



9<sup>th</sup> International Conference  
**Biosystems Engineering 2018**

**BOOK OF ABSTRACTS**

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9 – 11 May 2018  
Tartu – Estonia

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Book of Abstracts. 9th International Conference on Biosystems Engineering 2018

Editors: Olt, J., Kikas, T., Meneses, L.

<http://bse.emu.ee>

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ISBN: 978-9949-629-70-1

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# **I AGRICULTURAL ENGINEERING**

## Red clover drying coefficient dependences on air velocity at constant drying temperature

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**Abstract.** The clover is widely used as feed of animals and preservation of fodder is an important problem. This paper informs about the experimental and theoretical investigations of red clover (*Trifolium pratense*) drying by forced convection. This research is focused on verification of influence of different air velocities on the drying process of red clover in thin layer in mild temperatures (22 °C) and rather high relative humidity of air (70 %). The initial moisture content of clover was determined by gravimetric method using the hot air drying in the electric oven. Special device for convection drying with air flow passing through material from the bottom through supporting trays with a sieve (dimensions of mesh 3 x 4 mm) by constant temperature was used for drying when the air velocity 0.7 m s<sup>-1</sup>, 1.0 m s<sup>-1</sup>, 1.2 m s<sup>-1</sup> and 2.0 m s<sup>-1</sup>. These results was compared with drying by free convection. Changes of clover samples were determined from the measured values of weight using the gravimetric method. The function of drying coefficient  $K(t)$  is determined (using thin layer theory) and theoretical results are compared with experimental results. Using experimental results were determined relationships between air velocity and parameters included in function of drying coefficient. This allows theoretically to predict the drying process depending on the air velocity.

**Key words:** clover, conservation, drying theory, fodder, forced drying, natural drying.

## Comparison of consumption of tractor at three different driving wheels on grass surface

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**Abstract.** The paper deals with possibility of reduction of tractor fuel consumption when working on grass surface, and compares use of two versions of spike devices embedded to the original tyre body. The device was designed at Department Transport and Handling (Slovak University of Agriculture in Nitra). Older as well as newer system proposed in 2017 comprises spikes and it is assembled to common tractor tyre tread pattern with auxiliary grooves cut in. Same device can be set to two positions, allowing to work as 8-spikes and 16-spikes system. The spikes are tilted in grooves when moving on paved road. The spikes are ejected out to reduce wheels slip when operated in field. Remaining eight spikes are tilted in case of 8-spikes system. Measurements were realised on grass surface. Tractor Mini 070 type was loaded with heavier tractor MT8-065 type in tests with 3 different driving wheels, balancing the actual weight in all cases. Drawbar pull and fuel consumption were measured in tests, allowing to compute specific drawbar consumption and fuel consumption per hour for three different loads. The results pointed out a fact the tyre slip loss and energy consumption of tractor movement increase at the soil humidity 19.45%. It follows from results achieved that use of both 8- and 16-spikes wheel device versions reduced fuel consumption when cultivating higher humidity soil, preferable for tillage. Eight spikes system with semi-tilted remaining spikes is the most efficient method.

**Key words:** tyres, spikes devices, consumption of fuel, agriculture, drawbar pull.

**ACKNOWLEDGEMENTS.** Supported by the Ministry of Education of the Slovak Republic, Project VEGA 1/0155/18 “Applied research of the use of environmentally friendly of energy sources in the agricultural, forestry and transport technology”.

## Optimising cold compressive recovery of oil from the seeds of Sesame (*Sesamum indicum* L.)

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**Abstract.** Effects of the time rate of deformation and aspect ratio on mechanical response and performance in single cycle cold compression scheme were investigated for bulk sesame seeds and response forms fitted using forward stepwise multiple regression technique. The degree of deformation was dependent on the time rate of its induction and the equipment's aspect ratio. Energy requirement correlated positively with deformation rate and aspect ratio. Energy expenditure was however more efficient with larger aspect ratios than with smaller ones, given the associated volume energy demands. Strain resistance correlated positively with each of the two influence factors. The time rate of deformation was the most important predictor of oil yield and performance. All the fitted forms had highly significant effects in predicting the responses investigated with 76.7 – 99.6% of the behaviours of the system explained. The results are valid within the ranges of the influence parameters investigated.

**Key words:** oilseed, cold pressing, compressive stress, strain, energy.

**ACKNOWLEDGEMENTS.** This study has been supported by Integral Grant Agency of Faculty of Engineering, Czech University of Life Sciences Prague, grant number: 2017: 31130/1312/3111.

## Comparison between different types of bedding materials for horses

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**Abstract.** The sports horse lives a large part of the time inside the pen in constant contact with the bedding. Therefore the bedding material can deeply affect the welfare and health of horses kept in pens. The materials have to ensure the realization of a double aim: to create a comfortable and soft surface on which the animal can stand and relax; to give appropriate hygienic and sanitary conditions. Other important factors influence the choice, such as: the material must not be appetizing for the horse; the litter has to maintain a proper level of moisture, so that the hoof is kept healthy, elastic and hydrated. Also the costs for material and litter management have to be taken into account. In the present study, different organic materials are compared: wood chips, hemp, rice, flax and coconut. The trials took place in five box stalls, with square plan of 3 x 3 m. Environmental data were collected during the trials (air temperature and humidity, ammonia concentration, litter moisture). Management data were also collected, regarding the use of bedding materials, working time, costs. In the paper the main results of the comparison between the different litter materials used in horses pens are presented.

**Key words:** horse husbandry, bedding material, housing, sanitary and hygienic conditions.

## Intensification of rape seed drying process through the use of infrared emitters

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**Abstract.** The theoretical basis of the agricultural material drying techniques has been formed in the world for two and a half centuries. Nevertheless, despite the multitude of studies well presented in the literature, the industry still lacks universally recognized methods of design calculation for the majority of drying problems. Presumably, this is due to the fact that the dehydration of foodstuffs is one of the most energy-intensive and complicated work processes. In the process of thermal treatment during the drying, the physical state of the water in the treated item changes, the properties of the item itself are altered. Recently, the drying of foodstuffs by means of infrared (IR) radiation has been gaining ever wider acceptance. At the same time, the technologies for dehydrating foodstuffs and materials are now far ahead of the theory of drying. Not only the classical literature on the drying problems, but even special studies on the subject cannot provide any specific recommendations for the design of installations with the electro-magnetic principle of energy input. Whereas that is exactly the type of installations that are now actively making headway, while offering serious challenges in their modelling. For that reason, experimenting has until now been the only reliable way of their studying. Despite the available extensive scientific literature on the drying, including works on IR units, the practical issues of engineering IR driers have not been tackled. All the existing studies consider solely particular cases. This study discusses the process of drying the fixed bed of rape seeds with the use of the electromagnetic infrared emitter. The energy intensity of the process and the optimum thickness of the product bed are determined. The aim of the paper is to examine the effect that the operating condition parameters (energy input intensity, temperature, grain bed thickness) have on the drying kinetics and the energy characteristics of the process. The methods of research are based on the thermophysical analysis of the material's structure. The experimental studies were carried out with the use of monitoring and measuring equipment, up-to-date methods and instruments, including solutions developed by the authors. The analytical treatment was performed with the use of the software packages: MathCAD, Excel. The sample testing and examination took place in the laboratory and the methods were in compliance with the applicable standards. A comprehensive experimental investigation of the effect that the operating parameters (specific load and power) have on the rape seed IR-drying kinetics had been accomplished

**Key words:** agricultural engineering, rape, infrared emitters, drying, load.



## Theory of retaining potato bodies during operation of spiral separator

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**Abstract.** The increase of the efficiency and quality of performance of the work process of potato heap separation can be achieved by means of improving the design of the vibrational spiral separator and substantiating theoretically its rational parameters under the condition of eliminating damage to the potato tubers. An equivalent schematic model of the interaction between the potato tuber and the surface of the cantilever spiral springs has been devised. On the basis of the model, the kinematic characteristics of the tuber's flight and its impact contact with the elastic surface of the over mounted rebounding conveyor have been investigated. A new analytical mathematical model of the potato tuber's flight from the surface of the spiral separator and its subsequent encounter with the rebounding conveyor mounted above the spiral springs has been developed. New analytical dependences have been obtained for finding out the distance and height of the potato tuber's flight to the point of impact contact as well as the trajectory equation for the travel to the said contact, which makes it possible to obtain the kinematic constraints imposed on the allowed rate of travel under the condition of not damaging the tuber. On the basis of the obtained analytical dependences, the kinematic parameters of the improved design of the spiral potato harvester separator in its interaction with a potato tuber under the condition of not damaging the latter have been investigated.

**Key words:** potato, tuber, harvester, spiral separator, rebounding.

## Theory of impact interaction between potato bodies and rebounding conveyor

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**Abstract.** In order to increase substantially the quality of the potato heap separation, it is necessary to carry out the theoretical substantiation of the spiral separator's parameters with regard to the impact interaction between the product and the tools of the unit under the condition of not damaging the tubers. An equivalent schematic model of the impact interaction between a potato tuber and the surface of the rebounding conveyor has been devised. Taking into account the coefficient of restitution of the tuber's velocity in case of an impact, new analytical expressions have been obtained for determining the magnitude and direction of the potato tuber's velocity after the impact. They provided the basis for applying the principle of momentum at impact and obtaining the analytical expressions that allow determining the impact impulse and impact force at the impact of the tuber on the surface of the rebounding conveyor and, eventually, the dynamic constraints on the permitted velocity of the tuber prior to the impact interaction under the condition of not damaging it. A new analytical mathematical model of the impact interaction of the potato tuber during the potato heap separation has been developed. On the basis of the obtained theoretical results, studies have been carried out on the rational kinematical parameters of the high-quality performance of the above-mentioned work process under the condition of keeping the potato tubers undamaged.

**Key words:** potato, tuber, heap separation, impact interaction, impact impulse, rational parameters.

## Mathematical model of cleaning potatoes on surface of spiral separator

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**Abstract.** Cleaning potato tubers from soil impurities and plant debris after digging them out of soil is a topical problem in the work process of potato production. Therefore, the engineering of new designs of potato heap separators necessitates the further studying of them and the optimisation of their kinematic and design parameters, which must not only ensure the high quality of cleaning, but also rule out the possibility of damaging the tubers. The aim of this study is to determine the design and kinematic parameters of the improved design of the spiral potato heap separator, which will ensure the high quality of cleaning and rule out the possibility of damaging the tubers, on the basis of the development of the new theory of potato tuber's motion on the surface of the separator. An analytical study has been carried out resulting in the construction of the equivalent schematic model of the interaction between the potato tuber and separator, the tuber being approximated by a material point on the surface formed by the two cantilevered spirals, which are the separator's tools. The separator's spirals are driven to rotate and at the same time they can perform oscillations in the vertical and axial plane under the action of the varying load generated by the continuous feeding of the potato heap for separation. In the model, the forces acting on the potato tuber's body are applied to it, the coordinate axes that have been selected and appropriately oriented are shown. A system of equations has been set up for the constructed equivalent schematic model, comprising three differential equations of the potato tuber body's motion on the surface of the trough formed by the two cantilevered spirals. The determined kinematic and design parameters will allow to raise the quality of cleaning potato tubers from soil impurities and plant debris.

