulators requires a more detailed study. Therefore, such researches are relevant and significance in terms of both practical and scientific value.

Key words: white lupine, assimilation apparatus, chlorophyll, variety, productivity, growth stimulator, seed bacterization.

Variety, Seeding Rate and Disease Control Affect Faba Bean Yield Components

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Abstract. Faba beans (*Vicia faba* L.) have been grown since 8000 years B.C. in the Middle East. Despite their long growing history in the world, there are only few researches carried out in Baltic region in last decades about variety, seeding rate and disease control effect on faba beans' growth, development and yield formation. Research was carried out at the Latvia University of Life Sciences and Technologies during 2015–2017. Three factors were researched: A – variety ('Laura', 'Boxer', 'Isabell'), B – seeding rate (30, 40 and 50 germinate able seeds m⁻²), C – treatment with fungicide (with and without application of fungicide Signum (1 kg ha⁻¹)). Meteorological conditions were diverse and sometimes caused stress for crop, but in general they favoured faba beans' growth and development. High average yield of the field beans was obtained during all three trial years, however, yield differed significantly among them. Sowing time was constantly quite early, germination took longer time as expected due to the low air temperature, but later, temperature and humidity level improved and conditions were suitable for plant growth and development with some exceptions during flowering and pod filling. Number of productive stems per 1 m² was significantly affected only by seeding rate. Plant height in trial site was affected by variety ($p < 0.001$), fungicide application ($p = 0.008$) and meteorological conditions ($p < 0.001$) of the year. Number of pods per plant differed depending on trial year ($p < 0.001$). Number of seeds per plant had a close positive correlation with number of pods per plant. Whereas number of seeds per pod was a relatively stable and typical characteristic for variety. We can observe correlation between faba bean yield and number of productive stems per 1 m² at harvest, plant height, number of pods and seeds per plant.

Key words: field beans, agrotechnology, phenology, yield components.

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Analysis of flight parameters and georeferencing of images with different control points obtained by RPA

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Abstract. New techniques for analysing the earth's surface have been explored, such as the use of remotely piloted aircraft (RPA) to obtain aerial images. However, one of the obstacles of photogrammetry is the reliability of the scenes, because in some cases, considerable geometric errors are generated, thus necessitating adjustments. Some parameters used in these adjustments are image overlaps and control points, which generate uncertainties about the amount and arrangement of these points in an area. The aim of this study was to test the potential of a commercial RPA for monitoring and its applicability in the management of and decision-making about coffee crops with two different overlaps and to evaluate geometric errors by applying four grids of georeferenced points. The study area is located in an experimental Arabica coffee plantation measuring 0.65 ha. To capture the images, the flight altitude was standardized to a 30 m altitude from the ground, and a constant travel speed of 3 m/s was used. The treatments studied were two combinations of image overlap, namely, 80/80% and 70/60%. Six points were tracked through Global Navigation Satellite System (GNSS) receivers and identified with signs, followed by an RPA flight for image collection. The obtained results indicated distinct residual error rates pointing to larger errors along Cartesian axis Y, demonstrating that the point distribution directly affects the residual errors. The use of control points is necessary for image adjustments, but to optimize their application, it is necessary to consider the shape of the area to be studied and to distribute the points in a non-biased way relative to the coordinate axes. It is concluded that the lower overlap can be recommended for use in the flight plan due to the high resolution of the orthomosaic and the shorter processing time.

Key words: Orthorectification of images, geometric error, photogrammetry, UAS (Unmanned Aircraft System), overlap.

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Effect of nitrogen fertilization management on mineral nitrogen content in soil and winter wheat productivity

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Abstract. In recent years farmers must use integrated crop growing principles. One of the most important principle is to balance usage of mineral elements in crop cultivation, especially nitrogen management. Excessive and unbalanced usage of nitrogen fertilizer reduces nitrogen use efficiency and increases nitrate leaching in surface and groundwater. The dynamics of nitrogen forms in soil at different depths and different plant growth stages are studied to increase the productivity of winter wheat, promoting nitrogen uptake in plants and reducing nitrogen leaching during the vegetation period. Field experiments were carried out at the Research and Training Farm Vecauce of the Latvia University of Life Science and Technologies from 2012 till 2015. Researched factors were nitrogen (N) fertilizer rate: 0 – control, 85, 153, 187, and N rate determined by chlorophyllmeter (Yara N-tester) 180 (2012/2013), 150 (2013/2014), 205 (2014/2015) N kg ha⁻¹, nitrogen and sulphur (S) fertilizer rate – N175+S21 kg ha⁻¹, and conditions of the growing seasons: 2012/2013, 2013/2014 and 2014/2015. The content of nitrate (NO₃-N) nitrogen and ammonium (NH₄-N) nitrogen was determined in the soil layers 0–20 cm, 20–40 cm and 40–60 cm at the growth stages (GS) 30–32, 49–51, 69 and 90–92. All trial years the amount of nitrate nitrogen and ammonium nitrogen in soil decreased during vegetation, but increased with increasing fertilization dose. Nitrate nitrogen content was significantly influenced by year in 0–40 cm soil layer ($P < 0.01$) and by nitrogen fertilizer in the 20–40 cm soil layer. Ammonium nitrogen content had significant influence only on nitrogen fertilizer at 20–40 cm soil layer ($P < 0.05$). Average grain yields did not show significant correlation with the nitrate nitrogen and ammonium nitrogen in different soil layers and plant growth stages, except nitrate nitrogen content in soil layer 40–60 cm at GS 30–32 and ammonium nitrogen content in soil layer 40–60 cm at GS 69 and GS 90–92.

Key words: ammonium nitrogen, nitrate nitrogen, fertilizer, wheat.

Stress factors identification in plant production using thermal camera

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Abstract. The yields of plant production are limited by a number of stress factors affecting the plants during its vegetation. Heat, water stress, herbivorous organisms and other stress factors have a negative effect on the crop yields. One of tasks of modern agriculture is to decrease the consequences of their affect. Collecting information about the stress factors could reduce the negative influence for plants development. Using thermal cameras is one way how to collect data about the plants and through regular mapping is also possible to plan agrotechnic operations. This study is focused on describing the impact of stress factors of plants by monitoring the rape drying process by a thermal camera. The results of the measurement showed that the plant of rape resists heat and water stress for quite a long time without obvious damage, but after three hours of the drying process the damage started to occur very quickly. The plant transpiration stopped and gradually dries from the bottom leaves. Data collection of drying processes can help to decrease the loss of the yield during the heatwaves by setting the right time and amount of water for irrigation of the crops.

Key words: Stress factors, plant production, thermal camera.

ACKNOWLEDGEMENTS. Grateful thanks are extended to doc. Ing. Milan Kroulík, Ph.D. for his help in data collecting.

Crop production dependence on precision fertiliser application systems and agromicrolandscape conditions

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Abstract. Soil properties differ greatly in their small-scale distribution. The high spatial soil variability is the natural feature of soil covering in the North-West region of the Russian Federation. This heterogeneity requires site-specific management at the field scale to avoid wasting resources, environmental pollution and decreasing soil fertility. The main objective of the presented research is to examine the effectiveness of precision fertiliser application by reference of specific features of the agromicrolandscape conditions. The field site is a 22-ha field located in Leningrad region, Gatchina district. The soil was typical and gleyic sod-podzolic developed on red moraine sandy loam. The most important characteristic for the present research is the high spatial variability of soil properties. The spatial variation of organic matter and plant available potassium is the largest and the coefficient of variation is 26 and 25%, respectively. The spatial variability of plant available phosphorus and exchange soil acidity is less and the coefficient of variation is 18 and 6%, respectively. The introduced crop rotation was: potato – spring barley – perennial grasses of the first and second harvest year (a mixture of timothy with meadow fescue) – winter wheat. Research factors were (1) fertiliser systems (control (no fertilisation); CvF - conventional fertilising system: mineral fertilisers added annually according to conventional agriculture practice; PrF I mineral fertilisers added annually according to soil properties; PrF II - in 2008 only potassium fertilisers were applied precisely to reduce spatial variability of potassium content. During the following years, the after-effect was observed and mineral fertilisers were applied uniformly; PrF III – mineral fertilisers added annually according to yield map data); (2) agromicrolandscapes (accumulative-eluvial, accumulative, eluvial and transite-accumulative). Potato tuber yields with precision fertilisation according to soil properties were almost equal to conventional treatment. The highest potato tuber yield was achieved under precision potassium fertilisation. Unfertilised barley produced significantly higher yields in the accumulative agromicrolandscape compared to other ones. All treatments both conventional and precise gave positive results in barley grain growth. In 2010 the highest perennial grasses yield without fertilisation were harvested in accumulative and accumulative-eluvial agromicrolandscapes because of their better nutrient and water status. The significant extra yields were harvested when mineral fertilisers had been applied according to the soil properties under the conditions of eluvial agromicrolandscape. In accumulative-eluvial agromicrolandscape fertilisation according to potassium content was effective as well. The perennial grasses yield in 2011 were less than in 2010. It was because of gradual soil compaction till steady-state density. The extra yield was the lowest in eluvial agromicrolandscape. It is probably related to the large nitrogen leaching losses because of excessive precipitation. In 2012 all precision fertilising systems has significant differences as compared to conventional fertilisation. The average data of the five-year investigation show that the highest productivity without fertilisation was gained in the accumulative agromicrolandscape, and the lowest – in the eluvial agromicrolandscape. The highest yield of all investigated crops was harvested when potassium fertilisers had been applied precisely. In other cases, the yields were almost equal in conventional and precision fertilisation.

Key words: precision fertiliser application, agromicrolandscape, crop yield, spatial variability.

Soil-climatic conditions affecting yield and starch content of maize silage

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Abstract. The quality of maize silage production for energy purposes depends on the starch content under certain operating conditions. Starch production depends on soil, temperature and rainfall conditions, depending on the range of varieties and varieties of maize. The five-year results of small parcels of corn silage with a total of 4,879 reps were evaluated. Models were built in two steps. In the first case, starch content was predicted based on basic meteorological data, such as the average temperature in the month, the maximum and minimum temperature, the number of frost days, the monthly precipitation and the number of precipitation days of up to 5 mm and more than 5 mm in May to September. Highly significant regression functions were obtained with a prediction of starch content and yield depending on the weather in each month and depending on the aging of silage maize. Differences from actual starch values were the subject of further regression, which estimated the impact of soil, varieties, altitudes on starch content and yield of dry matter. The complex model of the regression model estimation reaches a value of R² of about 0.76. The starch content depends most on the temperature conditions in July, when the temperature in addition to the mid-wake group increases the starch content and in August, on the other hand, with the exception of the medium-late variety, the temperature is negative. On the basis of the difference between the content and the model content of the starch, the impact on the soil type and type, as well as the specific hybrids monitored in total 435, was determined. The influence of the type and type of soil on the starch content was not proved, the most suitable hybrids were evaluated for weathering and generation of revenue. The results serve to determine the outlook for biomass cultivation for energy purposes in specific regions.

Key words: Maize silage, temperature, precipitation, energy, starch, modelling.

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SAMS - International Partnership on Innovation in Smart Apiculture Management Services

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Abstract. Bee health and sustainable beekeeping are a key for sustainable agriculture worldwide. Risks of depleting honey production threatens livelihoods of beekeepers, but degradation of pollination power of suffering bee colonies threatens overall agricultural production and affects entire population. SAMS is a project funded by the European Union within the H2020-ICT-39-2016-2017 call. SAMS enhances international cooperation of ICT (Information and Communication Technologies) and sustainable agriculture between EU and developing countries in pursuit of the EU commitment to the UN Sustainable Development Goal “End hunger, achieve food security and improved nutrition and promote sustainable agriculture”. The project consortium comprises four partners from Europe (two from Germany, Austria and Latvia) and two partners each from Ethiopia and Indonesia. Beekeeping with small-scale operations provides perfect innovation labs for demonstration and dissemination of cheap and easy-to-use open source ICT applications in developing countries. SAMS proposes implementation of Precision Beekeeping by allowing active monitoring and remote sensing of bee colonies and beekeeping by developing appropriate ICT solutions supporting management of bee health and bee productivity and a role model for effective international cooperation. Precision Beekeeping (Precision Apiculture) is an apiary management strategy based on the monitoring of individual bee colonies to minimize resource consumption and maximize the productivity of bees. Precision Agriculture methods and techniques can be adapted for beekeeping improving the beekeepers knowledge about behaviour of individual bee colonies and prioritize different activities. SAMS addresses requirements of end-user communities on beekeeping in developing countries. It includes technological improvements and adaptation as well as innovative services creation in apiculture based on advanced ICT and remote sensing technologies. SAMS increases production of bee products, creates jobs (particularly youths/women), triggers investments, and establishes knowledge exchange through networks. The final outcome of the project will be a technologically enhanced beehive system and service including the following main components: a) A physical low-cost beehive model, that is locally produced and adapted to local conditions, including integrated open source sensor and information transition technology, as well as energy-supply solution; b) A decision support system that combines the sensor-based data-outputs with other information sources and predictive models to measure, analyse and describe different states of the bee colony such as health, vitality, production, etc.; c) An automatic advisory support tool, which will alert the beekeeper in an easily understandable way if any aberrations from normal states are metered and will provide advice on appropriate countermeasures. The response unit will support the user to avoid losses and to increase the profitability and stability of beekeeping; d) A bee management business concept for the local production and up-scaled implementation of the developed beehives with integrated beehive monitoring system. To find out more visit our project website <https://sams-project.eu/>.