**Key words:** potato, tuber, heap separation, impact interaction, impact impulse, rational parameters.

## Air flow conditions in workspace of mulcher

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**Abstract.** Currently, there has been a great effort on increasing the efficiency of agricultural machinery. The energy demands of mulching with the vertical axis of rotation depends on the amount of processed material per unit of time, its properties and efficiency of material processing. Another important factor that is affecting the overall energy demands is the energy losses, which can be even higher than energy, required for the processing of material. The efficiency of the material processing and the energy losses are influenced to a large extent by the air flow inside the mulcher workspace, which is created by the movement of working tools. The air flow ensures the repeated contact of the processed material with the working tools, affects the energy losses and the quality of work. The contribution deals with the air flow conditions inside the workspace of mulcher with the vertical axis of rotation. The velocity of the air flow was measured by means of LDA (Laser Doppler Anemometry) method in three planes above the surface (180, 100 and 20 mm) and in two directions (peripheral and radial). The laboratory model of one mulcher rotor from mulcher MZ 6000 made by BEDNAR Ltd. company was used for the measurement. From the results it is evident that the maximum values of peripheral velocity of the air flow reach approx. 50% of the velocity of the tools. In the radial plane an air vortex is created between 20 and 100 mm planes above the surface around the tip of the blade.

**Key words:** mulcher, airflow velocity, cutting tool, mower.

**ACKNOWLEDGEMENTS.** The paper was created with the grant support – CULS IGA 2016: 31190/1312/3116 – Effect of cutting tool shape on air flow in working area of mulcher with vertical axis of rotation and CULS IGA 2017:31190/1312/3119 – Analysis of the impact of biofuels on the pressure profile in the combustion chamber of turbocharged diesel engine. The authors also acknowledge the financial support from the project Reg. No. FSI-S-17-4444 funded by the Brno University of Technology. The authors also acknowledge BEDNAR FMT, Ltd. for providing blade section of mulcher and help with the design of mulcher model.

## Effects of fertilization on *Picea abies* stands situated on drained peat soils

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**Abstract.** Norway spruce used for afforestation of drained peat soils frequently has low productivity and decay in a long-term, which could be related to soil chemical composition and nutrient status. The research aim was to elucidate the effect of PSM on new Norway spruce plantings (1st experiment) and 20-year-old spruce stands (2nd experiment) on drained peat soils by evaluating: (1) nutrient accumulation in soil-plant system, (2) soil microbiological activity, (3) health status of spruce individuals, (4) growth intensity and productivity of spruce, (5) changes in composition of vascular plant and moss species. The study was conducted at two forest (*Myrtillus turf.mel.*) sites in Latvia, each consisting of two plots: control and treated with PMS (100 g m<sup>-2</sup> in September 2007, 50 g m<sup>-2</sup> in April 2008). During 2008-2016, regular analysis of soil, spruce needles, soil microbiology, assessment of tree crown vitality, stand productivity, inventory of vascular plant and moss species were done. The results showed that the fertilization with PMS resulted in a significantly improved K, Ca, Zn, and N status of trees, crown vitality and up to three times increased tree growth parameters at both experiments during the study period. The average count of bacteria and fungi in soil of fertilized plots, accompanied by a remarkable variability in the study years, was significantly higher only for the 1<sup>st</sup> experiment. Fungi : bacteria ratio for the fertilized and control plots differed significantly only for the 1<sup>st</sup> experiment. Significant increase of cover with nitrophilic plant (*Urtica dioica*, *Antriscus sylvestris*, *Rubus idaeus*) and moss (*Plagiomnium cuspidatum*, *P. ellipticum*) species at both fertilized sites were stated.

**Keywords:** Norway spruce, productivity, mineral nutrition, vegetation, microbiology.

**ACKNOWLEDGMENTS:** The financial support partly provided by the Forest Development Fund in Latvia for project 'Degradation of Norway spruce stands in Latvia: reasons and measures for possible solutions' during 2007-2008, as well as the Basic Research Funding, University of Latvia, for project 'Biological diversity – impacts, functions and protection', N<sup>o</sup> AAP2016/B034, ZD2015/AZ81, during 2016-2017, are gratefully acknowledged. The authors thank two anonymous reviewers for their valuable scientific advises and comments.

## **Alarm guard systems for the prevention of damage produced by ungulates in a chestnut grove of Middle Italy**

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**Abstract.** Wildlife populations, in particular ungulates and carnivores, have had a significant increase in most Italian regions over the last decades and for this reason ecosystems and agricultural and forest productions are threatened by damage produced by wildlife. In order to evaluate effective methodologies and technologies to mitigate the impact of this phenomenon, innovative protection systems, such as electronic acoustic alarm guard sensors, were tested. These devices are able to randomly produce a significant number of sounds and light projections. At the same time, camera traps were used, as a support instrument to show the presence or absence of wild fauna. Video analysis has provided information on the effectiveness of security systems, on the most suitable methods of installation and management of devices and their ecological impact. Experimental trials were carried out in a chestnut grove located in an Apennine area of the Middle Italy during the harvesting period (autumn). The results obtained have shown that these technologies seem to be particularly suitable for crops that concentrate production in a short time (e.g. vine and chestnut) and in areas not excessively large. Widespread use of devices could mitigate the conflict between public bodies involved in the management of wildlife and farmers.

**Key words:** alarm guard systems, camera trapping, forest productions, wildlife populations.

## On the degradation of metformin and carbamazepine residues in sewage sludge compost

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**Abstract.** Recent decades have shown intensive studies devoted to the fate of pharmaceuticals in the environment. These studies have involved the development of analytical tools, determination of pharmaceuticals in different compartments, composting technologies, and plant uptake of pharmaceuticals. The presence of organic pollutants in sewage sludge, including pharmaceuticals, is a problem of major concern. The re-use of sewage sludge should be encouraged since it represents a long-term solution provided that the quality of the sludge re-used is compatible with public health and environmental protection requirements. Composting is a widely recognized way of making the soil application of sewage sludge safer. In this study, the impact of sewage sludge composting on the degradation of metformin (MET), by far the most often prescribed antidiabetic drug worldwide, and carbamazepine (CBZ), a poorly biodegradable but widely used as an anticonvulsant drug to cure depression and seizures, were analysed. The anaerobically digested and dewatered sewage sludge samples were collected from municipal wastewater treatment plant. Composting experiments were performed under fixed conditions during 30 days. The results of the experiment showed that during a 1-month composting period more than 90% of MET residues degraded, but no degradation of CBZ took place during the composting period. The half-life of MET was 3 days for the compost mixture with the ratios of 1:3 and 1:2 (v:v). The results of this study show that composting may lead to the efficient degradation of MET, whereas for the elimination of CBZ from sewage sludge different means should be used.

**Key words:** sewage sludge compost, sawdust, fertilizers, metformin, carbamazepine.

**ACKNOWLEDGEMENTS.** The authors would like to thank Environmental Investment Centre of Estonia for funding this work.

## Odour reduction of manure through addition of boracic charcoal

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**Abstract:** Odours released during the land application of manure results from different gases released from the liquid phase. These gases do create objectionable odours in the vicinity of the land-applied manure. In order to reduce the intensity of odour during manure application, we investigated the effectiveness of combining Borkohle with manure during land application. Boracic acid is widely used as a flame retardant in cellulose insulation. During demolition of existing buildings, this insulation is sorted into its own residual waste fraction. The cellulose fibres are extracted and pelletized on site. Subsequently, the pellets are charred in a pyrolysis furnace. The resulting Borkohle – charcoal containing boron in various compounds - can be used as a soil enhancer and provides the trace element Boron to the fields. Furthermore, Borkohle provides long-term storage of carbon in the soil. Initial trials of combining boracic charcoal with manure additionally showed that odour emissions seemed to be significantly lower when manure was combined with Borkohle. This work presents methods to quantify the odour reductions resulting from the addition of Borkohle to manure as well as first results. Parameters like the influence of the amount of charcoal added and exposure time have been investigated. Charcoal was added at concentrations between 5 and 250 gL<sup>-1</sup>. While applying typical amounts of charcoal, a reduction of odour concentration of up to 85% was observed. A positive correlation between odour reduction and the amount of charcoal added was observed. Charcoal has a negligible effect when exposure times are less than 30 minutes.

**Key words:** Olfactometer, charcoal, insulation materials, demolition materials, manure.



## Development of new elements to automatized greenhouses

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**Abstract.** Development of new elements to automatized of greenhouses is always needed and be it is to improve the current situation because of the increase effectivity in greenhouses or their control. Czech University of Life Sciences Prague was to increase efficiency in greenhouses and therefore, devices designed to improve the automation in greenhouses have been designed and patented. The aim was to propose new improvements for automated greenhouses based on demand. This is primarily about solving the problem of lack of daylight and regularly occurring moss on the roof. This research and development are guided primarily because it is a agriculture branch in the stage of expansion, and it is essential that there is a continuous innovation and research in this field of science. New automatic features or upgrades to existing features in greenhouses, was solved on the basis of the current state of development curent technology. When designet new technologies also help us grants, personal experience with a real installation and cooperation with manufacturers (or with distributors) greenhouses systems. Designs for a light routing system and a system for removing moss from the roof were made.

**Key words:** greenhouses, light panel, applicator, inhibitor, development, roof.

**ACKNOWLEDGEMENTS.** It is a project supported by the CULS IGA TF “The University Internal Grant Agency” (Analisy of the influence of biofuels on operating parameters of combustion engines).

## Determination of moisture ratio in parts of the hop cone during the drying process in belt dryer

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**Abstract.** The paper deals with monitoring the moisture content of hop cones and their parts (strigs and bracts) in PCHB 750 hop belt dryer. When drying hop cones, the critical point is the sufficient drying of the strig. These are therefore dried to a moisture content of 6 to 8%. This exact moisture provides a sufficient guarantee ensuring that the strig is dried up. On the other hand, bracts are dried up to such a level which makes pressing the hops impossible. Therefore, after drying, the bracts are remoistened. This is called hops conditioning. After conditioning the moisture content of hops is optimal, ranging between 8 and 11%. There is no doubt that drying or any further moistening does not benefit the hop cone.

During the experiment, the moisture content was determined regarding the whole hop cones as well as the bracts and strigs separately, the samples of which had been taken from the hops prior to entering the dryer, from different parts of belts in the dryer and subsequently before and after the conditioning. The moisture content was determined by means of Mettler HE53 moisture analyzer. After the bracts and strigs had been dried, we calculated their weight ratio which was approx. 90% of bracts and 10% of strigs. Based on this ratio the weighted average was calculated which corresponds to the moisture content of the whole hop cone.

The measured values indicate that the average moisture content of hops below 10% was already at the beginning of the third belt of the dryer. The hops had been unnecessarily overdried along the whole third belt. Another output refers to the moisture ratio of hop cones, bracts and strigs in different parts of the dryer. The obtained values will serve as a basis for the follow-up design of a device for monitoring the dryer parameters and its visualisation.

**Key words:** hop, hop cone, bract, strig, drying, belt dryer, moisture.

**ACKNOWLEDGEMENTS.** This paper was created with the contribution of the Czech Ministry of Agriculture as a part of NAZV No: QJ1510004 research project. In the project solution, besides CULS Prague, are involved: Hop Research Institute Co., Ltd., Žatec; Chmelářství, cooperative Žatec; Rakochmel Co., Ltd., Kolečovice and Agrospol Velká Bystřice Co., Ltd.

## Differential thermal regulation of the growth of the bee colonies in the early spring period

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**Abstract.** This paper addresses the issue of the control of activity and growth of the bee colonies (brooding) in the early spring period. The bees are brooding up already in the late winter, and the intensity of brooding in this period is determined by daytime temperatures and sunshine hours that increase the temperature of the inner hive space. The objective is to design and verify a technology that would ensure the conditions for the optimal brooding in the early spring period and thus the numerically strong bee colonies. The experimental part was based on the temperature regulation in the inner hive space. A preset temperature was maintained inside the hive by an electric heating system with regulation. A differential thermal regulation which enabled the optimal growth of the bee colonies in accordance with the phenophases was chosen for verification. To verify the proposed method, two groups of the bee colonies were assembled. One group of the bee colonies had a heating system with regulation installed inside the hive. The second group of the bee colonies was in the hives without the heating system installed. The dependence of the brood area on time was monitored for the evaluation of both groups of the bee colonies. It was proven that the differential thermal regulation enables the optimal growth of the bee colonies in the early spring period in accordance with the phenophases. The brood area increased evenly for the group of the bee colonies with a regulated temperature of the hive space, reaching a larger area.

**Key words:** bee colonies development, brood area, hive thermal regulation.

## Mathematical description of loading curves and deformation energy of bulk oil palm kernels

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**Abstract.** The study aimed at describing the experimental and theoretical relationships between the force and deformation curves as well as the deformation energy of bulk oil palm kernels under compression loading. Vessel diameters of 60, 80 and 100 mm with initial pressing heights of the bulk kernels measured at 40, 60 and 80 mm were examined by applying a maximum compressive force of 200 kN and a speed of 5 mm min<sup>-1</sup>. For the theoretical description of the force and deformation curves, the tangent curve mathematical model was applied using the MathCAD 14 software where the force coefficient of mechanical behaviour,  $A$  (kN), the deformation coefficient of mechanical behaviour,  $B$  (mm<sup>-1</sup>) and the fitting curve function exponent,  $n$  (-) were determined respectively. The determined coefficients in addition to the maximum deformation values obtained from the compression test were used for the estimation of the theoretical or analytical deformation energy. The determined regression models expressing the deformation, numerical energy and theoretical energy as well as the tangent model coefficients  $A$  and  $B$  dependent on the vessel diameter and pressing height were statistically significant ( $P < 0.05$ ) or ( $F$ -ratio  $> F$ -critical). Improving the mechanical pressing of oil extraction for both domestic and industrial applications still remain a concern of researchers and engineers.

**Key words:** Bulk oil palm kernels, vegetable oil, compression test, force-deformation curves, theoretical models.

**ACKNOWLEDGEMENT.** The research was financially supported by the Internal Grant Agency of Faculty of Engineering, Czech University of Life Sciences Prague, grant number: 2017: 31130/ 1312/ 3111.

## Using the FEM model for design the heat treatment of an agricultural tools

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**Abstract.** Agricultural tools need mechanical properties such as abrasive wear, hardness and toughness. These mechanical properties are achieved by choosing a suitable steel and subsequent heat treatment of the steel. Phases of the microstructure affects the final steel properties. The phase composition in the steel is influenced with the designing of the heat treatment. 25CrMo4 steel was investigated for the production of agricultural tools. The heat treatments were designed for different cooling conditions. The salt bath was used to cooling as a medium with subsequent cooling on the water or in the air. The FEM method was used to designing the heat treatment conditions. The Johnson-Mehl-Avrami-Kolmogorov equation and the Koistinen-Marburger equations were used to prediction the microstructure phases. The microstructures were verified with experimental measurements. The ASTM G65 method was using for abrasion resistance tests. The results show that this procedure can be used to designing parameters of heat treatment of agricultural tools.

**Key words:** chisel, abrasive wear, microstructure of steel, hardness.

**ACKNOWLEDGEMENTS.** Supported by Internal grant 31140/1312/3114 agency of Faculty of Engineering, Czech University of Life Sciences in Prague.

## The rheological properties of undisturbed samples of Typical Chernozem and Vertic Solonetz

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**Abstract.** The rheological properties of undisturbed monoliths of Typical Chernozem of the Kursk region (Russia) and Vertic Solonetz of the Voronezh region (Russia) are presented in this article. The texture of Typical Chernozem's samples is silt loam, and Vertic Solonetz is silty clay. The rheological properties were determined by the amplitude sweep test on the rheometer MCR-302 (Anton Paar, Germany). Measurements of the rheological parameters were carried out at the state of the moisture content of the 3-day capillary swelling. It has been shown the linear viscoelastic range of Vertic Solonetz significantly exceeds the value of LVE-range of Typical Chernozem. This fact is probably related to the more heavy texture of Vertic Solonetz. At the same time, the storage modulus in the linear viscoelastic range of Vertic Solonetz's sample is much weaker than of Typical Chernozem's sample. Perhaps, this fact is due to a higher content the silt fraction (>40-55%) and the predominance of smectite minerals in them, which leads to the formation of weak inter-particle bonds due to the expanding crystal lattice, and the greater amount of absorbed moisture. Also, the weakening of bonds in the Vertic Solonetz is due to a high alkalinity (pH<sub>H2O</sub> 8.5-9.3), exchangeable sodium percentage (>30%) and accordingly formed to wide double electrical layers which do not allow forming the particles close contacts and disperse soil. The value of the intersection of storage modulus and loss modulus (crossover, yield point) of Vertic Solonetz's sample is considerably smaller than of Typical Chernozem's sample. This is evidence that Vertic Solonetz has faster transition to a viscous state with increasing of stress than Typical Chernozem. The structural properties of Vertic Solonetz, its stability to mechanical stresses is much less than that of Typical Chernozem. The combination heavy texture, smectite mineralogy, high alkalinity, exchangeable sodium percentage and low total salt concentration in soil solution leads to the degradation of the soil structure and reduces the resistance to mechanical loads.

**Key words:** soil physics, soil structure, rheology, amplitude sweep test, Chernozem, Vertic Solonetz.

**ACKNOWLEDGEMENTS.** The presented study was funded by RFBR according to the research projects № 16-04-01111 and № 17-04-00555.

## Irradiation level affects fluctuating asymmetry value of bilateral traits of cucumber in juvenile phase

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**Abstract.** Light is an important factor of the plant's environment. The aim of research was to confirm the hypothesis on the influence of different irradiation levels on the fluctuating asymmetry (FA) value of bilateral traits of plants cultivated in the indoor plant lighting. The object of research was the plants of cucumber (*Cucumis sativus L*) as one of the main glasshouse crops. Young 14-day-old cucumber plants in the first true leaf phase were studied. Different irradiation levels (15.0, 22.5 and 30 W·m<sup>-2</sup>) were maintained by fluorescent lamps. An essential asymmetry of bilateral structures in plants grown under different irradiation levels was observed. It was found that statistically significant lower values of FA, that is greater stability of plant development, correspond to increased plant performance. When the irradiation level was switched from 15 to 30 W·m<sup>-2</sup> (by 100%), the FA index for different bilateral structures varied by different amount: in terms of cotyledons mass it decreased from 0.046 to 0.032 relative units (by 30.2%), in terms of chlorophyll content in cotyledons it increased from 0.038 to 0.073 relative units (by 88.6%). In some bilateral structures the FA index variation was rather small: in terms of the cotyledon area it was zero, in terms of the cotyledon thickness – by 1.8%. It was experimentally prove through the example of cucumber plants that FA index could be used as an indicator of plant developmental stability, characterizing the deviations of the growing environment parameters from the normal state in the indoor cultivating.

**Key words:** indoor plant lighting, developmental stability.

**ACKNOWLEDGEMENTS.** Publication is created with support of European Regional Development Fund project “New control methods for energy and ecological efficiency increase of greenhouse plant lighting systems (uMOL)”, Grant Agreement Nr. 1.1.1.1/16/A/261.

## Analysis of Hop Drying in Chamber Dryer

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**Abstract.** This article is aimed at the analysis of the hop drying process that has been carried out in the chamber dryer of Rakochmel Co. Ltd. in Kolečovice with the Saaz hop variety. The values measured by means of dataloggers as well as fixed sensors show an identical trend. When the hops fall over from one slat box onto another, the drying air temperature declines and the relative humidity rises. A sharp increase in the relative humidity gradually decreases starting with the first slat box and finishing with the emptying conveyor, which points to a gradual levelling of the relative humidity and hop moisture. The hop moisture content, determined from laboratory samples, logically decreases depending on the measurement time. In comparison to belt dryers, chamber dryers clearly ensure continuous and more gentle drying during which the hops are not overdried and a moisture content of 10% is achieved practically only at the outlet of the dryer prior to conditioning.

**Key words:** hop cones, dryer monitoring, quality of hops.

**ACKNOWLEDGEMENTS.** This paper was created with the contribution of the Czech Ministry of Agriculture as a part of NAZV No QJ1510004 research project. In the project solution, besides CULS Prague, are involved: Hop Research Institute Co., Ltd., Žatec; Chmelařství, cooperative Žatec; Rakochmel Co., Ltd., Kolečovice and Agrospol Velká Bystřice Co., Ltd.