Key words: precision Beekeeping, smart beehive, bee colony monitoring.

VII PRODUCTION ENGINEERING

Suitability of 2.4 GHz and 5 GHz wireless communications in production processes

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Abstract. Today, it is increasingly modern to use wireless transmissions in production. It is possible to send information messages, control messages and it is often possible to access the technologies as IoT (the Internet of Things). The aim of this work was to find out which of the selected Wi-Fi frequencies is more suitable for use in syrup processing equipment. The evaluation was performed on the basis of attenuation and download speed at each frequency (2.4 GHz and 5 GHz bandwidth). These frequencies have been chosen due to their massive deployment for wi-fi networks that currently dominate wireless communications. Measurements were made downloading files on different frequency bands. Mean and maximum data throughput and signal strengths were also measured. By measuring, it has been found that when using 2.4 GHz wireless Wi-Fi technology, you can very often encounter strong interference effects. Despite the theoretically worse 5 GHz frequency spread, you can achieve up to 30% better data throughput on average. The results show the suitability of 2.4 and 5 GHz Wi-Fi technology. The main finding is that, despite the worse frequency spread of 5 GHz, it is more appropriate. Not only due to speed but also in the future due to better transmission capacities and future channel expansion.

Key words: wireless communication, wi-fi, production processes, IoT, frequency, data.

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Separation of dust particles in the low-pressure pneumatic conveying system

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Abstract. This paper focuses on the possibility of separation of dust particle created as a by-product of technological processing of composite materials. The aim was to design and verify technology for the separation of dust particles from polydisperse granular mixtures, which are created by physical-mechanical processes of materials processing (crushing, sorting, machining or surface treatment of products such as grinding or polishing the surface). Under experimental conditions, a low-pressure pneumatic conveying system was designed and tested in operation, supplemented by a powerful electrostatic dust particles separation system. The entry requirement was to design a system that would be able to work with high separation efficiency using low-pressure suction. The designed separation conveying device consists of three parts: the conveyance section for the grain material suction and conveying, the coarse grain share cyclone separator and the electrostatic precipitator of the dust particles released from the air flow. Operational capacity of the proposed technology was verified by evaluating the separation efficiency of processing the polydisperse granular mixture resulting from the crushing of laser printer toner cartridges. These contain toner powder residues, which are the source of composite dust particles. The separation efficiency of the system was monitored according to the set pressure of the air in front of the electrostatic separator. Evaluation of the results thus obtained confirmed the operational reliability of the system at low-pressure operation and the high separation efficiency of the electrostatic separator under the set operation conditions.

Key words: dust particles, electrostatic separation, low-pressure pneumatic conveying system.

Research on influence of cyclic degradation process on changes of structural adhesive bonds mechanical properties

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Abstract. The paper deals with an influence of a cyclic degradation process on changes of a shear tensile strength of single lap-shear adhesive bonds and their elongation according to ČSN EN ISO 9142. Five one-component structural adhesives used in a construction of car body works were used within the research. The degradation of adhesive bonds is a significant factor which influences a quality and a service life of adhesive bonds exposed to environment. A main requirement in production companies is not only reaching satisfactory initial mechanical properties but namely ensuring a reliability and a safety of adhesive bonds during their usage. These reasons show a great importance of adhesive bonds tests either directly in the operating environment or by a simulation of operating conditions in laboratories. The degradation process of adhesive bonds worsens mechanical properties of not only the bond itself but also of the bonded material. This process is progressing and it is usually permanent and irreversible. It is a change of mechanical and physical properties which can endanger a safety and a reliability of parts, prospectively of the whole equipment. It can lead up to a complete failure of its function in the extreme case. A temperature, a moisture, a direct contact with water and chemicals or an atmospheric corrosion belong among the most serious degradation agents. It is important to take into regard time of the processes influence at the same time which can act either independently or concurrently when their effects grow stronger. From that reason the adhesive bonds were exposed to the cyclic degradation process according to the standard ČSN EN ISO 9142. Subsequently, the adhesive bonds mechanical properties were tested on universal testing machine and by means of SEM analysis (TESCAN MIRA 3). Results of mechanical tests proved a fall of the shear tensile strength of single lap-shear adhesive bonds after 42 cycles of the degradation process of 12.8 to 21.7%. The bond strength fall was gradual and it showed a linear trend at some adhesives. Other adhesives showed a significant fall after the exposition to the degradation process after which the strength fall stabilized.

Key words: shear tensile strength, elongation, temperature, moisture, SEM, automotive, ageing process.

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Management of parts and components for units and assemblies in mechanical engineering industry and its impact on the environment

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Abstract. Most of the service centers operating in the repair and maintenance of machines and mechanisms apply warehouse management systems based on event prediction, which ensures inventory replenishment based on the initial diagnosis of the units. Such methodology is enforced measure, since the components and assemblies, even from the same manufacturer, having similar functions, design and connecting components have their own engineering numbers and part numbers for ordering. Unfortunately, this method is relevant only with perfect logistics and minimal time factor. If these criteria cannot be fulfilled, the maintenance and repair time increases, especially at a distance from logistic centers.

By reducing lost sales and quick customer satisfaction, own warehouse stocks based on statistical data increases. Unfortunately, none of the modern methods gives a 100% result and eventually leads to overstocking and formation of deadstock. On the other hands more and more components are made from composite materials, complex alloys, permanent joints are being used. But due to ineffective management the significant part of expensive components is became needless. The aim of this research is to develop an algorithm allowing to optimise the logistics chain and reduce the inventory and deadstock, reduce disposal of used and obsolete units and assemblies, resulting in significantly lower consumption of natural resources, energy and reduced negative impact of waste on the environment. Our research shows that in various fields of science there are being developed methodologies, which would solve the described tasks by combining those methodologies in a single algorithm.

Key words: management of parts and components, impact on the environment, parts algorithm.

Linear pressing of coconut copra meal (*Cocos nucifera* L.) under different temperatures

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Abstract. Pressing of vegetable oils plays an important role in the food processing. This study described the compression behaviour of copra (*Cocos nucifera* L.) using the universal compression testing machine and vessel diameter of 60 mm with a plunger. The influence of heat treatment on oil recovery efficiency and specific mechanical energy were determined. Compression tests at the rate of 1 mm.s⁻¹ under five different temperatures 20, 40, 60, 80 and 100°C were performed. The measuring range of force was between 0 kN and 50 kN. It has been found that the amount of obtained oil increased and specific mechanical energy decreased with increased temperature. Measured data were analysed by computer software Mathcad 14 (MathCAD 14, PTC Software, Needham, MA, USA). Mathematical model describing the mechanical behaviour of bulk copra under compression loading was represented.

Key words: coconut oil, compression loading, compressive force, specific mechanical energy.

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Improving the quality of critical tractor parts through the dynamic stabilisation of the manufacturing process in regard to CNC machines

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Abstract. This article focuses on the evaluation of a rod improvement which is considered in detail below. The rod in question is part of an hydraulic cylinder manufacturing process which takes place on CNC machines. The need for ensuring a process improvement in this area arose because the rod often breaks down under operational conditions. It was found that the cause of this is a finishing operation in the existing production process. The effect of charging which occurred during the grinding process brings about the embedding of abrasive particles into the workpiece surface layer. Therefore, at the running-in stage, the mating surfaces on the rod and the system being used to seal the rings both experience intense wear in their contact areas, with this being caused by abrasive microparticles which serves to reduce the performance characteristics of the part in question. However, even if we dispense with the grinding process, ensuring the necessary roughness of $R_a = 0.63 \mu\text{m}$ at the machining stage alone will present problems of their own for a number of reasons. First and foremost is the connection with the phenomenon that results in an auto-oscillation processes which is generated by the manufacturing system, as well as the formation of flow chips during machining on CNC machines. In this regard, in order to avoid any negative factors creeping into the process, we propose that a new approach be taken in achieving the necessary surface roughness, one which is based on the suppression of the auto-oscillation process during machining by means of creating a selective metastable structure. At the machining stage, any inhomogeneous structure in the local chip formation area will be destroyed, thereby suppressing the auto-oscillation process and reducing the surface roughness. Eventually, the proposed method will allow the grinding operation to be dispensed with entirely from the manufacturing process.

Key words: production process, local laser impact, metastable structure, machining process system, chip formation, auto-oscillation processes, surface roughness.

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Analysis of plant materials pre-treated by steam explosion technology for their usability as insulating materials

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Abstract Raw materials of annual plants fibres are not easily usable for industrial production applications. Pre-treatment of the annual plant fibres is necessary to increase the homogeneity of the material and to improve the material properties. This study deals with the influence of steam explosion treatment on the quality of annual plant fibres used as insulating material.

Maize and wheat straw were selected for production of insulating panels. To clarify the changes within the structure of the plants due to the pre-treatment process material analysis was carried out using FT-IR spectroscopy and raster electron microscope. Furthermore, the bulk density and the thermal conductivity were analysed as important values for insulating materials.

The results showed that the pre-treatment process homogenizes the materials and the processes could be used for the production of bulk insulation.

Key words: thermal-hydro treatment, thermal conductivity, maize straw, miscanthus.

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Thermal analysis of asynchronous machines under intermittent loading

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Abstract. The operation of electric machines is accompanied by losses which are mostly converted to heat. The heat needs to be dissipated from the machine. With a properly dimensioned motor, the arising heat is balanced with dissipated one. After the motor is started at ambient temperature, all functional parts of the machine are gradually warmed until stabilized. Any overloading of the machine leads to stabilization at temperatures higher than expected by the designers. High temperatures in the machine could cause a crash by damaging an insulation. In case of machines with permanent magnets, the temperature affects their magnetic properties and can lead to demagnetization at the Curie temperature. Therefore, the measuring of temperature is so important for verifying the allowed warming of the motor. Contact and noncontact methods could be used for temperature measuring. Thermal warming and temperature distribution in an electric machine can be also determined by theoretical calculations based, for example, on the finite element method. This method is used by a number of computer software such as Ansys. The article deals with generation and propagation of heat in electric motors and with measuring of warming characteristics with a variable value of a load factor for intermittent periodic loading of asynchronous machine. The loading is carried out by the dynamometer. The temperature measurement is implemented by temperature sensors which are located on the stator winding of the asynchronous motor and are in operation for the whole time the motor is loaded.

Key words: electric machine, loading, losses, load factor, warming.

VIII RENEWABLE ENERGY

Fast Power Measurement for Renewable Sources to Enhance Distribution Grid Stability

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Abstract. This paper deals with measurement of fast active power for monitoring the renewable sources connected to the distribution grid. Fast measurement of active power is the key point of reliable operation of the distribution grid. In past years we can observe increasing ratio of generated power from renewable energy sources. Renewable energy sources have specific behaviour under the specific weather conditions. Under the term “specific behaviour” should be understood the oscillations of output power supplied to the distribution grid. The oscillations could be caused e.g. by wind gusts – wind turbine or passing clouds – photovoltaics. Such kind of active power oscillation could lead to large blackout. To prevent large blackouts, we need to perform fast active power measurement. This paper will disclose the method of fast active power measurement and its application for monitoring the dynamic response of the distribution grid.

Key words: renewable sources, distribution grid, power generation, blackout.

Autonomous Photovoltaic System for Night-time Lighting in the Stable

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Abstract: Autonomous photovoltaic (PV) systems are suitable, for example, for powering various appliances or scientific instruments in the field, for automatic data collection, for signaling, etc. At the Czech University of Life Sciences Prague, we have designed an experimental autonomous PV system designed for night-time lighting for orientating in a stable for horses. The article describes the construction of a PV system with a PV panel rated at 170 W_p, with a lead-acid accumulator and a 1,5 W LED light source. The data collection was automated. The data evaluation shows that during the whole year, the PV system has been recharged and there was no lighting failure. The paper also presents important measured characteristics.