## Analysis of the environmentally friendly fluid conveyor

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**Abstract.** Environmentally fluid (liquid) flow conveyor is considered. Conveyor actuator blades move in cycloidal motion, but the fluid flows away from them in a straight line. The blade movement is synthesized from two axial rotations. The first rotation takes place around the central axis of each blade, while the other rotation moves around this centre around the central axis of the conveyor. There is shown how to create a cycloidal spatula motion so that it is environmentally friendly. For this purpose, the blade movement has synthesized, which does not break the flood and its particles (e.g. fish, beetles, worms, etc.). The movement has designed in such a way that the central axis rotates twice as fast as the blades around its axles. The kinematics and dynamics of the transporter movement are analysed, taking into account the characteristics of the drive motor and the impeller interaction forces with multiphase fluidity. The results of the analysis are shown in the graphs obtained by computer modelling. The design used in the work can also be applied for other purposes, for example, for the generation of energy from fluid flow. Additional work and additional schedules are provided over this opportunity.

**Key words:** fluid movement, wing oscillations, drag variation, fluid conveyor.

## Analysis of cost and performances of agricultural machinery: reference model for sprayers

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**Abstract.** Management of agricultural operations is currently rapidly changing caused by increased attention to the concepts of sustainable development and sustainable intensification. Enhancement of productivity and efficiency of agricultural machinery are the leading factors in sustainable agriculture. The complete application and exploitation of engineering advances require the revision of traditional agricultural machinery management process. The definition of the farm fleet (tractors and implements), as well as machinery planning and management, must consider different parameters, including not only the cost of the machines but also their dimensions, weight, working width, needed power, etc. All of this information related to an agricultural machine is eventually influencing the impact on productivity, on the return on the investment, and also on the environment.

The present work is aimed at identifying the most relevant parameters which are influencing costs and performances of sprayers, including tank volume, maximum flow, needed power, weight and price. The different parameters are analysed in a correlation matrix, in order to allow identification of dependencies and to extract reference models.

The study is based on linear and multiple linear regression analysis carried out on technical specifications of about 700 models of sprayers. Relevant correlations were highlighted between price and weight, between weight and tank capacity and in some cases between power and weight. Following such correlations, models have been proposed, which can be implemented in order to support the decision making phases.

**Key words:** agricultural machinery, sprayer, optimization model, stepwise regression, correlation analysis.

## **II AGRICULTURAL ECONOMICS**

## Evaluation of the mechanized harvest of grapes with regards to harvest losses and economical aspects

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**Abstract.** The aim of the study was to evaluate the mechanized grape harvest conducted by the trailed harvester. As a criterion was introduced the performance, harvest losses of grapes and economic efficiency from the perspective of its introduction. The calculations consist of total annual and partial unit costs also with regards to indirect costs which are formed by the grape losses during the harvest. Evaluation was conducted on three varieties of grapes. The losses of grapes, total annual and partial unit costs were calculated for selected varieties of grapes and also for whole production area. The mean grape losses for whole production area were determined at 470 kg ha<sup>-1</sup>, while the greatest portion of these losses (9.7%) was observed in case of Neronet variety. Among other analysed aspect were the efficiency of mechanized harvest introduction by definition of labour costs and the ransom price of grapes in relation with minimum required area. A substantial part of total costs for area 100 ha was formed by direct costs up to 15.24% greater than the indirect costs. The efficiency of machinery introduction into the harvest process was observed at minimum area of 16.92 ha in case of rental mechanized harvest of grapes. In case of mechanized harvest conducted by previously bought trailed grape harvester the value of minimal efficiency was determined at 27.42 ha year<sup>-1</sup>. As a result then serves an effective utilization of mechanized grape harvest in selected company but it is not limited to it and can be applied on any other scenario.

**Key words:** grapes, harvest, yields, harvest losses, economic benefits.

**ACKNOWLEDGEMENTS.** This work was supported by AgroBioTech Research Centre built in accordance with the project Building 'AgroBioTech' Research Centre ITMS 26220220180; and by the Ministry of Education of the Slovak Republic, Project VEGA 1/0155/18.

## The model for calculation of forest operations cost and sensitivity analysis

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**Abstract.** The technological process of forest operations involves logging, off-road and road transport of round wood, harvesting residues and wood chips, soil scarification and pre-commercial thinning, as well as other less conventional operations like stump extraction and undergrowth removal before felling. The technological process of harvesting can involve different interfering phases with specific productivity parameters, which will have impact on the productivity of harvesting and delivery, as well on the prime cost of logs and biofuel. Detailed prime cost calculation allows to assess the impact of various factors on costs of the products, as well as to define threshold values for certain parameters affecting the productivity. The base model elaborated within the COST action FP0902 is complemented with standard economic methods and adopted to the technological process of harvesting and any other forest or farming operation including systems consisting from several machines. The model is designed in a way, which is simple in use, easily extensible with additional parameters and machines and with possibility to change individual input data. The cost calculation section of the model consists from investments (base machines and equipment), labor costs (salaries, social charges, insurance and other payments) and operational costs (fuel, lubricants, maintenance, repair and other consumables). The average hourly cost is calculated according to number of working hours per year. Engine hours are used in calculation to synchronize input data with service statistics from dealers' centers. The indicators of the forest stands affecting productivity, like diameter or volume of an average extracted tree, number of relocations per year, average off-road transport distance, driving speed and other parameters are defined in the calculation. Productivity and load size can be set as fixed values or equations (in case if the sensitivity analysis should be done). The model calculates the hourly cost (productive, engine and proposed working hours) and the unit price for each phase of the work process. Sensitivity analysis part of the prime cost model shows impact of various factors, like number of working hours per year, dimensions of the average extracted tree, forwarding and road transport distance, fuel price and fuel consumption by default or any other parameter, which can be added to the sensitivity analysis. The model is validated against actual harvesting contracts and hourly cost of rental machines. Default parameters in calculations are summaries of information provided by contractors or service companies.

**Key words:** cost calculation, forest operations, productivity.

**ACKNOWLEDGEMENT.** The study is implemented within the scope of the memorandum between LSFRI 'Silava' and Joint stock Company 'Latvia state forests' from 11.10.2011.

## Performance evaluation of rural areas: the case of Estonian rural municipalities before the administrative reform

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**Abstract.** Estonian municipalities have recently passed an administrative reform that has resulted in the reorganisation of municipal management and decreased the number of municipalities. Unfortunately, no thorough scientific research has been done to find out whether the emerging helps to increase the efficiency. The aim of this paper is to estimate the efficiency of Estonian rural municipalities and to identify the factors that influence their efficiency. In this study we use a two stage analysis. In the first stage, we use the DEA Slacks-Based Model's (SBM) output-oriented approach. In the second stage, we use the Fractional Regression Model (FRM) to determine relevant exogenous factors that are associated with efficiency. 170 Estonian rural municipalities have been analysed. According to the DEA results, 28% of municipalities (48) are efficient, the average efficiency of municipalities is 0.762. The analysis implies that there are considerable differences between smaller and larger rural municipalities. FRM results revealed that larger share of subsidies characterize inefficient municipalities. The weaker the municipality, the more state support the municipality must receive. A larger share of people with a higher education increases the efficiency, it is related to higher salaries and therefore higher revenue to the municipality. Elderly residents in the population increases the efficiency, however it isn't sustainable in the long-run because more inputs are needed to offer various public services. The results indicate that the further away a municipality is from the capital, the more inefficient the municipality becomes.

**Key words:** technical efficiency, rural municipalities, DEA, FRM.

## Results of pilot studies on modelling of soil carbon stock changes in cropland and grassland

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**Abstract.** Estonian municipalities have recently passed an administrative reform that has resulted in the reorganisation of municipal management and decreased the number of municipalities. Unfortunately, no thorough scientific research has been done to find out whether the emerging helps to increase the efficiency. The aim of this paper is to estimate the efficiency of Estonian rural municipalities and to identify the factors that influence their efficiency. In this study we use a two stage analysis. In the first stage, we use the DEA Slacks-Based Model’s (SBM) output-oriented approach. In the second stage, we use the Fractional Regression Model (FRM) to determine relevant exogenous factors that are associated with efficiency. 170 Estonian rural municipalities have been analysed. According to the DEA results, 28% of municipalities (48) are efficient, the average efficiency of municipalities is 0.762. The analysis implies that there are considerable differences between smaller and larger rural municipalities. FRM results revealed that larger share of subsidies characterize inefficient municipalities. The weaker the municipality, the more state support the municipality must receive. A larger share of people with a higher education increases the efficiency, it is related to higher salaries and therefore higher revenue to the municipality. Elderly residents in the population increases the efficiency, however it isn’t sustainable in the long-run because more inputs are needed to offer various public services. The results indicate that the further away a municipality is from the capital, the more inefficient the municipality becomes.

**Key words:** technical efficiency, rural municipalities, DEA, FRM.

## Evaluation of break-even point and gross margin economic risks in producing winter oilseed rape

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**Abstract.** The economic result of growing winter oilseed rape is influenced by a number of variables, such as natural influences, input prices and the used technology. One of the ways to improve the business's profitability is to use the experience and knowledge provided by consulting companies. This paper analyses two data series covering the period of 5 to 10 years regarding specific selected key parameters for companies using the counselling services of the Union of Oilseeds Growers and Processors in Prague (UOGP) and some other companies that make no use of these services (OTHERS).

For the selected key parameters, the risk analysis of reaching the gross margin and the break-even point was conducted with the aid of the Monte Carlo stochastic simulation method. The results of the calculations show that the companies using UOGP consulting achieve on average, at the same level of risk, a gross margin higher by 30% and their break-even point is lower by 11%. Taking advantage of the knowledge and services provided by a consulting company has positive economic benefits, and it increases the competitiveness of companies.

**Key words:** risk analysis, Monte Carlo method, counselling, consulting services.

**ACKNOWLEDGEMENTS** This paper was completed as part of the project no. MSM6046070905, supported by the Czech Ministry of Education, Youth and Sports.



## Patterns in Dairy Value Chain: Case of Dairy Exports in Estonia, Latvia and Lithuania

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**Abstract.** Fast economic growth in Baltic states during last decades has caused significant structural changes. The competitiveness of agricultural commodities in international market is changed and the structure of foreign trade is changed. Integration of Baltic economies into World economy, the unification with European Union and more recently financial crisis and Russian import restrictions have been main drivers behind the dynamics of competitiveness of Estonian, Latvian and Lithuanian dairy sector in export markets.

The aim of the paper is to analyze the shifting patterns in dairy value chain of three Baltic countries and show the path dependence of dairy exports during the period 1996-2016.

In current paper, trade data is used to describe the path dependency in dairy value chain in three Baltic countries. Choices made after regaining independence in the beginning of 1990s and most importantly the choices made after EU accession, have affected the structure of dairy production and exports making for example Estonia as raw milk producer and exporter and Lithuania as a successful processor of milk.

An assumption is made that the structure of international trade describes both the relative costs of production and non-price factors. Detailed trade data is aggregated into three broader groups for distinguishing between various stages of the dairy chain.

Example of Estonia shows that there have been changes in the structure of comparative advantage considering the products in various stages of the dairy chain. Contrary to processed products both for household and for industry use, there has been increase in export advantage of primary products.

There are various stages to be considered. First, the period before 2004 when there is a decline in overall export advantage of dairy products. Second, the period from 2004 to 2009 when Latvia becomes raw milk exporter. And third, period after 2009 when exports of Estonian raw milk have become more advantageous compared to other products.

## Optimization of arable land use to guarantee food security in Estonia

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**Abstract.** Agricultural and food sector has an important role to play in ensuring food security. A competitive agricultural sector warrants food security through increasing level of self-sufficiency in food, and export of surplus production. One of the strategic tasks of the state is to secure food supply for the population. To perform this task, the state should estimate its capacity to produce food to meet the needs of population. Mathematical modelling can be used as a tool in solving this problem. The paper demonstrates possibilities of implementing linear programming model in optimizing the use of arable land for ensuring the food demand of Estonian population. The Estonian arable land use optimization model is essentially a static balancing model that simulates the demand and supply of basic food products (meat, dairy products, cereal products and potatoes). The basis for the demand side in the model is Estonian population, divided into 10 groups according to gender and age. The energy and protein needs of the respective population groups are taken into account. The supply side of the model is a typical agricultural production model that guarantees the consistency of crop and livestock farming. The model consists of 163 variables and 178 constraints (equations). The objective of the model is to minimize the use of arable land for field crops to ensure fodder for animal feed, and food for human food consumption. The model is used to analyse various land use strategies. According to the modelling results for ensuring food security of Estonia and to maintain export of dairy products in the 2016 volume, the total optimal arable land equals to 490,688 ha. There should be 83,600 dairy cows (with average milk yield 9,000 kg cow<sup>-1</sup>). It is necessary to grow 755,700 piglets per year in order to secure 40 kg of pork per inhabitant. Land use optimization results indicate that Estonian agriculture is able to supply Estonian people with the minimum necessary main food products to guarantee food security, and allows to export essential products (cheese, butter, skimmed milk powder, whole milk powder).

**Key words:** food security, linear programming model, Estonian agriculture, land use optimization.

## Changes in composition and spatial distribution of knowledge-based economy in rural areas of Latvia

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**Abstract.** One of the features in the 21st century is growth of knowledge-based economic sector, which is referred as new growth theory. New growth theory reflects the attempt to understand the role of knowledge and technology in driving productivity and economic growth. In this view, key factors are investments in research and development, education and training and new managerial work structures. The aim of research is to estimate the composition and geographic location of knowledge economy and its perspectives in rural areas of Latvia in post-crisis stage. A special focus was placed on the mentioned processes in territorial units of the regions – municipalities, as the life of residents is influenced not only by national policies, but also by on-going processes in the administrative territories of local governments. The Eurostat classification of industries was used for the analysis of changes in composition and spatial distribution of knowledge-based economy. Data were processed by quantitative and qualitative statistical analysis, as well as grouping methods. The analysis of the information allows concluding that: municipalities with high and medium-high business is increasing and the business directions with bioeconomic features are the fastest growing ones in terms of composition. It must be stated that the economic growth in the rural territories was greatly affected by the quality of local governance and the fact that local community residents' readiness for active, innovative and inclusive action is strengthened.

**Key words:** knowledge-based economy, Eurostat classification of industries, composition and spatial distribution, local governance, local community

**ACKNOWLEDGEMENT.** The research is financially supported by National research programme EKOSOC-LV.

## Restricting the practices of maintenance of permanent grassland – spatial analysis of potential effects on agricultural land use

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**Abstract.** Maintenance of permanent grassland is one of the environmental objectives of the EU Common Agricultural Policy (CAP), contributing to the overall climate and biodiversity objectives of the EU. The minimum requirements for activities for the maintenance of permanent grassland under the single area and greening payment scheme (SAPS) is determined by the EU member states. Until 2014, in Estonia, the minimum activity for the maintenance of permanent grassland was chopping the grass and leaving it on the ground. In 2015 and 2016, the area on which the chopped grass could be left on the ground was restricted with an aim to increase incentives for more active land use, and for agricultural production. In order to evaluate the effects of restrictions of the practices used for the maintenance of permanent grasslands, a survey was conducted at the end of 2016. An online questionnaire was sent to a sample of 5 611 SAPS applicants from the total population of 15 571 applicants. Response rate was 30.2%. The survey results indicated that if all chopped grass should be gathered up in the future, crop farmers and those whose main activity is maintenance of permanent grassland, intend to give up some of the permanent grassland. Cattle and sheep farmers intended to increase their land use. Therefore, one could reason that restricting the practices of maintenance of permanent grassland would increase more active use of land and agricultural production in cattle and sheep farms. However, a precondition for that is that farmers who intend to give up some of their permanent grasslands would be located in the neighbourhood of those farmers who intend to increase their land use and agricultural production. Therefore, in this paper, we aim to analyse on the spatial level whether the location of farms who intend to give up some of the permanent grassland is in a reasonable distance for those farms who intend to increase their land use. If these farm groups are not located near to each other, the actual change in active or passive land use would be limited. Restricting maintenance practices of permanent grassland would thus result in decreasing area of permanent grassland under subsidy schemes and potential land abandonment, therefore hampering achieving the biodiversity and climate aims of the EU. For the analysis the field parcel data from Estonian Agricultural Registers and Information Board (ARIB) will be complemented with information about farm type of each SAPS applicant and the intended changes in the land use of the respondents of the survey. GIS and statistical analysis methods will be combined in the analysis. The analysis will compare two regions: one with high share of permanent grassland and the other with low share of permanent grassland in total utilised agricultural land.

## **III BIOENERGY**

## Agricultural residues in Indonesia and Vietnam and their potential for direct combustion: with a focus on fruit processing and plantation crops

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**Abstract.** Energy consumption in Indonesia and Vietnam has grown rapidly in recent decades. To meet the energy needs of both countries, a higher utilisation of waste biomass sources may represent an adequate solution. Investigated samples represent major crop residues (waste biomass) originating mainly from the agriculture sector of the selected countries. Herbaceous waste biomass from Indonesia is, namely, cassava stems and root peelings (*Manihot esculenta*), coffee leaves (*Coffea arabica*), cacao leaves (*Theobroma cacao*), banana leaves (*Musa acuminata*), bamboo leaves (*Bambusoideae* spp.) and aloe vera leaves (*Aloe vera*). Furthermore, fruit and aquatic waste biomass originating from Vietnam is, specifically, sugarcane bagasse (*Saccharum officinarum*), durian peelings (*Durio zibethinus*), rambutan peelings (*Nephelium lappaceum*), banana peelings (*Musa acuminata*), water milfoil (*Myriophyllum spicatum*) and water hyacinth (*Eichhornia crassipes*). All mentioned types of waste biomass were subjected to proximate and calorimetric analysis: moisture, ash and volatile matter contents (%) and higher and lower heating values ( $\text{MJ}\cdot\text{kg}^{-1}$ ). Obtained values indicated the highest level of ash content in fruit biomass samples in the case of sugarcane bagasse (0.84%), in herbaceous biomass in the case of cassava stems (3.14%) and in aquatic biomass in the case of water hyacinth (14.16%). The highest levels of lower heating values were achieved by following samples (best samples from each biomass type): cassava stems ( $17.5 \text{ MJ}\cdot\text{kg}^{-1}$ ); banana peelings ( $17.3 \text{ MJ}\cdot\text{kg}^{-1}$ ) and water hyacinth ( $12.8 \text{ MJ}\cdot\text{kg}^{-1}$ ). The overall evaluation of all observed samples indicated that the best suitability for energy utilisation by direct combustion of investigated representatives is fruit waste biomass, followed by herbaceous waste biomass and then aquatic waste biomass.

**Key words:** renewable energy, waste management, biological residues, waste biomass, calorific value, energy potential.

**ACKNOWLEDGEMENTS.** The research was supported by Internal Grant Agency of the Faculty of Engineering, Czech University of Life Sciences Prague and further then by the Internal Grant Agency of the Czech University of Life Sciences Prague, grant number 20173005 (31140/1313/3108).

## Chemical composition of agromass ash and its influence on ash melting characteristics

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**Abstract.** The increasing demand for biofuels leads to a growing need for agromass, such as herbaceous plants and agricultural waste. However, agromass contains high quantities of alkali metals, mainly potassium and sodium, which limits agromass usage in thermoconversion processes. Alkali metals react with other ash forming elements which leads to ash related problems such as agglomeration, fouling and slagging during agromass burning. In this study, chemical composition and melting behaviour of ashes formed at 550°C are investigated. Three herbaceous plants (reed canary grass, hemp, orchard grass), four types of agricultural waste (straws of rye, wheat, buckwheat and canola) and two types of woody biomass (birch, spruce) are selected. Ash melting behaviour, composition and bulk structure are determined using a high temperature furnace with a video camera, inductively coupled plasma atomic emission–spectrometry and X–ray diffraction technique, respectively. Ash melting behaviour of selected agromass types shows that the hemp ash has the highest shrinkage starting temperature which reaches 1079°C. This is due to the high content of calcium and low content of potassium and sodium in hemp ash. Three main components calcium carbonate, potassium sulfate and potassium chloride have been identified in ashes after agromass and woody biomass are heat–treated at temperature of 550°C.

**Key words:** agromass, agrofuels, ash, ash melting, alkali metals.

## Management of Brazilian hardwood species (Jatoba and Garapa) wood waste biomass utilization for energy production purposes

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**Abstract.** In the Federative Republic of Brazil, Jatoba (*Hymenaea courbaril*) and Garapa (*Apuleia leiocarpa*) trees are intensively harvested. The yield of one log is approximately 45–55%, which indicates a great amount of produced wood waste biomass. Present research monitored the suitability of wood waste biomass from Jatoba and Garapa trees for bio-briquette for solid biofuel production. The research was focused on chemical parameters, and energy potential of such biomass kinds. Jatoba wood waste biomass was used for the production of bio-briquette fuel and its final mechanical quality was investigated by determination of their mechanical quality indicators. Results of chemical analysis (in wet basis) exhibited great level of ash content in case of both species (Jatoba – 0.31%, Garapa – 3.02%), as well as high level of energy potential; net calorific value equal to 18.92 MJ·kg<sup>-1</sup> for Jatoba and to 18.39 MJ·kg<sup>-1</sup> for Garapa. Analysis of elementary composition proved following levels of oxygen content: Jatoba – 41.10 %, Garapa – 39.97 %. Mechanical analysis proved bio-briquette samples volume density  $\rho$  equal to 896.34 kg·m<sup>-3</sup> which indicated quality bio-briquette fuel, while the level of rupture force RF occurred at a lower level – 47.05 N·mm<sup>-1</sup>. Most important quality indicator, the mechanical durability DU, unfortunately, occurred at a lower level; DU = 77.6% compared to the minimal level of bio-briquette fuels intended for commercial sales which must be > 90%. Overall analysis proved materials suitability for energy generation purpose with certain limitations which can improve by changing production parameters of briquetting.