Key words: Photovoltaics, Off-grid PV system, LED.

Heat Storage Energy Balance and Optimization of Insulation

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Abstract. In order to match any production and consumption, a storage facility is required. In energy engineering, there are three main functions for storage: smoothing of peak loads, security and quality of supply. Systems have thermal storage capabilities even if they are not created with the specific intention. For example, massive construction elements in residential buildings or water circulating in district heating networks have thermal inertia, and the fuel supply near the consumer has chemical energy. For example, a fuel near the consumer could be firewood and the chemical energy is the burning value. The authors focus primarily on the thermal energy supply, whose dynamics helps describe the energy flows moving in and out of the thermal system. The mathematical model provides answers to questions about efficiency and availability. The hypothesis claims that insulation of the storage from the surrounding environment is not necessary under certain conditions.

Key words: insulation, storage, energy, balance, heat.

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Usage of grid support inverter on long distribution grid lines

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Abstract. The paper focuses on the evaluation of new possibilities to improve voltage quality in remote branches of 230 V grid. Decrease of power electronic costs may potentially make battery-backed inverters a viable alternative to the costly reconstruction of 230 V distribution grid connections, which are of poor quality or cannot match changing load requirements, extending power transmission lines or adding boost transformers. The object of the current study is a household-type consumer with 20 A single-phase connection to distribution line with a distance of 2 km to a 20 kV transformer station. The calculated resistance of the power line is 2.8 ohms. The load profile was captured during 5 days in summer and 10 days in winter and was used to calculate the capacity of the grid support equipment. Measurements indicated, that in the worst case 2% of time the voltage was below 10% of nominal and 8% of time – below 5% of it. This is outside of the regulatory limits of EU and national regulations. The experimental setup for a voltage quality improvement system was based on an OutBack Power Radian series grid inverter with 7 kW output power. Battery consisting of 12 V 120 Ah VRLA accumulators wired in 48 V system was used. The inverter was configured to work in grid support mode using battery power when the consumer's active load increased above 1.2 kW. Results showed improvement in voltage quality over the full consumer load range. The total efficiency of the grid support system was 89%. The use of DC bus and batteries allows easy incorporation of renewable energy sources, thus giving the opportunity to scale power and battery capacity of the system. An Additional benefit of using a battery-backed inverter in grid support mode is that consumer can temporarily use more power that is allowed by grid due to its capacity constraints.

Key words: distribution grid, load, voltage quality, inverter efficiency.

Effective control and battery charging system of an island PV power plant

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Abstract. The paper presents a new concept of an autonomous PV power plant regulatory system with LiFePO₄ batteries, which was functionally verified. The hardware system is significantly simpler and more operationally reliable. It also shows higher efficiency and lower acquisition costs than conventional commercial systems. The proposed control system was optimized for charging a multi-cell battery by PV electric energy. The system automatically maximizes the power supplied by the photovoltaic source and minimizes the power loss caused by balancing the individual cell charging processes. The problem of charge balancing is solved without the balancers. Battery cells are recharged from the separate converters supplying the PV power. The converters are controlled to observe a LiFePO₄ battery charging mode while controlling the photovoltaic generator (PVG) load resistance based on an MPP monitoring. PVG power is not supplied to the charged cells, which are in this way protected from overcharging. The entire PVG power is fed to the cells to be charged. The transmission from the converters is controlled in order not to exceed the voltage and current limits at the terminals and to minimize the actual voltage deviation from the control voltage at the PVG output. The control voltage is generated as an MPP voltage approximation according to the load characteristics and the actual PVG operating conditions.

Key words: LiFePO₄ battery, autonomous PV power plant regulatory system, MPP tracking.

The influence of changing hydropower potential on performance parameters of pump in turbine mode

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Abstract. Various types of hydromotors that enable energy recovery simultaneously with the required pressure reduction can be used in the field of fluid pumping systems. Similar principle is applied, for example, in the case of use of hydrodynamic pumps in turbine mode (PAT), which are also used as an alternative to conventional turbines in small hydropower plants. However, these pumps do not usually have the possibility of regulating hydraulic parameters, as it is common with conventional turbines. This specific feature needs to be taken into account, when designing such system. Article analyses computational methods for the conversion of the performance characteristics and compares these results with experimentally measured data on a particular pump in turbine mode. The results indicated that conversion can be well used in practice to predict outputs as well as to determine the optimum total head and flowrate to ensure maximum efficiency of PAT operation. Further computations were influenced by deviations resulting from the change in efficiency during PAT operation.

Key words: pump as turbine (PAT), total head, flowrate, power output, efficiency.

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Energy management algorithms for buildings that use predominantly photovoltaics and energy storage to achieve energy independence

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Abstract. The focus of the study is the creation of an algorithm to achieve independence of the building from external sources of electricity with the predominant use of photovoltaic systems, additional possible source is the use of wind energy. The object of research is buildings connected to an external network where equipment is used that meets the requirements of a network company for a permanent connection. At the core of the building's electrical system (ES) model, the simplified model proposed earlier by one of the authors is used to make fundamental decisions about the feasibility of innovation. The model contains two levels of elements: the main parts of the electrical system (parts of the building or types of technical systems that can be a separate stage of innovation) and local elements of the model. They have significant power /consumption, significant cost or can be a source of technical risks. The previously created simplified model is developed and detailed for the use of renewable energy. The new algorithm is supplemented by a module of storing and management the generated and consumed energy. The module calculates the maximum power required for the accumulation of energy, determines the main parameters of its use - the periods of accumulation, the time and amount of energy for transfer to the ordinary network. The new algorithm also contains a module for monitoring to use innovative solutions for energy saving. This module provides control over the degree of compliance of a particular electrical system with the principles of a "smart grid" (level of automation and feedback from the external network). The degree of implementation of measures stipulated by the energy saving policy is also monitored: the use of modern solutions for lighting, cooling and other HVAC systems. If there is a fixed need for innovation to increase the independence of the building from external sources, the algorithm contains control over the payback period of innovative solutions. The novelty of the approach presented in the publication in the active use of conventional technical documentation and interactive databases, which simulates the processes that affect the energy balance of the building and simple methods that are understandable with the usual engineering knowledge. The proposed algorithm corresponds to the principles of BIM and IPD, in modeling technical processes for the most part corresponds to the principles of BEM and in the future can be used together with BMS. The focus of the publication is the study of the ES in order to find features negatively affecting the achievement of independence from external energy sources.

Key words: photovoltaic, model, wind energy, electrical, storing.

Analysis of non-stationary flow interaction with simple form objects

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Abstract. The paper is devoted to the analysis of a non-stationary rigid body interaction in a fluid flow. Initially, an approximate method for determining the forces due to fluid interaction with the rigid body is offered. For this purpose, the plane movement of a mechanical system with an infinite DOF (degrees of freedom) is reduced to 5 DOF motion: 3 DOF for the body and 2 DOF for the areas of compression and vacuum in fluid flow. Differential equations of non-stationary motion are formed by the laws of classical mechanics. The use of an approximate method has been quantified by computer modelling. The average difference in results was found to be small (<5%). The analysis of the fluid (air) interaction is carried out for a rigid body of two simple geometries - flat plate and diamond. The results obtained are used to refine the parameters of the proposed approximate method that is addressed in the present study for fluid interaction with the non-stationary rigid body. Theoretical results obtained in the final section are used in the analysis of the movement of prismatic bodies in order to obtain energy from the fluid flow.

Keywords: Degree of freedom, energy, fluid interaction, mathematical modelling, flow parameters, rigid body.

IX VEHICLES & FUELS

Possibilities to Identify Defective Electric Automobile Batteries

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Abstract. A pack of batteries is one of the most important and expensive assemblies for an electric vehicle. A pack of batteries is comprised of several batteries connected in series. The number of the batteries connected depends on the operating voltage of the vehicle's on-board system as well as on the individual characteristics of the batteries used, e.g. the operating voltage of a single cell. One or several cells of a pack of batteries could be damaged if improperly exploiting an electric vehicle– excessively discharging the batteries or overloading the electric vehicle. If a self-converted vehicle does not use an intellectual BMS (battery management system) that can identify and register voltage drop for any individual cell in the high-load regime, e.g. when accelerating, it is difficult to identify and change the cells damaged. In case a cell does not demonstrate a complete failure, it is almost impossible to identify a defect in any regime other than the load regime. The research developed and compared three different methods for identifying defective battery cells. The methods were approbated on a converted Renault Clio. The experiment involved making voltage measurements in road tests, running the electric vehicle on a roll test bench and making voltage measurements of maximally discharged batteries in the no-load regime. A comparison of the measurement results revealed that the measurements made in the road tests were the most accurate and useful. After the experiment, the defective battery cells were replaced, thereby restoring the performance of the battery pack.

Key words: electric vehicle, battery pack, battery voltage, test.

Combustion characteristics of compression ignition engine operating on rapeseed oil-diesel fuel blends

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Abstract. The effect of biofuels on the operational parameters of the combustion engines, such as performance parameters or emission production, are monitored often. These changes are, however, based on the effect of biofuels on the course of combustion pressure inside the combustion chamber. The contribution deals with the effect of rapeseed oil-diesel fuel blends on the combustion characteristics of turbocharged compression ignition engine. The course of cylinder pressure was monitored and analysed and heat release rate was calculated. The brake specific fuel consumption, indicated and brake thermal efficiency were calculated and evaluated, in-cylinder temperature and ignition delay were also evaluated. As a test fuels a 5% and 20% concentrations of rapeseed oil in diesel fuel were selected while 100% diesel fuel was used as a reference. Turbocharged CI engine Zetor 1204 located in the tractor Zetor Forterra 8642 was used for measurement. During measurement the rotation speed of the engine was kept constant at approx. 1950 min⁻¹ and the load of the engine was selected at approx. 20, 60, 80 and 100%. The results showed decreased cylinder peak pressure, decreased intensity of heat release rate and earlier end of combustion in all tested loads for both tested fuel blends in comparison with diesel fuel, while the lowest peak cylinder pressure was reached using fuel with 5% rapeseed oil. Fuel with 5% rapeseed oil also showed highest indicated efficiency. Ignition delay was found shorter with both of the blended fuels in comparison with diesel fuel.

Key words: biofuels, cylinder pressure, heat release rate, engine efficiency.

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Combustion studies of a non-road diesel engine with several alternative liquid fuels

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Abstract. Sustainable liquid fuels will be needed for decades to fulfil the globally growing energy demands. Combustion systems must be able to operate with a variety of renewable and sustainable fuels. The focus of this study was on how the use of various alternative fuels affect the combustion process, especially in-cylinder combustion. In the study, baseline fuel and six alternative liquid fuels were investigated in a high-speed compression ignition (CI) engine to understand their combustion properties. The fuels were light fuel oil (LFO, baseline), marine gas oil (MGO), kerosene, rapeseed methyl ester (RME), renewable diesel (HVO), renewable wood-based naphtha and its blend with LFO. The heat release rate (HRR), mass fraction burned (MFB) and combustion duration were determined at intermediate speed at three loads. The combustion parameters seemed to be very similar with all studied fuels. The HRR curve was slightly delayed with RME at the highest load. The combustion duration of neat naphtha decreased compared to LFO as the engine load was reduced. The MFBs of 50% and 90% occurred earlier with neat renewable naphtha than with other fuels. It was concluded that all other investigated alternative fuels can be used in the non-road engine without modifications except neat renewable naphtha.

Key words: CI engines, alternative fuels, in-cylinder combustion, heat release rate, combustion duration.

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Effect of long-term operation of combustion engine running on n-butanol – rapeseed oil – diesel fuel blend

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Abstract. The short time use of biofuels in compression ignition engines is being studied by many authors. However, in many cases the real long-term operation of the engine on biofuels may cause problems. The article deals with the operation parameters of the combustion engine, fuelled by n-butanol – rapeseed oil – diesel fuel blend, during 70 hours operation in total. Two brand new diesel power generators Kipor KDE 6500 with output power of 4.6 kW were used for certain testing. The first generator was operated on 100% diesel fuel and it was used as a reference and the second generator was operated on experimental fuel containing 10% n-butanol – 20% rapeseed oil – 70% diesel fuel blend. The generators were equipped with single cylinder compression ignition engine Kipor KM 186 with the rated power of 5.7 kW. For the first 10 operating hours approx. 40% load was applied. Then, the generators worked for another 60 operating hours with approx. 70% load. The harmful emissions, smoke, fuel consumption and the amount of produced particles were also measured after 10 hours run-in period and then after another 60 hours of operation. Consequently, the results were compared. Measurements were carried out at gradually increasing electric power output, approx. 14%, 28%, 42%, 56%, 68%, 82% and 95% (in results can be found in Watts). Emission analyser and opacimeter BrainBee and Engine Exhaust Particle Sizer TSI were used for the measurements. The results showed increased production of emission of the engine running on fuel blend after 70 hours of operation. On the other hand, engine which operated on standard diesel reached lower fuel consumption. After 70 hours the blended fuel tended to produce more particles in comparison with diesel fuel.

Key words: emissions, fuel consumption, biofuels, power generator, particles, opacimeter.

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Analysis of operating parameters of hybrid vehicle under real traffic condition

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Abstract. Nowadays, protecting the environment and reducing harmful emissions is an increasingly discussed topic. One way to reduce vehicle emissions, especially for individual car traffic, is to use a hybrid drive. The advantages of the electric drive and the classic combustion engine are used here. By combining both types of drive, a synergetic effect is achieved, where both drives can be used in optimal operating mode. The aim of the experiment was to demonstrate the benefit of a hybrid vehicle in real driving. The operating parameters of the Lexus LX400h hybrid vehicle was compared to a conventional low-class vehicle Škoda Fábía 1.2 HTP with a classic SI engine. The experiment took place on a route including typical urban, extra-urban and motorway traffic condition. During experiment, the engine operating parameters and CO, CO₂, HC and NO_x emissions were measured. The results show that the emission production and fuel consumption of the hybrid vehicle are significantly lower in urban traffic condition than the vehicle with classic internal combustion engine. On the contrary, in motorway conditions, the hybrid vehicle must use both drives, as higher performance is required to overcome higher driving resistances and therefore achieves higher fuel consumption and higher emissions than a conventional vehicle.

Key words: fuel consumption, emission production, urban traffic, energy recuperation.

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Periodic polynomial regression analysis of urban driving characteristics

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Abstract. Urban driving characteristics with a focus on energy consumption have been tested in Riga on three main city streets with inflexible coordinated traffic lights control. The aim of this article is to investigate periodic polynomial regression analysis method to analyse car urban driving parameters' change during weekday twenty-four hours to assess the influence of vehicle technologies on energy consumption in city driving, to map the energy demand on Riga city main street sections and to evaluate the traffic lights control on flow energetic characteristics. The tests have been done using GPS and OBD data loggers on a test car repetitively driven along a pre-planned route at around-the-clock hours. A regression analysis using periodic polynomials was developed and applied to evaluate the traffic flow characteristics with a given time shift. It was concluded that using polynomial regression function, the polynomial order has to be at least seven although a visual conformation of good regression line to the measured data has to be checked especially with lower orders. To evaluate the traffic conditions at a given 20 minutes to one hour shift the application of regression function is limited for the periods with fast changing traffic flow, especially after the end of rush hours when the usability of regression line for the given data has to be checked individually for tested street sections.

Key words: city driving, energy consumption, traffic flow.

Analysis of operation parameters of electric and gasoline vehicle in real driving

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Abstract. The reduction of transport-generated energy consumption and consequent emission production are currently a problem of global interest. Electric vehicles (EVs) are considered as one promising technological solution for limiting transport-generated energy consumption and emission production, but their operating parameters are strongly influenced by immediately operating conditions and it is often very problematic to prove or disprove benefits of EVs in real operation. The aim of this paper is to present comparison of operating parameters of the full-electric vehicle VW e-UP! with identical vehicle Skoda Citigo with gasoline engine in real driving. Both vehicles were tested together in several different areas of the Czech Republic. The experiment was focused on analysis of energy (fuel) consumption and production of exhaust gases (CO, CO₂, NO_x). VAG-COM diagnostics system was used for sensing engine operating parameters, GPS coordinate were measured by Garmin GPS-18x, vehicle Skoda Citigo was equipped by the PEMS analyzer VMK for RDE emission sensing (CO, CO₂, HC, NO_x). The results bring a real comparison between the electric vehicle and the vehicle with gasoline engine in terms of fuel consumption and emissions production.

Key words: real driving emissions, vehicle range, fuel consumption, recuperation.

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Contamination of transmission and hydraulic oils in agricultural tractors and proposal of by-pass filtration system

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Abstract: Tractors use various types of lubricating oils in transmission and hydraulic system. Oils are contaminated by different ways depending on the work of the lubricated system. There are general requirements on the cleanliness level of the oil in the tractor transmission and hydraulic system according to the standard DIN 51524. According to all that, this paper presents research conducted by two tractors. The tractor John Deere 8100 used only its own implements (ploughs, trailers etc.) and it was operated in compliance with user manual. In this tractor, the oil cleanliness level met the standard DIN 51524 because reached the stage 7 (NAS 1638). The tractor Zetor Forterra 124 41 contained extremely contaminated oil, it reached stage > 12 (NAS 1638), due to the non-standard operation which was opposite to user manual. Both ways of tractor operation are typical for farmers activity in the Slovak Republic, depending on the tractor type and style of agricultural production at most. The second part of this paper is aimed at the proposal of by-pass filtration system to eliminate the oil contamination. The by-pass filtration system is the second stage of the oil filtration in the tractor, whereas the first one means standard tractor filter. Function of the system was tested according to the decrease of chemical elements concentration characterising the oil contamination and visual method based on filter stain and its change after operating of tested tractor. There was evaluated the decrease in of concentration of Fe (41.6%), Cu (28.7%) and Si (20.5%) after by-pass filtration system was running under operational conditions. It can be concluded that the by-pass filtration system was proposed correctly, and it is suitable for tractors operation.

Key words: tractor oil, tractor maintenance, elimination of the oil contamination, quality of lubricants.

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Effect of alternative liquid fuels on the exhaust particle size distributions of a medium-speed diesel engine

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Abstract. The main objective of this study was to find out how alternative fuels affect the exhaust gas particle size distribution. Along with low-sulphur marine light fuel oil (LFO), a medium-speed diesel engine was fuelled by circulation-origin marine gas oil (MGO), the 26/74 vol.-% blend of renewable naphtha and marine LFO, and kerosene. Particle size distributions were measured by means of an engine exhaust particle sizer (EEPS). No exhaust aftertreatment was used. During the measurements, the 4-cylinder, turbocharged, intercooled engine was loaded by an alternator, the maximum power output being set at 600 kWe at a speed of 1,000 rpm. The partial loads of 450, 300, 150 and 60 kWe were also used for the measurements. At each load, the particle size distributions had a distinct peak between 20 and 100 nm regardless of fuel. Relative to the other fuels, circulation-origin MGO emitted the lowest particle numbers at several loads despite the highest viscosity and highest density. Compared to baseline LFO and kerosene, MGO and the blend of renewable naphtha and LFO were more beneficial in terms of total particle number (TPN). Irrespective of the load or fuel, the TPN consisted mainly of the particles detected above the size category of 23 nm.

Key words: diesel engine, medium-speed, exhaust particle number, alternative fuel, renewable naphtha, circulation-origin MGO, kerosene, light fuel oil.

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Exhaust particle number of a non-road diesel engine fuelled by methyl esters with different fatty acid compositions

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Abstract. The main aim of this study was to find out how methyl esters with different fatty acid compositions affect the exhaust particle numbers. Along with fossil diesel fuel oil (DFO) and renewable diesel (HVO), a high-speed non-road diesel engine was fuelled by rapeseed (RME) and soybean (SME) methyl esters. Particle numbers within the size range of 5.6–560 nm were measured by means of an engine exhaust particle sizer (EEPS). The exhaust smoke, gaseous emissions and the basic engine performance were also determined. During the measurements, the 4-cylinder, turbocharged, intercooled engine was run according to the non-road steady cycle. Methyl esters reduced particles within the size range of 70 to 200 nm. For RME and SME, both positive and significant correlations were found between the sum of the particle numbers detected above the size category of 23 nm and methyl palmitate (C16:0), methyl stearate (C18:0) and methyl linoleate (C18:2) contents at 10% load at rated speed. In terms of nitrogen oxide (NO_x) and hydrocarbon (HC) emissions, HVO was beneficial while carbon monoxide (CO) emission was the lowest with DFO. The level in smoke emission was negligible.

Key words: diesel engine, particle number, methyl ester, fatty acid composition.

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Behavior of B20 fuels in arctic conditions

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Abstract. Several renewable and sustainable liquid fuel alternatives are needed for different compression-ignition (CI) engine applications to reduce greenhouse gas (GHG) emissions and to ensure proper primary energy sources for the engines. One of the shortcomings of several bio oils and first generation biodiesels has been their cold properties. Still, the need for alternative fuels is also present in arctic areas where the storing of the fuels may become problematic. The main aim of the current study was to determine how the storage related properties of fuel blends change if the fuels first freeze and then melt again. The samples were analyzed three times: as fresh, and after the first and second freezing-melting phase transitions.

The share of renewables within the blends was 20 vol-%. Rapeseed methyl ester (RME) and animal-fat based methyl ester (AFME) were blended with LFO in a ratio of 80 vol-% of LFO and 20-vol% of RME or AFME.

The investigated and compared properties were the FAME content of the neat FAMEs, and kinematic viscosity, density, oxidation stability index, and acid number of the blends. Cold filter plugging point was measured for AFME and its blend. According to the results, the quality of the FAMEs and their blends did not change significantly during the freezing over. The freezing-melting phase transition seems, thus, not to be as big a threat to the fuel quality as the high temperatures are. According to the results of this study, the studied fuels were feasible after the freezing-melting phase transition.

Key words: Alternative fuels, fuel blends, storage conditions, arctic conditions, fuel stability, medium-speed engines.

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Feasibility of new liquid fuel blends for medium-speed engines

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Abstract. Several sustainable liquid fuel alternatives are needed for different compression ignition (CI) engine applications to reduce GHG emissions and ensure proper primary energy sources for the engines. The reduction of fossil reserves together with the concern related to emissions does have promoted the research of alternative fuels in internal combustion engines (ICEs). In the present study, five different fuel blends were therefore thoroughly investigated. As the basic renewable fuel, rape seed methyl ester (RME) was used. It was blended with low-sulfur light fuel oil (LFO), kerosene, marine gas oil (MGO), and naphtha. Of these fuels, MGO was a circulation economy fuel, manufactured from used lubricants. Naphtha was renewable since it was a by-product of a renewable diesel production process using tall oil as feedstock. The blend of RME and naphtha was, hence, fully renewable and it has not been studied before. Besides with RME, naphtha was also blended with LFO. The main aim of the current study was to determine all the most important properties of the five fuel blends to create fundamental knowledge about their suitability for, in particular, medium-speed CI engines. The share of renewables within these five blends varied from 20 vol.-% to 100 vol.-%. The investigated and compared properties were the cetane number, distillation, density, viscosity, cold properties and lubricity. According to the results, all the studied blends may be operable in medium-speed engines when the proposed target of 35% of renewable share of the total energy consumption set by the European Parliament. Blending of new renewable fuels with more conventional ones relieves the technical transitional period so long as the availability of renewable fuels is limited. In this study, especially 100% renewable naphtha-RME blend is an interesting supplement in biofuel genre.

Key words: Alternative fuels, renewable energy, renewable naphtha, marine gas oil.

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X NANOCOMPOSITES AND NANOMATERIALS & WASTE RECOVERY

Polymer acrylic hydrogels with protein filler: Synthesis and characterization

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Abstract. The water-retention hydrogel composites were synthesized by the free-radical polymerization depending on the order of addition filler of the protein hydrolysate. As the filler was used protein hydrolysate, 'Biostim', obtained by processing cattle hides. The influence of gelation time on the synthesis parameters of hydrogel compositions was investigated. It is found that the gelation time of the sample without filler is 2-2.5 times longer than filled of hydrogel compositions. The structural characteristics of polymer composition by TGA, DSC and atomic force microscopy were determined. FTIR spectra found decrease in the intensity of vibrations of (-COO-) groups, indicating about additional ionic interactions. Decrease the beginning evaporation temperature of polymer composites with increase concentration of protein filler, indicating the destruction of the ordered structure of the polymer material revealed by thermogravimetric analysis (TGA). The influence of various media, such as distilled water, saline solution, and buffer solutions at different pH on the swelling behavior of hydrogels was also assessed. Maximum swelling capacity showed sample prepared with order of addition filler at the end of synthesis (Scheme I). The kinetics of the release protein hydrolysate from the polymer matrix was measurement by spectrophotometric method. The synthesized hydrogel composites with protein hydrolysate and improved physicochemical properties are of practical interest as water-retaining materials for increasing of crop the yield in agricultural.