**Keywords:** Briquetting, direct combustion, renewable energy, waste management.

**ACKNOWLEDGMENTS.** The research was supported by Internal Grant Agency of the Faculty of Engineering, Czech University of Life Sciences Prague and further by the Internal Grant Agency of the Czech University of Life Sciences Prague, grant number 20173005 (31140/1313/3108). The research was performed in the cooperation with kovocite a.s., the company in the Czech Republic which provided the processed investigated wood waste biomass materials<sup>2</sup>.



## Yeast as a Production Platform in Biorefineries: Conversion of Agricultural Residues Into Value-Added Products

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**Abstract.** In contrast to a petroleum-based economy, which relies on the unlimited presence of fossil fuels, a biobased economy utilizes a broad spectrum of natural crops and biomass as raw substrates for the production of valuable materials. Biorefineries represent a promising approach for the co-production of bioenergy (biofuels, biogas) and value-added products (biochemicals, biomaterials, food). Within Europe, wheat straw represents the major crop residue and has been extensively considered as a promising feedstock in the biorefining process. Firstly, wheat straw is hydrolysed to obtain a sugar solution that is further converted into the desired product in a biocatalytic manner. Microbial fermentation is the core component of biorefineries and yeast, as for instance *Candida guilliermondii*, is an effective production platform for both, biofuels and biochemicals. One limiting aspect in using yeast in the biorefinery approach is the presence of inhibitors in lignocellulosic hydrolysates, such as acetic acid or furfural, influencing cellular growth and diverse metabolic processes. In order to overcome this problem, several genetic engineering approaches are used to increase yeast resistance towards these inhibitors and to enhance the overall production. In this paper, we summarized: 1) the pretreatment technologies for wheat straw bioconversion; 2) the *Candida guilliermondii* genetic engineering technologies and their biotechnological potential. In conclusion, biorefineries are a crucial factor in the transition towards a biobased and circular economy, and the implementation of yeast into this system offers a great opportunity to develop innovative strategies for a sustainable production in an environmentally friendly and economically feasible manner.

**Key words:** biorefinery, wheat straw, genetic engineering, yeast, *Candida guilliermondii*.

**ACKNOWLEDGEMENTS.** We thank Dr. Manuel Selg for critical reading the manuscript and helpful suggestions. Dr. Alvaro Cristobal-Sarramian's and Denise Atzmüller's research for this work was funded within the scope of the European Union Program 'IWB/EFRE-Regionalprogramm 2014-2020' (Project name: Combined Agro-Forest Biorefinery – CAFB) from the purse of the European Regional Development Fund (ERDF) and the Federal State of Upper Austria.



## Anaerobic co-fermentation of molasses and oil with straw pellets

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**Abstract.** The average grain and straw production in Latvia is increasing in last decade. Straw is not always managed properly and its utilisation in biogas plants can be considered as an alternative. Straw is not the best feedstock for methane production, because it has high C/N ratio. Co-fermentation with other biomass with higher N content can improve the methane production. Purpose of investigation is to evaluate the wheat straw pellets biomass suitability for production of the methane and effect of its co-fermentation with molasses, fried sunflower oil and catalyst Metaferm. The anaerobic digestion process for biogas production was investigated in 0.75 L digesters, operated in batch mode at temperature  $38 \pm 1.0^\circ\text{C}$ . The average biogas yield per unit of dry organic matter added from digestion of wheat straw pellets was  $0.540 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  and methane yield was  $0.285 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$ . Average biogas yield from co-fermentation of wheat straw pellets and molasses was  $0.777 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  and methane yield was  $0.408 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$ . Average biogas yield from fermentation of wheat straw pellets with 1ml Metaferm was  $0.692 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  and methane yield was  $0.349 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$ . Average biogas yield from co-fermentation of wheat straw pellets and sunflowers oil was  $1.041 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  and methane yield was  $0.639 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$ . All investigated biomasses can be used for methane production.

**Key words:** anaerobic digestion, biogas, methane, molasses, sunflower oil, wheat straw pellets.

**ACKNOWLEDGEMENTS.** This work has been supported by the Latvian National Research Programme LATENERGI.

## Suitability of Common nettle (*Urtica dioica*) and Canadian goldenrod (*Solidago canadensis*) for methane production

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**Abstract.** Support for biogas production in Latvia was decreased. There is need to investigate the suitability of various inexpensive biomasses for energy production. Also, there is necessary to explore possibilities to improve the anaerobic fermentation process with the help of various catalysts. Biocatalyst Metaferm produced in Latvia was used in previous studies with other biomass and shows increase in biogas and methane production. The article shows the results of studies on biogas (methane) production from chopped fresh Common nettle (*Urtica dioica*) and Canadian goldenrod (*Solidago canadensis*) biomass and effect of catalyst Metaferm in anaerobic fermentation process. The anaerobic digestion process was provided in 0.75 L laboratory digesters, operated in batch mode at temperature  $38 \pm 1.0^\circ\text{C}$ . The average specific biogas or methane production per unit of dry organic matter added (DOM) from Common nettle was  $0.709 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  or  $0.324 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  respectively. Average specific biogas or methane volume produced from chopped Canadian goldenrod in anaerobic fermentation was  $0.548 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  or  $0.267 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  respectively. Average biogas or methane yield from digestion of chopped Common nettle with 1 mL Metaferm was  $0.752 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  or  $0.328 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  respectively. Average specific biogas or methane yield from anaerobic fermentation of chopped Canadian goldenrod with 1 mL Metaferm was  $0.624 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  or  $0.276 \text{ L} \cdot \text{g}^{-1}_{\text{DOM}}$  respectively. Adding of catalyst Metaferm increases methane yield from chopped nettle or Canadian goldenrod by 1.2% or 3.4% respectively. All investigated biomasses can be used for methane production.

**Key words:** anaerobic digestion, biogas, Canadian goldenrod, methane, nettle.

**ACKNOWLEDGEMENTS.** This work has been supported by the Latvian National Research Programme LATENERGI.

## Analysis of the sugar composition in birch wood hydrolysates by iodometric titration and UPLC-ELSD

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**Abstract.** Demand for oil and other fossil fuels is increasing, alternative to this is biorefinery. Biorefinery as a concept is using biomass acquired from renewable resources to produce energy and various chemicals. Hydrolysis is often the first stage in a biorefinery concept, during which wood is pretreated yielding a sugar-rich aqueous fraction (hydrolysate) and a solid lignocellulose fraction. Autohydrolysis of birch wood is a mild pretreatment process, which gives a notable yield of sugars – monosaccharides and oligosaccharides – in the aqueous hydrolysate, while a solid lignocellulose fraction can be further processed into other valuable products within a biorefinery concept. Monosaccharides and lower oligosaccharides can be used for the production of bioethanol. Hydrolysis of oven dry birch wood with particle size 0.2 – 0.63 mm was performed at six temperatures from 150 ° to 200 °C for up to 120 min. The obtained solid lignocellulose residue was 61 – 75 % of the dry feedstock. In this work the sugar content in wood or other industrial biomass hydrolysis products was determined by two analytical methods – iodometric titration and UPLC-ELSD analysis. Iodometric titration of sugars is based on the oxidation of  $\alpha$ -diols by sodium periodate. While the titrimetric method is suitable for determining all sugars present in the samples as a chemical class, liquid chromatography is used to determine individual compounds. Both methods showed that the highest yield of sugars (27 % of oven dry feedstock) was obtained by hydrolysis at 180 °C for 75 min. In addition of sugars, concentrations of acetic acid, furfural and 5-hydroxymethylfurfural (5-HMF) were determined. The concentration of acetic acid in the hydrolysates increased almost linearly up to 6 % with treatment time, acting as a catalyst and increasing the yield of the other products. The concentration of furfural and 5-HMF increased up to 0.2 % and 0.03 % in the hydrolysates, respectively. The advantages of UPLC-ELSD are the speed of analysis and superior selectivity, which allows not only to quantify pentoses and hexoses separately, but also to avoid possible interferences of other non-sugar components in the samples. The iodometric method is a simple, inexpensive method for determining the total content of sugars, including oligosaccharides.

**ACKNOWLEDGEMENTS.** The work was supported by the National Research Programme “Forest and earth entrails resources research and sustainable utilization – new products and technologies” (ResProd) Project Nr.3 “Biomaterials and products from forest resources with versatile applicability”.

## Low temperature BMP tests using fish waste from invasive Round goby of the Baltic Sea

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**Abstract.** Round goby (*Neogobius melanostomus*) is an invasive fish species in the Baltic Sea. While meat can be used for human consumption, fish processing residues are considered as a waste. Within circular economy and bio-economy perspectives fish waste could be used as a valuable feedstock for biogas production. However, the research is mostly focused on evaluating biogas yield at mesophilic conditions (i.e. 37°C). In this study the impact of low temperature on Biochemical Methane Potential (BMP) tests has been investigated. Round goby's processing leftovers - heads, intestines and skin/bone mixture were tested in codigestion with sewage sludge. Anaerobic digestion (AD) was carried out in 100mL batch tests at low temperature 23°C and 37°C conditions, over an incubation period of 31 days. The results show that AD at low temperature occurs twice as slowly as under 37°C conditions. However, after 31 days the BMP values for 23°C samples were only 2% lower than for high temperature samples. Heads and skins showed similar BMP values reaching on average 502 L CH<sub>4</sub> kg<sub>VS</sub><sup>-1</sup> and 556 L CH<sub>4</sub> kg<sub>VS</sub><sup>-1</sup> respectively. BMP for fish intestines was higher, reaching on average 870 L CH<sub>4</sub> kg<sub>VS</sub><sup>-1</sup>. Average BMP for mixes of fish heads, skins, intestines and bones was 660 L CH<sub>4</sub> kg<sub>VS</sub><sup>-1</sup>. Acquired BMPs were further compared with the theoretical BMPs from Buswell's formula. Research results suggests that anaerobic digestion of fish waste under low temperature conditions could be feasible as the process still efficiently occurs, in fact opening a new opportunity to explore the overall sustainability of technologies based on these conversion processes.