Keywords: hydrogel, radical polymerization, filler, protein hydrolysate.

Selenium in nanosized form as an alternative to microfertilizers

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Abstract. Nowadays, it is an obvious fact that it is necessary to look for new approaches to agriculture, which would ensure the maximum reduction in the dependence of the volumes and quality of the crop on external factors. The use of nanopreparations in crop production is the most promising. The development of new technologies and techniques using nanomaterials, which would ensure high yields and quality of potato products, is relevant and has great practical importance. The research in recent years has established the important role of selenium in the regulation of plant activity. The purpose of this work was to research the effect of selenium nanoparticles and selenium in the form of micronutrient fertilizers on early-maturing varieties of potatoes for table use: adaptive capacity and nutritional value. Selenium nanopowder in the form of a solution contained the optimum nanoselenium concentration applied—0.13 g per hectare seeding rate. The potato tubers were soaked in distilled water 30 minutes before seeding. The treatment of potato tubers with selenium micronutrient, the dose of which amounted to 400 g per 1 hectare, was also carried out before planting. The soil preparation and agrotechnology cultivation generally accepted in the Ryazan region. The research results showed that presowing treatment of potato tubers with selenium nanopreparation had the most favorable effect on the adaptive capacity of plants (heat resistance, water-holding properties), as well as on yield increase, than treatment of tubers with selenium in the form of microfertilizer. The use of Se nanoparticles leads to an increase in the protein and vitamin C content. The Udacha potato variety showed great responsiveness to the entering of various forms of selenium in comparison with others. The use of selenium in the form of microfertilizer leads to an increase in the accumulation of starch and dry matter. These figures were the highest in potato tubers of the Zhukovskiy Ranniy variety.

Keywords: selenium, nanoparticles, microfertilizer, potatoes, water-holding capacity, heat resistance, yield, starch, dry matter, protein, vitamin C.

Physical-chemical properties and possible applications of clay minerals and humic acid composite materials

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Abstract. Pollution caused by pharmaceuticals has become an increasingly serious issue, therefore innovative and cost – effective methods of pharmaceutical’s removal must be studied. Clay – humic acid composite materials can be considered as prospective and low cost sorbents for contaminants. The aim of this study is to develop clay mineral and humic acid composite materials and to characterise their possible applications. For this research, three types of clay minerals (montmorillonite, kaolinite and bentonite) were modified with three types of humic substances: technical humic acid from lignite, humic substances extracted from raised bog peat and technical K humate from lignite. The sorption was characterised according to the chosen clay mineral and humic acid type and concentration. The obtained material was characterised by Fourier Transform Infrared spectroscopy and Scanning Electron microscopy. The composite materials were tested for sorption of pharmaceuticals (chlorpromazine hydrochloride). The obtained results characterise clay mineral and humic acid composite materials’ possible applications as sorbents for removal of pharmacologically active substances.

Key words: clay composites, humic acids, sorption, environmentally friendly technologies.

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Plant mediated syntheses of silver nanoparticles using common weed (Plantago Major L.)

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Abstract. Metallic nanoparticles with diameter ranging from 2 to 100nm have received enormous attention during the past decades due to their unique properties. The more recent increased demand of Ag nanoparticles in biomedical applications is due to their very low toxicity coupled with cost-effective and eco-friendly synthesis procedures. Plant mediated synthesis methods for silver nanoparticle production offer all those aforementioned advantages and have been the focus of many recent investigations. Another advantage of green synthesis is a direct functionalization of the surface of the nanoparticle by the plant extract, producing a synergetic effect. We have synthesized silver nanoparticles (range 10-80 nm) via plant extract of Plantago Major. A rapid precipitation of nanoparticles is observed. The structural study highlights the simultaneous presence of Ag and AgCl as secondary phase. The proportion of this secondary phase largely depends on the growth conditions and will be discussed. These nanoparticles have demonstrated efficient antimicrobial properties when tested against common bacteria and yeasts. The production yield is also discussed and indicates a possible industrial scalability of plant mediated synthesis of silver nanoparticles using common weeds such as Plantago Major.

Keywords: *Green synthesis, Nanoparticles, Silver, Silver Chloride, Biocidal properties.*

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The energy intensity of the briquetting process in terms of profitability of waste treatment

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Abstract. Modern agricultural industry is a source of a considerable amount of waste, which can come in various forms and states. Such waste, and not just agricultural waste in the form biomass, is highly desirable for further processing, depositing or utilising its energy potential. Briquetting technology is suitable for all these purposes. The briquetting press for industrial use is complex technical equipment. The economy of its operation has a major impact on the profitability of the produced briquettes and hence on the efficiency of waste and biomass processing as such. The paper deals with the energy demands of briquetting in terms of waste treatment and economic profitability of production in the whole context of waste processing as a whole.

Key words: briquetting, energy demands, bio-briquettes, economic profitability.

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Hydrogen production using waste aluminium dross: from industrial waste to next-generation fuel

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Abstract. This article describes the production of hydrogen from white aluminium dross, an industrial waste generated in the aluminium smelter plants. Hydrogen is generated by metal-water reaction between aluminium and water in presence of alkalis like sodium hydroxide and potassium hydroxide. Aluminium dross is described as a heterogeneous material with its major constituents being metallic aluminium, alumina and other salt fluxes like NaCl and KCl. Utilizing the metallic aluminium content entrapped in the matrix of alumina for the metal-water reaction has been the driving force for the waste recycling and simultaneous hydrogen production. Bulk aluminium dross was crushed and downsized. The finer fraction of the powdered aluminium dross is used for the experiments. The effects of dross in the alkaline solution, temperature of the solution and the time of the reaction were studied to understand the generation of hydrogen. The alkaline solution breaks the protective layer of alumina and exposes the entrapped aluminium content to water, thereby commencing the hydrogen liberation.

Key words: Aluminium dross, hydrogen, waste management, recycling.

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PHB-co-HV polymer production by halophilic organisms from organic acids

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Abstract. Polyhydroxyalkanoates (PHAs) are intracellular biopolymers used as energy and carbon store in numerous bacteria. These biopolymers are of particular industrial interest due to their similar properties to polyethylene (PE) and therefore their potential to replace conventional crude oil based polymers. However expensive upstream and downstream processing in the production of the biopolymers reduced the commercial competitiveness. The use of agricultural and forestry waste as substrate for PHA production and halophilic bacteria, reduced costs and paved the way for new ways of biowaste valorisation could be pursued. The conversion of this residual material contributes to achieving the goal of decarbonizing the world economy set by the UN Climate Change Conference COP21 in Paris in 2015. Within the presented paper, three different halophilic strains were investigated for their potential to produce PHB-co-HV from an organic acid profile, similar to the acid profile produced in the hydrolysis phase of biogas production plants. Three halophilic strains (*Halomonas halophila* (DSMZ 4770), *Halomonas elongata* (DSMZ 2581) and *Halomonas boliviensis* (DSMZ 15516)) were investigated for their potential to use butyric acid, propionic acid and acetic acid as single substrate to produce Poly(3-hydroxybutyrate-co-3-hydroxyvalerate) P (HB-co-HV) polymers. All strains were previously tested under comparable growth conditions for acid tolerance with total acid concentrations up to 25 g·L⁻¹. In order to better observe the substrate utilization and PHA production of these strains during growth and stationary phase, samples were taken 6 times daily in an observation time of 99 h. The substrate utilisation was analyzed using a Shimadzu HPLC at 65 °C with an AMINEX HPX87 H column. PHA content was determined quantitatively using a GC-FID (HP 5890 Series II). [5] The utilization of all supplemented acids as well as glucose as an additional C-source could be shown in growth and stationary phase of the two strains already examined. The P (HB-co-HV) production could be detected in the strains with additional glucose as well as with the organic acids as the sole C-source. Interestingly, the relative proportion of co-polymers increased when only organic acids were used, however the absolute P (HB-co-HV) concentration was increased in both strains with additional glucose. Based on these results promising halophilic strains were found for the P (HB-co-HV) production on hydrolysis substrate. However the productivity must be optimised with future media and process optimisation as the maximum PHB-co-HV content achieved was 27.11 % ± 1 % produced by *Halomonas halophila*.

Key words: PHA-production, halophilic organism, organic acids, alternative bio-waste substrate.

Management of wastewater from landfill of inorganic fiberglass

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Abstract. Sustainability is one of the key factors in smart environment management and include the reduction of environment footprint. The waste and wastewater management plans are aimed on actions to reduce the amount of waste and environmental pollution. This includes collection of waste, logistics, storage, processing or valorisation and also treatment. The aim of this research was to evaluate environmental pollution risk and to demonstrate one of the wastewater management schemes to reduce the pollution level. Evaluation of the better management scheme was performed in one of the landfills in Latvia, where fiberglass waste and other inorganic waste is stored. Onsite evaluation results demonstrated the need to develop a better wastewater management scheme of inorganic fiberglass landfill. After that, laboratory–scale experiments for conventional coagulation and biodegradation tests have been performed for efficient management.

Key words: landfill leachate, fiberglass, wastewater management, wastewater treatment, environmental pollution.

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XI FOOD SCIENCE & TECHNOLOGY

The effect of cadmium and lead pollution on growth and physiological parameters of field beans (*Vicia faba*)

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Abstract. Research on the impact of soil contamination on crops is important as plants directly take up heavy metals from the soil through the roots, so heavy metals can enter the food chain. The aim of this study was to investigate the impact of cadmium (Cd) and lead (Pb) pollution on growth and physiological parameters of field beans. Plants in the vegetation experiment were grown under controlled conditions. Changes in growth and physiological parameters were studied at five levels of Cd (0–25 mg L⁻¹) and at 6 levels of Pb in substrate: from (0–1000 mg L⁻¹) at the first day of the experiment, to (0–2000 mg L⁻¹) at the end of the experiment after gradual Pb additions after every sample collecting day. Methods used for analysing the plant material: the content of amino acid proline and photosynthetic pigments were determined by spectrophotometry; chlorophyll *a* fluorescence parameters – using continuous excitation chlorophyll fluorimeter. The fresh weight of plant above-ground parts and roots was detected. The growth and development of field beans was slightly influenced by increasing amount of Cd and Pb in substrate only at the end of the experiment. The highest Cd treatments (Cd20 and Cd25) caused 2.5 and 1.3 times increased proline concentration in bean leaves. The chlorophyll *a+b* content and chlorophyll *a* fluorescence parameter F_v/F_m changed differently throughout the experiment. In general, during the experiment, there was a tendency for the content of proline in leaves for Pb treatments to be increased compared to control. At the end of the experiment the content of proline in field bean leaves of the highest Pb treatments (Pb600+100+400+500, Pb800+100+400+500 and Pb1000+100+400+500) was 1.66, 1.44 and 1.55 times higher, respectively, than that of the control plant leaves. The negative impact of exposure to Pb on chlorophyll *a+b*, chlorophyll *a* fluorescence parameter P_{Index} and F_v/F_m in bean leaves was less pronounced compared to Cd. The obtained results confirm that field beans until their flowering stage can grow and develop in the presence of a large amount of Cd and Pb in substrate without significant growth inhibition and detrimental impact on physiological parameters, if optimal cultivation conditions are provided.

Key words: heavy metals, *Vicia faba*, photosynthesis parameters, proline.

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Development of encapsulated extracts on the basis of meadowsweet (*Filipendula ulmaria*) in the composition of functional foods with oncoprotective properties

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Abstract. Meadowsweet (*Filipendula ulmaria*) is a quite common plant throughout the European countries, including Russia. Therapeutic and prophylactic properties of the meadowsweet are mainly associated with the action of biologically active substances (BAS), in particularly tannins, phenolic compounds, phenolcarboxylic acids, catechins, flavonoids, essential oils etc. The main substances with proven clinical effects are salicylates and flavonoids, what allows to consider meadowsweet as an anti-inflammatory, immunostimulating, antioxidant, hepatoprotective, nootropic, adaptogenic and antihypoxic agent. The aim of this study was to analyze the content of BAS in water and 70 % ethyl alcohol extract of *F. ulmaria* flowers from different regions of Russia and develop their encapsulated forms for further use as an ingredient for functional food products. To increase the shelf life of meadowsweet extracts and create a stable form for their delivery to the human body with various food products, encapsulated forms of extracts in the form of micro- and nanosized capsules were developed. The method of encapsulation was carried out using a spray dryer. It was shown that encapsulated meadowsweet BAS can be added to a chicken pate without negative effect on the organoleptic properties of the finished product. The calculation of the cost of the meat product with the complex functional dry mixture showed a slight increase in the cost of the final product compared to the traditional analogue. This study shows that encapsulated meadowsweet BAS can be used for inclusion in various food products, to ensure the functional properties of food and optimize the population's rations.

Key words: meadowsweet (*Filipendula ulmaria*); flavonoids; encapsulated extracts; biologically active substances.

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Use of lipids of *Chlorella* microalgae in poultry meat marinades and sauces recipes

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Abstract. The aim of this study is to develop formulations and technologies for fermented poultry meat products with the addition of whey and lipid extracts obtained from *Chlorella* microalgae. Lyophilized microalgal biomass was obtained from cell suspensions of *Chlorella sorokiniana* (strain 211-8k) cultivated in a closed photobioreactor under laboratory conditions. For the cell wall disintegration, the biomass samples were homogenized using a high-speed homogenizer at 10,000 vol. min⁻¹ for 5 minutes. The lipid extraction was performed on a Soxhlet apparatus Buchi E-812 SOX with the solvent extraction system ethanol: n-hexane (1: 9). The higher fatty acids composition of the obtained microalgal lipid extracts was determined by gas chromatography with flame-ionization detection using nitrogen as a carrier gas. The ω -3 and ω -6 content represented 26.59% and 19.05% respectively, which indicates that these lipid extracts have high nutritional values. The curd whey was obtained from cow's milk of summer and winter production from 2017 to 2018 (Lomonosov district auxiliary farm, Leningrad region); and lyophilized Direct Vat Set (DVS) cultures (Ch. Hansen, Denmark). The organic acids and carbohydrate content in the serum was determined by ion-exclusion HPLC. The FD-DVS CHN-19 culture was selected to produce a serum with improved organoleptic characteristics and a lower propionic acid content (0.01 g.l⁻¹). To obtain an optimal ω -3 / ω -6 ratio, a phyto-additive mixture based on sunflower oil and lipid extracts from *C. sorokiniana* microalgae at a ratio of 5-10: 1 is proposed to be used in recipes and technologies of sauces and marinades. It is established that the use of curd whey marinades allow to increase the water-holding capacity (WHC) by 6–8% and to reduce losses during heat treatment of poultry meat from 2 to 11%.

Key words: microalgal biomass, *Chlorella*, microalgal lipid extract, curd whey, DVS-cultures, marinades and sauces, poultry meat.

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Biochemical analyses of millet (*Panicum miliaceum* L) germinating grains suggest its utility for the production of quality flour for general and specialized dietary foods.

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Abstract. During past decade, there has been an active search for new sources and means to produce bioavailable foods with pre-defined properties, particularly, for the production of foods, which could be incorporated into gluten-free diets (GFD). This search prompt the development of various technologies utilizing biologic modification of raw plant materials to obtain foods with greater digestibility and nutritive value. In this study, we evaluated changes in the enzymatic activities in germinated proso millet (*Panicum miliaceum* L) grains. Our analysis demonstrated that grains of four selected cultivars of proso millet had similar germination rates in different media. However, the pikes of amylolytic and proteinase activities were detected at the 2nd and 3rd days of germination, whereas the pike of lipase activity was associated with the 4th day. The highest and the lowest enzymatic activities were detected in grains germinated in whey and in NaCl, respectively. During germination, cumulative phenolic content increased up to 3.5 times reaching the highest levels by day 5. Based on this data, we produce batches of flour from grains germinated for 3 days and evaluated its utility in producing non-rising dough for shortbreads, pastry, and pancakes. Collectively, our data demonstrated that germination of proso millet grains for 3 days provides optimal activation of enzymes to increase bioavailability of the flour and that this flour could be used for partial substitution of the wheat flower in traditional and specialized GFD diets.

Key words: Proso millet, germination, enzymatic activity.

Accelerated technology of rye bread with improved quality and increased nutritional value

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Abstract. Accelerated bakery technologies do not always ensure high bread quality. The taste and smell of bread is less pronounced when compared with the traditionally prepared bread and it is quickly subjected to microbial spoilage. The aim of the research was to develop an improved composite mixture for the accelerated technology of rye bread, which would improve its quality, nutritional value, extend shelf life and microbiological stability. Rowan powder (botanical species *Sorbus aucuparia*) as unconventional raw ingredients of high nutritional and biological value was used. Rowan powder has high acidity (40 degrees or 5.7% in terms of malic acid) and contains a wide range of organic acids, including volatile acids (2–3%) and preservative acids (such as sorbic acid), as well as other micro- and macronutrients. New acidifying additive with rowan powder was created. The optimal dosage of rowan powder in the new acidifying additive by 13% per 100 kg of flour allows bread making with higher specific volume, acidity and porosity of the crumb compared with the control sample. The research proves that rowan powder usage in the accelerated bread technology improves its organoleptic and physico-chemical indicators and also increases the content of dietary fiber, vitamins and minerals. The content of fibers in custard bread with rowan powder was 1.85 times higher than in the control sample. The rowan powder usage has a positive effect on the preservation of bread freshness during its storage. The rowan powder usage slows down the custard bread mould disease.

Keywords: bread, rye, rowan powder.

Development of formulation and technology of yogurt with prolonged shelf life enriched with biologically active substances from fennel seed extract

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Abstract. Spray drying is most common drying technology in food industry and can be used as an alternative to freeze drying method for the production of extracts in powder form. Fennel seeds are used to treat diabetes, bronchitis and chronic cough. They possess antibacterial, antifungal, antithrombotic, anti-inflammatory, hepatoprotective and antidiabetic activities. The aim of this study was to obtain fennel extract in dry form and investigate the influence of dry fennel extract incorporation on the possibility of yogurt production. The effect of inlet temperatures on wettability, solubility, moisture content and water activity of spray-dried fennel seed extract obtained by decoction technique was investigated. The inlet temperature 165°C was preferred. Lactic acid accumulation during fermentation occurs faster in the sample with fennel powder. Based on the results of rheological, organoleptic, physico-chemical properties, water- holding capacity and shelf life of the finished product, the recommended doses of dried fennel powder for yogurt manufacture is not more than 1%.

Key words: decoction, fennel extract, natural food preservation, spray drying.

Development of formulation and technology of fermented dairy beverage for musculoskeletal disease prevention

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Abstract. According to the data of World Health Organization, 20-33% of people across the world suffer from painful musculoskeletal conditions, which lead to restricted mobility, dexterity and functional mobility. The aim of the research was to develop formulation and technology of yogurt for prevention of musculoskeletal disease. The results of sensory characteristics, physico-chemical parameters, rheological characteristics, fatty acid composition have shown that it is possible to create the new product with curcumin, grape seed oil, hyaluronic acid and chondroitin sulfate, which are recommended to use for improving various symptoms of musculoskeletal disease. However, the chosen components increase the manufacturing process. It was observed that fermentation time increase was caused by addition of curcumin, which inhibits the lactic acid bacteria growth within 2,5–3 h. The combination Tween 80 and lecithin allows to obtain stable product during the storage period.

Key words: musculoskeletal disease prevention, curcumin, grape seed oil, emulsion.

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Effect of Different Sugar Sources on *P. rhodozyma* Growth and Astaxanthin Production

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Abstract. Xanthophyllomyces dendrorhous (formerly, Phaffia rhodozyma) is one of the most promising natural sources of commercial astaxanthin; capable of biosynthesizing astaxanthin in quantities up to 84% of its total carotenoid composition output. Although astaxanthin production from *P. rhodozyma* is lower than *H. pluvialis*, the former is preferred due to higher growth rates and easier cultivation conditions that might decrease the production time at industrial scale. Moreover, *P. rhodozyma* may utilise different carbon substrates including glucose, maltose, sucrose, cellobiose, xylose, arabinose, lactose, etc. This provides an irresistible opportunity to further lower production cost by using industrial waste such as molasses. This research work therefore evaluates the growth dynamic and astaxanthin production of *P. rhodozyma* growing on soy and sugar beet molasses. Liquid media with 2% sugar concentration composed of soy molasses, sugar beet molasses or standard glucose (as control) were inoculated with 48 hrs. old seed culture (grown in standard glucose media: 2.0% glucose, 1.0% peptone, 0.2% yeast extract) and grown at 18 °C - 22 °C with stirring speed of 220 rpm for 7 days. Samples were taken daily throughout the study period to assess; cell count, dry cell mass and amount of astaxanthin. The composition of media was varied with presence or absence of yeast extract or peptone. *P. rhodozyma* was subsequently cultivated in 3 L fermenter with optimum media composition and temperature. Astaxanthin was quantified using HPLC. Results of preliminary studies places soy molasses as chief, in comparison to standard glucose media and sugar beet molasses-based media, with biomass and astaxanthin yield of 12 g/l and 839 µg/g respectively. Eliminating/reducing the need for additional resources (e.g. yeast extract, peptone) or the production of higher amount of astaxanthin with molasses-based media compared with equivalent standard glucose media, we hope to establish optimum conditions for the maximum growth and astaxanthin production by *P. rhodozyma* on molasses-based media and hence provide a cheap alternative for the cultivation of *P. rhodozyma* and production of astaxanthin.

Key words: Phaffia rhodozyma, astaxanthin, molasses.

Surface wax composition of wild and cultivated Northern berries

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Abstract. Surface wax of plants is the outer layer, which protects the plant from dehydration, extreme temperatures, UV radiation and changes in the environment, as well as attacks from moulds and bacteria. Studies of berry surface wax are of importance to understand metabolism character (factors affecting wax layer composition in different berry species) as well as to increase the shelf life of berries and increase the microbial resistance. The aim of this study was analysis of surface wax composition of commercially grown 8 blueberry (*Vaccinium corymbosum*) varieties, wild bilberry (*Vaccinium myrtillus* L.) and bog bilberry (*Vaccinium uliginosum* L.). More than 80 different compounds were identified and quantified belonging to 9 groups of compounds, namely, alkanes, phytosterols, alcohols, fatty acids, phenolic acids, ketones, aldehydes, esters and tocopherols. Significant differences were found between blueberry (*Vaccinium corymbosum*) and bog bilberry (*Vaccinium uliginosum* L.) surface wax composition. Amongst studied berries differences were found in concentrations of triterpenes (up to 62% in blueberries), and fatty acids (up to 26% in bilberries) identifying species related differences influencing associated functional properties of berry wax (antimicrobial activity, stress caused by environmental changes). Blueberry variety ‘Polaris’ had the highest amount of ursolic acid (9.30 g 100 g⁻¹), alpha-amyrin (11.07 g 100 g⁻¹) and lupeol (10.2 g 100 g⁻¹). Research on berry surface wax composition could help reduce loss of commercially produced berries due to environmental impacts or microbial attacks, prolonging shelf life and overall quality of fruits and vegetables post-harvest.

Key words: blueberry, bilberry, bog bilberry, cuticular, cuticle, surface wax, chemical composition, lipids.

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Investigation of extruded cereals enriched with plant by-products and their use in fermented beverage production

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Abstract. The aim of the study was to analyse the quality of extruded cereals enriched with plant by-products and to obtain fermented drinks from production rejects. Extrusion was performed with co-rotating twin-screw extruder (compression ratio 8:1) at MILZU Ltd. from rye and oat flour (80:20, control samples) with addition of apple (ABF), carrot (CBF) and pumpkin (PBF) by-product flour in various amounts (10%, 15% and 20%). Naturally fermented kvass production process was used for non-alcoholic fermented beverage production. Total dietary fibre (TDF), textural properties and sensory features of extruded products after addition of by-products (BP) were determined. Dry matter, active acidity and sensory properties were analysed in fermented beverages. The obtained results showed a 12-55% increase in TDF of extruded cereals ($11.8 \text{ g } 100 \text{ g}^{-1}$) after addition of plant by-products. All extruded samples with BP showed lower hardness levels than control ($35.55 \pm 2.95 \text{ N}$); samples with PBF were the least hard ($P < 0.05$). Samples with the lowest bulk density were obtained by the addition of 10% and 15% PBF, and 15% CBF, whereas addition of apple by-product flour in all tested concentrations gave the samples a higher bulk density compared to control. Highest taste and aftertaste scores using 5-point hedonic scale were given to samples with addition of 15% and 20% ABF, which also showed high consumer acceptance. With regards to fermented drinks, the highest dry matter content was found in PBF and ABF drink, 8.1 ± 0.1 and 7.0 ± 0.1 , respectively. Sensory evaluation of fermented beverages showed that the intensity of flavour, acidity and aroma was most pronounced in sample with ABF, whereas colour was most pronounced in sample with PBF. In order to reduce production costs, it is possible to use production rejects of extruded cereals enriched with plant by-products to obtain new products.

Key words: by-products, extrusion, dietary fibre, fermented beverage, sensory properties.