**Key words:** Biomethane, low temperature, fish waste, anaerobic digestion, *Neogobius melanostomus*.

**ACKNOWLEDGEMENTS.** The work has been supported by the National Research Program 'Energy efficient and low-carbon solutions for a secure, sustainable and climate variability reducing energy supply (LATENERGI)'. Latvian State Institute of Wood Chemistry is acknowledged for chemical composition testing of biomass.

## Effect of alternative sources of input substrates on biogas production and its quality from anaerobic digestion by using wet fermentation

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**Abstract.** The aim of the study was to confirm the suitability of alternative input substrates for production of biogas in order to decrease the need of utilization of high quality maize silage. All of the experiments were conducted by employment of wet fermentation process in mesophilic conditions (temperature in fermentor  $40\pm 1^\circ\text{C}$ ) in experimental fermentor with volume  $5\text{ m}^3$ . The experiments were realised in operating conditions of biogas station designed for utilization of agricultural biowaste. The experiments were divided into two alternatives (I and II cycle) and one control input substrates. In the first alternative (I cycle) was daily dosage formed by 33 kg of *Amaranth* and 250 L of control manure mixture. In this cycle, more than 3-times greater specific production of biogas was observed with average methane content 63.9% in comparison with control manure mixture (80:20%, liquid manure and manure). In the second alternative (II cycle) was daily dosage formed by 19.5 kg of sugar beer cuts, 3.3 kg of maize silage, 1.9 kg of oil-seed rape moldings, 2.5 kg of glycerine and 250 L of control manure mixture. In this cycle, more than 5.9-times greater specific production of biogas was observed. The decrease in average methane content 55.1% however also decrease in average content of hydrogen sulphide (128 ppm) was observed as well. An unquestionable advantage for both tested alternative mixed substrates was increase in biogas production and its quality in comparison with control substrate based on manure. At the basis of these findings can be concluded that both tested alternative input substrate mixtures are suitable as co-fermentation substances with great potential to increase the biogas production and its quality in case of wet fermentation processes.

**Key words:** biogas, co-fermentation, co-substrates, anaerobic digestion, wet fermentation.

**ACKNOWLEDGEMENTS.** This work was supported by AgroBioTech Research Centre built in accordance with the project Building 'AgroBioTech' Research Centre ITMS 26220220180; and by the Ministry of Education of the Slovak Republic, Project VEGA 1/0155/18.

## Evaluation of dried compost for energy use via co-combustion with wood

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**Abstract:** There is still a question of utilization of compost of unsatisfactory quality. This article deals with energy utilization of untreated compost. The energy utilization of raw compost as a fuel is not directly possible without further processing. Separation might be necessary due to large amount of mineral content (soils and other inert substances). This article is focused on the analysis of the basic fuel characteristics of compost. Proximate and elemental analyses were performed and stoichiometric combustion was calculated. Finally, the sample was co-burned with wood biomass in a fixed grate combustion device and the gaseous emissions were determined in dependence on the amount of combustion air supplied. The emissions were expressed in graphs against excess air coefficient and flue gas temperature. Elemental analysis of the compost sample shows high percentage of ash up to 61.70% wt. on dry basis causing low average calorific value of 8.51 MJ.kg<sup>-1</sup> on dry basis. For combustion tests, the heating value was increased by addition of wood chips to reach an average calorific value of the mixture to 13.4 MJ.kg<sup>-1</sup>. The determined stoichiometric parameters can help in optimization of diffusion controlled combustion of composts or similar materials. In combustion of the mixture of compost and wood biomass an optimum of emission parameters was found not exceeding the emission limits. Measured emission concentrations show the possibility of optimizing the combustion processes and temperatures while lowering CO emissions via the regulation of combustion air.

**Key words:** combustion, emissions, elemental analysis, calorimetry.

**ACKNOWLEDGEMENT.** The article was financially supported by the Internal Grant Agency of the Czech University of Life Sciences Prague, Czech Republic, Grant No. 20183001.

## Specialty types of waste paper as an energetic commodity

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**Abstract.** The collection and recycling rate of paper and paper packaging material has been on a rise. From 2010 to 2016 in Czech Republic, the recycled amount of all paper went up by 32%, while the share of energy use in waste paper utilization decreased from 5.5% to 3.8%. However, not every paper and cardboard product can be recycled, and some are rejected from the recycling stream. Recycling specialty types of paper with other grades of recyclable paper is often not possible and their production is not high enough for their separate recycling to be feasible. If material utilization is not feasible then within the waste hierarchy the next best treatment is their energy utilization. Therefore, this article evaluates selected types of specialty paper for their energy content. They were silicone coated papers, polymer coated papers, and paper cores. For all samples proximate, elemental and calorimetric analyses were determined and based on them stoichiometric combustion calculations were performed. Silicon coated papers fared generally well having small to reasonable ash content 1-10% and net calorific value from 15.10 to 17.10 MJ kg<sup>-1</sup> on dry basis. Polymer coated papers had ash content around 6% and net calorific value from value from 16.29 to 22.98 MJ kg<sup>-1</sup> on dry basis. With the exception of paper cores and self-copying paper, all evaluated paper types could be recommended as a component in refuse derived fuels. The least suitable samples were paper cores with nearly 20% wt. of ash and net calorific value 12.45 MJ kg<sup>-1</sup> on dry basis.

**Key words:** non-recyclable paper, proximate analysis, stoichiometric calculations, heating value.

**ACKNOWLEDGEMENT.** The article was financially supported by the Internal Grant Agency of the Czech University of Life Sciences Prague, Czech Republic, Grant No. 20183001.



## Optimizing the sample size to estimate growth in I-214 poplar plantations at definitive tree density for bioenergetic production

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**Abstract.** In Europe, over the last decades, the arboriculture for woody biomass production has significantly expanded, often using poplar plantations. In order to maximize production, the flexibility of the cultivation algorithms becomes necessary. For this reason, it is necessary to apply monitoring tools for the evaluation and estimate of the wood productions, without significantly affect the production costs. In particular, for the estimate of the productions, the choice of the sample size is of particular importance. The aim of this study was to verify a simplified sampling approaches in poplar plantations characterized by constant tree density. The research was conducted in a poplar plantation on the Tuscan hills (Italy). The surveys were carried out each year for 13 years, from 4 to 16 years old. Through different statistical techniques, the change in the social position of each tree over time was evaluated. The results showed that the social position of each tree has been characterized by the first years after the plantation. Consequently, the estimate of the productions can be carried out by analysing the diameter increment of 10% of the trees, included in the diameter classes around the medium-sized tree at the time of the survey. This study provided a valid method for forest managers characterized by a simplified approach useful to estimate the growth and yield of hybrid poplars. This method will permit reliable biomass estimates, but also a reduction of the costs in the sampling activities in the field.

**Key words:** poplar, woody biomass, basal area, medium rotation forestry, cluster analysis.

**ACKNOWLEDGEMENTS.** We thank the Department of Agraria of Mediteranean University for supporting our research. In addition, we thank the anonymous reviewers for their careful reading of our manuscript and their many insightful comments and suggestions. Following the suggestions, we included several improvements in the manuscript.

## Sunlight potential for microalgae cultivation in the mid-latitude region – the Baltic states

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**Abstract.** Products, e.g. food and feed from microalgae are a promising part of bioeconomy. One of the most investigated and highly demanded microalgae is *Spirulina*. Light is one of limiting factors for biomass cultivation by photosynthesis. Sunlight is cheap and climate friendly light source. The aim of this study was to evaluate available sunlight potential in the mid-latitude region - the Baltic states (Europe, 55-60°N) for microalgae, e.g. *Spirulina* growth. The data of Climate atlas based on satellites of EUMETSAT and data from an observation station in Riga were analyzed. The latitude and climate (cloudiness) were main parameters affecting the total solar radiation received by Earth's surface. The sunlight potential in the Baltic states was higher than in most of Europe in similar latitude. Multi-year mean daylight intensity in the Baltic states was slightly less than in Southern France or Bulgaria, (26 klux and 30 klux, respectively, in summer) where *Spirulina* is commercially produced. Hourly solar radiation varied a lot in the Baltic states – from 880 W m<sup>-2</sup> to 200 W m<sup>-2</sup>, sunny and overcasted noon of summer day, respectively; average value (8 a.m.-4p.m.) was 450 W m<sup>-2</sup>. Summer days are longer than 12 h, reaching 18 h in midsummer. The sunlight potential is suitable for microalgae, e.g. *Spirulina* cultivation in this period. From November till February days are shorter than 10 h and solar radiation is less than 300 W m<sup>-2</sup> even in noon of sunny days.

**Key words:** Sunlight, solar radiation, microalgae, mid-latitude, Europe, the Baltic states.

**ACKNOWLEDGEMENTS.** This work has been supported by European Regional Development Fund within the project “Influence of the magnetic field initiated stirring on biotechnological processes” No. 1.1.1.1/16/A/144.

## Energy valorisation of citrus peel waste by torrefaction treatment

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**Abstract.** The article deals with the issue of processing and utilization of citrus peel, which often ends unused with other biodegradable waste. The research is concerned with the energy potential of this raw material and its torrefaction conversion. The tested materials were orange peel (*Citrus sinensis* Osbeck cv 'Valencia', *Citrus sinensis* Osbeck cv 'Murcia') and grapefruit peel (*Citrus paradise* 'Ruby red'). Samples of dried materials underwent torrefaction treatment at 225°C, 250°C and 275°C for 30 minutes. Samples before and after torrefaction were analysed for proximate and elemental composition and for calorific value. Consequently, stoichiometric combustion analyses were done. The torrefaction was performed in a LECO TGA 701 thermogravimetric analyzer under nitrogen atmosphere. The results of proximate and elemental analysis showed positive influence of torrefaction on the samples. The highest net calorific value for orange peel is 24.97 MJ kg<sup>-1</sup> at the temperature of 275°C. The greatest differences in net calorific values are between 225°C and 250°C where the increase is almost 3 MJ kg<sup>-1</sup>. Subsequently, the increase between the 250°C and 275°C torrefaction temperatures is 1 MJ kg<sup>-1</sup>. Weight loss at respective torrefaction temperatures showed similar time-dependent curves for all samples. Stoichiometric combustion analysis shows slight differences between original samples, but great differences after torrefaction processing. Stoichiometric combustion parameters also change proportionately with increasing temperature of torrefaction. The resulting combustion balance figures show significantly lower need for mass of fuel in the case of the torrefied material for a given heat output thanks to the net calorific value being nearly doubled.

**Key words:** calorific value, heating value, elemental analysis, stoichiometry, heat output.

**ACKNOWLEDGEMENT.** The article was financially supported by the Internal Grant Agency of the Czech University of Life Sciences Prague, Czech Republic, Grant No. 20173003.