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The effect of humic acids on the natural resistance of the body of broiler chickens and the quality of their meat

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Abstract. The aim of the work is to study the effectiveness of the concentration of humic acids of *Reasil Humic Vet* feed additive on the increase of the feed bioavailability for poultry and the probability of its negative impact on the safety and marketable characteristics of the final product. Studies were conducted on the basis of the Saratov State Agrarian University in two similar groups of broiler chickens “Cobb 500”, 100 heads each. Poultry feeding consisted of the same complete feed, but the drinking water for the broilers of the experimental group was enriched by humates in the amount of 0.5 ml l⁻¹. Based on the data obtained by daily weighing of the poultry and considering the feed intake, a positive trend of the influence of the feed additive on the average daily weight gain and feed conversion per unit of production was noted. The results of slaughter and anatomical cutting of broiler carcasses revealed that metabolic processes were more active in the body of an experimental poultry, reflected in the intensive growth of muscle tissue and fat deposition, which contributed to an increase in the yield of edible parts from carcasses by 9.9%. Studies of composition of broiler blood indicate non-toxicity of the recommended concentration of humates in the feed additive, its stimulation of non-specific resistance of the organism, contributing to the functioning of the immune system and the development of internal organs and, as a consequence, ensuring the safety of the products obtained from them.

Key words: body resistance, humic acid, *Reasil Humic* additive, live weight, muscle and adipose tissue, safety.

Technology development of obtaining essential fatty acids from hydrobionts hydrolyzates

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Abstract. ω -3, 6-fatty acids from hydrobionts are a minor component in the nutrition of European countries population. This causes a number of diseases, such as cardiovascular ones, cancer etc. There is a task of concentrating these acids in oil due to the fact that to meet their daily needs it is problematic to use large quantities of fish oil-from 15 to 20 g. Particularly rich in ω -3, 6-acids are wastes from the cutting of hydrobionts, containing muscle tissue and skin. Protein hydrolysates were obtained from rainbow trout (*Oncorhynchus mykiss*) and Atlantic herring (*Clupea harengus*) wastes by the electrochemical method using electrolyzers of the original design which are allowed to be used in food industry. A technological scheme of separating of lipids from protein hydrolyzates has been developed and experimental batches of oil samples have been developed. To concentrate the fatty acids the cryoconcentration method was used. The phase transitions of the obtained lipids were studied after their cryoconcentration in the temperature range from + 15°C to minus 40°C in the environment of calcium chloride using a low-temperature refrigeration unit. To analyze phase transitions the plant was used, which is a container with a solution of calcium chloride cooled by a low-temperature refrigeration machine. The properties of 5 fractions of lipids formed at the time of lipid phase transitions have been identified and studied (the fractional composition, acid, iodine numbers, the content of polyunsaturated fatty acids (PUFAs), vitamin D₃ and A). It was established that as cryoconcentration increases the concentration of PUFAs, reaching values close to 90%, which allows the resulting product to be attributed to biologically active food additives (BAA). By calculation, it was shown that to create functional food products on fish base from fish of the Gadidae family it is enough to inject 4 grams of BAA to 100 grams of the product. Organoleptic properties of food products from low-fat fish species were improved.

Key words: Fish oil, omega-3-fatty acids, omega-6-fatty acids, functional food, cryoconcentration, biologically active food additives.

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Phenolic and volatile compound composition influence to specialty coffee cup quality

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Abstract. With increasing specialty coffee consumption, more attention is focused not only on the cup quality (sensory quality) of the coffee beverage but also about the impact of coffee on health. The beneficial effects of coffee on human health are mainly based on a wide range of biologically active components, including phenolic compounds. The aim of the study was to evaluate the influence of phenolic and volatile compound composition to specialty coffee cup quality. Seven specialty coffees from two Latvian roasteries were selected and analysed. Total phenolic and flavanoid content and radical scavenging activity by DPPH and ABTS assay were determined spectrophotometrically. Sensory evaluation (cup quality) was performed by trained panellist team using the SCAA protocols cupping specialty coffee. Volatile compounds were extracted by SPME and analysed by Gas Chromatography-Mass Spectrometry (GC-MS). Coffee final cup quality score ranged in amplitude of 83-90.25 points. HON_2 with dry fruits and melon characteristics has shown the highest final cup quality score. Almost detected volatile compounds in KEN_1 is associated with positive specialty coffee characteristics. In ETH_1 coffee with the final cup quality score 88.25 was detected highest floral, fruity compounds and highest coffee-like roasted notes. The highest total phenolic content and DPPH, ABTS^{•+} value showed Roastery_1 coffee samples (HON_1; KEN_1; COL_1) and the lowest values Roastery_2 coffee samples (HON_2; ETH_1; HON_3; SAL_1). The results indicate that the roastery specific roasting process parameters could influence not only volatile compounds profile and cup quality but also the total and individual phenolic compound content.

Key words: phenolic compounds, coffee aroma, cup quality, volatile compounds.

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Winter rye grain quality of hybrid and population cultivars

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Abstract. Rye (*Secale cereale* L.) is an important European crop used for food that is grown primarily in Eastern, Central and Northern Europe. Consuming rye grain products provides a rich source of dietary fibre as well as several bioactive compounds with potentially positive health implications. The goal of the research was to compare the rye grain quality of hybrid and population cultivars. A field trial was carried out in Priekuli Research Centre, Institute of Agricultural Resources and Economic (in Latvia) during a three-year period: 2014/2015, 2015/2016, and 2016/2017. The trial included population winter rye cultivars 'Kaupo', 'Amilo', 'Dankowskie Amber' and hybrid rye cultivars 'Brasetto', 'Su Drive', 'Su Mephisto'. Rye grain quality indices were analysed at Latvia University of Life Sciences and Technologies, in Grain and Seed Research laboratory. Average data in our investigation (three years) show that cultivar, crop-year (weather conditions) and cultivar×crop-year interaction significantly ($p < 0.05$) affected rye grain protein content, starch content and Hagberg falling number. A significant negative correlation was found between protein content and starch content $r = -0.937$ (population cultivars grain), $r = -0.944$ (hybrid cultivars grain), medium strong negative correlation was found between protein content and falling number, respective $r = -0.549$ and $r = -0.573$. Differences between hybrid cultivar grain protein content, falling number and starch content comparing with population cultivar grains were not observed. The results of the current research show that the quality of all the studied cultivars meets the requirements for high-grade rye grains for food consumption.

Key words: winter rye, protein content, starch content, Hagberg falling number.

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Investigation of various factors on the germination of chia seeds sprouts (*Salvia hispanica L.*)

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Abstract. *Salvia hispanica L.* is capable to produce a large amount of green matter, which can be used as a source of biologically active substances. The purpose of this research was to select the optimal factors for the chia seed sprouts (*Salvia hispanica L.*) germination. Dark variety chia seeds (100 grains/sample) were investigated. The most significant factors for the process of sprouting were selected as the study factors, such as the water mass fraction, the temperature and the light exposure for seed germination. The output parameters of the experiment were seed germination energy, germination of seeds, speed of germination and seedling vigor. It was revealed that the mass fraction of added water had the greatest influence on the growing process of chia seed sprouts. The optimal amount of water for producing the chia seed sprouts was in the average of 4 ml/sample. As a result, it was noted that an insufficient or excessive amount of water had a negative effect on the chia seed sprouts germination. The optimum temperature for germination of chia seed sprouts was 25°C. The optimal light factor was also determined; in particular light exposure peaks occur in the red spectrum with a wavelength of 660 nm and a blue spectrum with a wavelength of 450 nm.

Key words: chia seed sprouts; *Salvia hispanica L.*; germination factors; microgreens.

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The impact of plant powders on acrylamide content in bakery products

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Abstract. This work is devoted to studying acrylamide (ACR) formation and the changes in its levels display during the storage in bakery products (BP) made of wheat flour enriched with plant powders (in the optimal amounts established earlier): blueberry – 3%; pine nut – 6%; rowan – 5%; sea buckthorn – 5%. BP were baked at two temperatures – 220 and 200 °C. ACR level was determined with the use of ‘Kapel 105 M’ capillary electrophoresis system in various BP parts (crust, sub-crust layer, crumb) 3 and 24 hours after baking. ACR formation differed in different BP layers. All plant powders slowed down its formation in the crust and the sub-crust layer. The process was influenced by formation of heterocyclic compounds (lactams) as a result of the Maillard reaction. In the crumb, ACR formation depended on the type of the used plant powder. In BP cooked with blueberry and rowan powders, the ACR level decreased, while in BP cooked with sea buckthorn and pine nut powders, it increased in comparison with other layers. Lowering the baking temperature helped to decrease acrylamide formation by 15–20% in the crumb and by 25–35% in the crust. After storing BP for 24 hours, a decrease in the ACR level was found, mainly in the crust and crumb. The intake of ACR in the human body of 70 kg when used with 100 g of BP enriched with plant powders will come to 0.16–0.2 µg. Lowering the baking temperature will decrease ACR level by 3–6%.

Key words: bakery products, acrylamide, crust, sub-crust layer, crumb, plant powders, storage.

Effect of Ultrasonic Treatment on the Dissolution of Milk Solids During the Reconstitution of Skim Milk Powder

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Abstract. The producing reconstituted milk products that retain the same sensory properties as those of raw milk products is of high interest to the food industry. In the technology of producing reconstituted milk processing products, the most significant factor that determines the component transition degree and the usefulness of the product being produced is the recombination process. It determines the possibility of bringing the organoleptic characteristics of reconstituted milk to the properties of the genuine one. One promising method to improve the process of milk powder recombination is ultrasonic exposure. The aim of the present study is to improve the process of milk powder recombination using ultrasonic exposure. The results of the conducted studies show that the ultrasonic treatment eliminates the agglomerates of dried milk particles in water and provides more accessible interaction between the particles and water, and as a result, improves the recombination process. The application of ultrasonic treatment during the reconstitution of the skim milk powder improved the dissolution of milk solids, as evidenced by around a 75% reduction in the amount of centrifuged insoluble sediment. The mass fractions of protein and lactose have increased by 4.8 and 6.5%, respectively.

Key words: reconstituted milk products, ultrasonic exposure, skim milk powder.

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The Study of the Effect of Acid Whey pH on Lactobionic Acid Production by *Pseudomonas taetrolens*

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Abstract. Productivity of lactobionic acid by microbial production can be affected by various factors. The present research examined the effect of initial substrate pH on the yield and productivity of lactobionic acid production by *Pseudomonas taetrolens* DSM 21104 and NCIB 9396. Acid whey chemical composition was determined by MilcoScanTM Mars (Foss, Denmark), pH by pH-meter Jenway (Bartword Scientific Ltd, Essex, UK). *Pseudomonas taetrolens* NCIB 9396 (NCTC, England) and *Pseudomonas taetrolens* DSM 21104 (DSMZ, Germany) were used for lactobionic acid production. Assays were carried out at different initial pH levels (4.25, 5.0, 5.5, 6.0, 6.5 and 7.0) and pH was adjusted by adding 6 M NaOH. Lactobionic acid concentration was analysed by high performance liquid chromatography (Shimadzu LC 20 Prominence, Japan). The adverse effect of pH has been identified as important factor affecting lactobionic acid production. *Pseudomonas taetrolens* DSM 21104 and NCIB 9396 showed reduced cellular distribution at pH less than 6 and a further delay of the lactobionic acid production. The results showed that *Pseudomonas taetrolens* DSM 21104 and NCIB 9396 strains are most active around of pH 6.5. These results will help to upgrade lactobionic acid production with *Pseudomonas taetrolens* DSM 21104 and NCIB 9396 using acid whey as a substrate for lactobionic acid production.

Key words: lactobionic acid, *pseudomonas taetrolens*, acid whey, lactose oxidation.

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Impact of using the developed starter culture on the quality of sourdough, dough and wheat bread

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Abstract. There is no technological necessity of sourdough usage when preparing wheat bread as it can be prepared without sourdough but only with yeast using. However, sourdough helps to solve such problems as fast microbial spoilage, unexpressed taste and smell, crumbling crumb. The use of sourdough prepared with directional cultivation of microorganisms allows to produce high-quality competitive bread. Developing a starter culture with an optimized microbial composition was the purpose of this study, allowing the quality and the microbiological stability of wheat bread improving. A new starter microbial composition for the sourdough was developed. Lactic acid bacteria strains *L. plantarum* E90, *L. brevis* E120 and yeast *S. cerevisiae* Y139 were selected for the new composition. It was proven that the rice products using to microorganism immobilization allows saving the largest number of living cells after drying and during storage. The rate of acid accumulation in sourdough was established. The sourdough dynamic viscosity decrease at the end of fermentation by 2.2 times was established, which means that the fermentation process leads to the sourdough liquefaction. The optimal dosage was established (5-10% flour in sourdough). This dosage provided good physico-chemical and organoleptic quality indicators of bread. It was proved that the sourdough usage allows getting good-quality bread even when the flour with unsatisfactory amylolytic activity (high drop number) is used. Slowing down the microbial spoilage in sourdough bread was proven. In general, the developed sourdough wheat bread biotechnology improves bread quality and its resistance to the rosy-bread disease.

Keywords: wheat sourdough, sourdough bread, yeast, lactic fermentation, microbial spoilage.

Effect of high pressure processing on raw pork microstructure and water holding capacity

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Abstract. High pressure processing (HPP) is widely used as an alternative to thermal food preservation technologies, including processed meats treatment. This technology affects food texture and water-holding capacity, which may have beneficial effect on product yield. After thermal treatment, meat partially releases water together with water-soluble proteins, which is concerned as a loss. It is very important not only because of changes in taste properties, but also economic aspects such as reduced final product weight. The aim of the study was to evaluate changes in the meat microstructure and water-holding capacity upon high pressure treatment. Pork samples were treated at various pressures and holding times, namely, 300 and 600 MPa with a 1 and 15 minutes holding time at each pressure. Untreated sample was regarded as a control. Microstructure of pork meat was evaluated after the paraffination of the samples. Fibre cross section area and space between fibres were measured and reported. Water-holding capacity was measured by centrifugation of meat samples over filter and calculating released amount of juice. Results indicated that fibre size did not change significantly after treatment at 300–600 MPa pressure comparing to the control sample – untreated meat. However, high pressure can affect hydrophobic properties of myofibrillar protein. The experimental results showed that water-holding capacity increases with the high pressure treatment. It is important issue in meat processing industry, because HPP treatment allows reducing the water loss in fresh pork

Key words: high pressure processing, histology, expressible water, pork.

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Biosynthesis of glycosidase inhibitors on wheat bread wastes hydrolysate medium by *Streptomyces sp. 170*

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Abstract. The aim of the present study is to investigate the potential effect of bread hydrolysate as a novel nutrient medium for cultivating *Streptomyces sp. 170* (*S.170*). Moreover, it evaluates the productivity and inhibitory activity of pancreatic α -amylase inhibitors (PAAI). Bread hydrolysate medium (BHM) and corn starch hydrolysate medium (CHM) prepared with α -amylase enzyme concentrations (1.5 and 2.5 units g⁻¹ bread) and (1.5 units g⁻¹ corn starch), respectively were utilized in the study. The Seherde-Blair and modified Akulova methods were applied to evaluate the carbohydrates concentration and the inhibitory activity of the media respectively. Results of bread and corn media were compared to each other. Furthermore, the activity of PAAI synthesized by *S.170* was compared to other *Streptomyces* species. The results showed a significant difference ($P < 0.05$) between the total simple sugars (glucose + maltose) concentration produced in CHM (27.5%) and BHM prepared with α -amylase 1.5 units (45.1%). Besides, BHM produced by α -amylase 2.5 units demonstrated the maximum total concentration of simple sugars (49.9%). In addition, 48 h of *S.170* incubation were quite enough to exhibit the highest inhibitory activity (2632 IU mL⁻¹) in BHM prepared with α -amylase 2.5 units. The analysis demonstrated a non-significant difference in the inhibitory activity of PAAI in CMH (1300 IU mL⁻¹) and BMH with α -amylase 1.5 units (1111 IU mL⁻¹). Also, compared to other *Streptomyces* species, *S.170* conferred highly active PAAI. In conclusion, BHM showed its efficiency to a great extent in the cultivation of *S.170* and production of PAAI with a notable high activity.

Keywords: bread hydrolysate medium, corn starch medium, *Streptomyces sp. 170*, inhibitory activity, pancreatic α -amylase inhibitors.

Blends of unrefined vegetable oils for functional nutrition

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Abstract. The unbalanced ratio of ω -3/ ω -6 of polyunsaturated fatty acids (PUFAs) causes a number of alimentary-dependent diseases, and the intake of capsulated forms as biologically active additives does not always take into account the established eating behavior of the population and the hedonic aspect of food consumption in general. The Saratov region is one of the leading agricultural regions in the Russian Federation, one of the leaders in the cultivation and processing of low-used but valuable oily raw material, such as seeds of mustard, milkthistle, camelina, safflower. The object of the study were the above listed oils and their food compositions obtained by blending. The functionality and biological efficiency of the initial oils were investigated by gas-liquid chromatography. Applying the methods of mathematical modeling, new food systems with the specified characteristics were designed (achieving the optimal ratio of ω -3: ω -6 acids). The most promising samples were selected through sensory analysis. Functional and sensory properties were taken as reference points for selection. The developed mathematical model is applicable to this food system, which was proved by the study conducted empirically. As a result of the work performed, blends of elite unrefined vegetable oils with health-promoting properties were obtained; their use in nutrition is designed to contribute to the formation of a healthy and active longevity in general, as well as to the minimizing the deficit of essential factors of nutrition in the child's body, athletes in the popular sports and sports of records.

Keywords: blends of unrefined vegetable oils, sources of polyunsaturated fatty acids, safflower oil, camelina oil, milkthistle oil.

Some morphological and chemical characteristics of oregano (*Origanum vulgare* L.) in Latvia

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Abstract. By European Cooperative Programme for Plant Genetic Resources (ECPGR), oregano (*Origanum vulgare* L.) is included on the list of priority species of medicinal and aromatic plants. In Latvia, it is important to cultivate oregano for keeping biodiversity and for meeting the needs of medicinal plant's production. 44 accessions of oregano from the *ex situ* collection of genetic resources of medicinal and aromatic plants, attached to the Latvia University of Life Sciences and Technologies, were analysed during 2012 – 2014. Plants' morphological characteristics were described by the Draft Descriptor List of oregano, using the methodology of ECPGR. The essential oil was isolated using solvent-free microwave extraction method and analysed by gas chromatograph Hewlett Packard 6890 equipped with flame ionization detector FID and polar capillary column HP 20M. The results showed, that oregano accessions differ morphologically. Accessions are characterized with dense branching and the possibility to create big biomass. Local oregano is poor in content of essential oil, but 17 compounds were identified as the principal. As well as the correlation between the content of essential oil and colour of flowers in full flowering stage was observed - it is higher for accessions with dark flowers. Also, the influence of meteorological conditions per vegetation period (year) on chemical characteristics was significant ($p < 0.05$).

Key words: essential oil, Draft Descriptor List, accessions.

The effect of ageing on chosen quality characteristics of skeletal muscles of Aberdeen Angus bulls

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Abstract. The objective of the trial was to study the qualitative parameters of two muscles of Aberdeen Angus bulls with 250–300 kg carcass weight. After slaughter, *longissimus thoracis et lumborum* (LD) muscle and unseparated *semimembranosus* and *adductor femoris* (SMA) muscles were removed from the chilled carcasses. Muscles were vacuum-packed and wet aged at +2°C for 10, 14, 18 and 20 days. Meat pH, electrical conductivity, shear force and colour were measured in all ageing times. Two thermal treatment methods (sous-vide (SV) and grilling) were used to determine cooking losses. The effects of muscles, ageing times and muscles by ageing times interaction was found with two-factorial analysis of variance. The effects of muscles, ageing times and muscle groups by ageing time interaction for raw and SV treated meat shear force was significant. Ageing decreased SV treated meat shear force from day 10 (40.8 N) to 18 (29.7 N). Fresh and SV treated LD muscle was tougher compared to the SMA muscle group, but SM showed a better response to the tenderness within 20 days of ageing. Redness and yellowness value was higher in the SM group in comparison to LD. Muscles showed good colour (lightness, redness and yellowness) stability within ageing for 20 days. No interactions were found between muscle groups and ageing times for SV treated and grilled beef cooking losses. However, SV treated meat lost more weight than grilled meat slices. The present study suggests that the optimal ageing time for meat is 18 days when the grilled meat cooking loss is the lowest.

Keywords: beef cattle, *semimembranosus*, *adductor femoris*, *longissimus*, muscle, colour, shear force, cooking loss, Aberdeen Angus.

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Possibility and Prospects of Preservation of Minor Components in Technology of Fruit Raw Materials Conservation

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Abstract. According to modern research, traditional methods of preserving fruits and vegetables do not allow obtaining products identical to natural products for biological value. At the same time, there is a need to provide the population with minor components of food, including concentrated form. The aim of the study was to preserve the minor components in canned fruit raw materials for a long time. The study was carried out comparing the data of bioflavonoids and vitamin C in fresh oranges and dehydrated oranges (immediately after dehydration and storage for 12 months). The analysis was performed by reversed-phase HPLC on Dionex Ultimate 3,000 chromatograph ('Thermo Scientific', USA) using Luna 5U C18(2) 100A, 5 μ m 4.6 mm \times 150 mm column ('Phenomenex', USA), system number 125617-12. The identification of components was performed by comparison of retention times of standard flavonoid samples. Dehydration was done by means of resonant IR drying, gradually lowering the temperature from intense (67-75 °C) to soft (32-35 °C) temperature regimes. Analysis of chromatograms of fresh and dehydrated oranges shows that they all have a similar profile, but differ significantly in the content of certain components. The presence of vitamin C 1,926.9 mg per 1 g of dehydrated oranges was noted, which is identical to the content of 10 g of fresh orange. The following flavonoids have been found: prunus and a component related to the polymer form of naringin, the content in 1 g of dehydrated oranges is approximately seven times more than that for 1 g of fresh orange. The loss of vitamin C by 8% during storage of dehydrated orange for 12 months was noted, the amount of flavonoids varies insignificantly by 2-3%. Studies have shown that the technology of dehydration with the help of resonance IR drying allows to keep the minor components in the native state for a long time.

Key words: dehydration, flavonoids, preservation of minor components, vitamin C.

The determination of impact of malt grist moisture on porosity and permeability using measurement of differential air pressure

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Abstract. This article is focused on determination of malt grist and spent grains porosity and permeability using measurement of differential pressure of the air passing through the layer of malt grist and spent grains. For preparation of malt grist were used different disintegration equipment (two roller mill and disc mill). The method of differential pressure measuring is used for the determination of porosity of malt grist layer, defined as fraction of the volume of voids over the total volume. Measurement confirmed the logical assumption; the higher-pressure difference is above and below the spent grain layer, the lower value of porosity.

Key words: malt grist, special surface area, porosity, permeability, spent grains.

Utilization of image analysis for description of drying characteristics of selected tropical fruits

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Abstract. This study is focused on the utilization of image analysis for description of dimensions, and colours changes of fruits during drying process. Selected tropical fruits such are banana (*Musa acuminata*), mango (*Magnifera indica*) and pineapple (*Ananas comosus*) originally from North Sumatera in Indonesia were used in this experiment. Sliced pieces of the fruits were dried in experimental oven under temperature 90 °C for period of time 180 min and image of fruits samples were recorded by digital camera with HD resolution continuously throughout drying process. With aid of image analysis using Image J software and regarding to drying characteristics the colours and dimensions of the samples were analysed.

Key words: shape, dimensions, properties, mango, banana, pineapple.

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The study of physical properties of spray dried whey and milk permeates lactose

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Abstract. The aim of this study was to investigate substrate and environment effect on the physical state of lactose crystals, their stability and behaviour comparing with pure lactose which traditionally used in an analysis. Sweet and acid whey permeate as well as milk permeate were analysed. Mini spray-drier (BÜCHI B-290, Labortechnik AG, Switzerland) was used for the study. Lactose optical rotation was measured with a polarimeter, structural characteristic was carried out by X-ray diffractometer and glass transition analyses was made by TGA/DSC. α -Lactose monohydrate (Sigma-Aldrich, Germany) was used as a control. All spray-dried permeates samples showed amorphous state lactose crystals. The DSC analysis demonstrated a glass transition in the interval of 85–95°C, melting 202–204°C for spray-dried permeates lactose. In turn, the control sample showed crystallization at 158±0.5°C and a melting peak at 226±0.5°C. Optical rotation of spray-dried lactose obtained from sweet and acid whey permeate and milk permeate was in the range from 18 to 28°, control sample 52°. The study results showed that substrate, sample pH, ingredients and their derivatives impact lactose glass transition and mutarotation. The current study highlights the essential physical properties of spray-dried permeates lactose and the importance of its purity in food, cosmetic and pharmaceutical industry.

Key words: lactose, milk permeate, whey permeate, glass transition, mutarotation.

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