## Potential use of invasive plant species as solid biofuel by using binders

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**Abstract.** The aim of the current research is to find sustainable pellet resources that are not made from forestry, agricultural materials or food products. Evaluation has been done by experimentally determining biofuel parameters of 2 invasive plant species. In comparison to finding a new application, their use in the production of solid biofuel pellets would not require additional investments for the construction of a new pellet production plant. Hypothesis of the article suggests that biofuel parameters of invasive plant species are sufficient for the production of solid biofuel and their properties can be improved by binders that are available as residues worldwide. The experiment was carried out for two invasive plant species that are widely spread in Latvia – *Heracleum sosnowskyi* Manden and *Solidago canadensis* L. The binders used include potato peel waste and spent coffee grounds. All the tests have been performed according to ISO standards on biofuel testing. Results show that *H.sosnowskyi* is more suitable for solid biofuel than *S.canadensis* as it has a higher calorific value and 2 times lower ash content – 3 wt%. Coffee grounds are a suitable binder because they increase calorific value. The type and amount of binders partly confirms the hypothesis, since both binders reduced the amount of ash in pellets. Further research is needed to perform pellet durability tests. It is also necessary to carry out an economic analysis ~~too~~, to evaluate how beneficial it is to use *H.sosnowskyi* as a solid fuel in existing pellet production plants, thus avoiding large initial investments and not encouraging the cultivation of invasive plant species.

**Key words:** *H.sosnowskyi*, *S.canadensis*, spent coffee grounds, potato peel waste, pellets.

**ACKNOWLEDGEMENTS.** The work has been supported by the National Research program ‘Energy efficient and low-carbon solutions for a secure, sustainable and climate variability reducing energy supply (LATENERGI)’. Thanks to Environmental Science student Ieva Laganovska for her participation in the experimental part of the research.

## **IV ERGONOMICS**

## Dynamics of non-fatal and fatal work accidents in agriculture in the past decade in Estonia

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**Abstract.** Work accidents (WA) in agriculture are a problem all over the world. Even if the most of work tasks become more automated, farmers, family members and farm workers are facing risks at work that are higher than in most other occupations. Many accidents involve the handling of machinery or animals. The costs of WAs are increasing, exhausting national economy as a whole. Work-related ill-health and injury is costing the European Union 3.3 % of its GDP. That's €476 billion every year which could be saved with the right occupational safety and health strategies, policies and practices. In Estonia the estimates of the costs of WAs in 2012 showed €2,4 billion per year and due to permanent lost work ability €25 billion costs in total for society. The aim of this study is to analyze accidents at work in Estonian agriculture in the past ten years.

**Method.** The database of accidents in agriculture (2008–2017) has obtained from the Estonian Labour Inspectorate. The dynamics of absolute numbers of WAs and incidence rate per 100 000 workers in agriculture have been described by the sub-sectors - horticulture and farming, forestry and fishery. Also, the statistics of WAs by gender, severity, type and body region and regional distribution of injuries.

**Results.** The total number of WAs in agriculture in 2008-2017 was 1696, and it formed a whole 4% of all WAs in Estonia. There were 1683 non-fatal accidents from which 1235 mild and 448 severe accidents. In the past decade only 13 fatal work accidents have recorded. The number of WAs shows the tendency to increase during the observed period. The incidence rate of WAs was lowest in 2012 – 543 and highest in 2017 – 801 cases per 100 000 workers. Most often WAs took place in the years 45-54 and mostly among the men (879 M vs 817 F). However, work accidents in horticulture and farming dominated among the female (671 M vs 794 F) but in forestry and fishery *vice versa* – about 90% of WAs happened to men. By the type of injury most often wounds and superficial injuries (40,4% of the total), bone fractures (25,6%) and concussion and internal injuries (16.2 %) have been registered. Upper and lower limbs (35,7% and 33%) were the most often injured body regions. The biggest number of accidents was registered in the counties Järvamaa and Lääne-Virumaa.

**Conclusion.** It is important to pay more attention on improvement of safety culture and prevention of work accidents in agriculture in Estonia.

## Influence of ventilation on air-borne microorganisms in sport facilities

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**Abstract.** This paper is focused on the microclimatic research in several buildings and rooms used for sport at the University. The attention is paid mainly to the problems of dimensions of space, capacity and activity of sportsmen, and influence of space ventilation. The air samples for microbiological analyses were taken by the microbial air sampler Merck Mas-100 Eco and cultivated by potato-dextrose agar and nutrient agar. Captured microorganisms, are expressed as colony forming units per m<sup>3</sup> (CFU m<sup>-3</sup>). Measurement results showed that bacteria average quantity was statistically significantly less without students (562 CFU m<sup>-3</sup>) than with students (1,024 CFU m<sup>-3</sup>). The students inside the rooms increased the bacteria concentration. From this point of view the ventilation is not adequate for the removal of bacteria from ventilated spaces. From the results we can conclude that the great importance on the air quality in terms of a specific bacteria concentration has the specific volume of the room per one athlete. The worst situation is in rooms with the smallest volume, which has the largest biological load of the space. The lowest quantity of bacteria was in the swimming pool all year round (152 to 300 CFU m<sup>-3</sup>). The opposite situation was in average quantity of filamentous fungi, which was with students and ventilation (57 CFU m<sup>-3</sup>) and (109 CFU m<sup>-3</sup>) without students but without ventilation. The pollution of air by fungi was higher without ventilation. Sufficient ventilation by clean air caused lower pollution by fungi in all rooms.

**Key words:** air, gyms, indoor environment, pollution, swimming pool, ventilation.

## Air-conditioning in the cabins of passenger cars

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**Abstract.** The objective of this paper is to analyse the current state of the constructional design and operational conditions of air-conditioning device in passenger cars. The research was focused on the function of air-conditioning equipment of passenger cars Skoda and KIA in various modes of operation during the winter, spring and summer season at different levels of air conditioning (without air-conditioning, minimum, medium and maximum level). Air temperature, air humidity, globe temperature, CO<sub>2</sub> concentration, dust concentration and noise inside the cabin were measured. Solar radiation plays a big role to rise up temperature inside the cabin. It resulted in the higher values of globe temperature than temperature of the air. The results of the measurements showed that CO<sub>2</sub> values were significantly lower than 2,500 ppm at minimum air-conditioning, lower than 600 ppm at medium and lower than 500 ppm at maximum level of air-conditioning. For all vehicles, dust concentration was greater when it measured with the air conditioning switched off than with the air conditioning system turned on. The measurements confirmed that the total dust concentration was not more than 47 µg m<sup>-3</sup>, PM<sub>10</sub> lower than 28 µg m<sup>-3</sup> and PM<sub>1</sub> lower than 27 µg m<sup>-3</sup>. The noise levels ranged from 49.1 to 68.7 dB(A). The air-conditioning had very positive impact on the inside comfort in car cabins from all points of view during all periods of the year.

**Key words:** air humidity, carbon dioxide, drivers comfort, dust, noise, temperature.



## Physioacoustic Treatment in a Tractor Seat

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**Abstract.** The goal of this project is to decrease musculoskeletal symptoms and disorders (MSD's) in agriculture. Recent studies indicate that MSDs is the most common reason for disability pensions among farmers. One considerable MSD risk factor is long hours of operation of mobile machinery like agricultural tractors, combines, excavator etc. As a potential solution to this problem we initiated a study of the impacts of physioacoustic treatment on tractor drivers' musculoskeletal symptoms. We tested if physioacoustic treatment in the tractor driver's seat can activate and accelerate recovery of the driver's back muscles. This preliminary study was funded by the Farm Machinery Research Foundation and Natural Resources Institute Finland (Luke). The project was headed by Luke in collaboration with Next Wave Ltd, Finnish Physioacoustic Association and Finnish Institute of Occupational Health. Preliminary tests were organized at Luke's farm machinery test facilities in Vakola, Vihti in August 2017. Valtra Inc. provided a tractor and seats for the test. Two test days had an identical driving program. During the first day the four test drivers used a standard tractor seat and during the second day a physioacoustic tractor seat, which included four specific acoustic elements located against the driver's buttocks and lower back. Test driving was conducted on a standardized test track. A 50 minute driving period was followed by the physioacoustic program which included a 10 minute activation and 30 minute recovery program. Each test drive lasted one and half hours. Finnish Institute of Occupational Health specialist Juha Oksa measured the test drivers' muscle stiffness from the back muscles before and after the test program. Furthermore, electrical muscle activity (EMG) were measured from the lower and upper back and shoulder muscles during driving. Tractor speed, efficiency, fuel consumption and location were measured simultaneously for later tractor driving stress analysis. The test results indicated that the physioacoustic treatment in the tractor seat significantly decreased muscle strain in test drivers. The total strain was reduced by 43% in low back muscles and 28% in upper back muscles when using the physioacoustic tractor seat, compared to standard seat. After the physioacoustic activation phase during driving, the decrease in low back muscle strain reduction was up to 55% compared to standard seat. Shoulders were not in contact with the physioacoustic tractor seat, and there were no significant differences in muscle strain in the shoulder area. The preliminary results are promising and more extensive tests have been planned to investigate physioacoustic seats in future studies.

## **Ergonomics modeling parameters and its influence on planning the workplaces**

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**Abstract.** Modern economic researches divide all economics into structural levels: megaeconomics, macroeconomics, mesoeconomics, microeconomics and nanoeconomics. From the point of such traditional division, the research is topical in the primary economic structure of society – nanoeconomics and hence work operations can be subdivided into workplaces as transformation processes. The aim of the research is to develop ergonomics modeling parameters and find out its influence on workplaces' planning stage based on case study. The research involved workplace ergonomic planning methods and principles. Solutions of a series of problems related to the improvement of workplace ergonomics, may be found in the following ways: improvement of work organization at every workplace by using work process micro-elemental methods and determination of work expenditure, heaviness degree of work, complexity of work and social importance of a workplace. These parameters allow to find out workplace quantity characteristics, i.e. the generalized parameter which conforms to the requirements describing a workplace and in operational management by a condition of workplaces and the wage systems. The research provides case study where ergonomics modeling parameters are developed and concrete workplace interventions has been introduced.

**Key words:** human factors, work, workplace, case study, intervention.

## Human Factors and Ergonomics in Safety Management in Healthcare: Building New Relationships

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**Abstract.** Human factors are playing an essential role in ensuring occupational health and safety at work. In healthcare sector relevant factors include optimising the interaction of humans with their technical, social working environment, human characteristics such as knowledge and a motivation. Those factors affect the ability to provide good quality of healthcare and safety performance. The aim of this paper is to analyse factors related to safety knowledge, communication and professional competence among care givers in nursing homes. The investigated group of professionals (n=241, includes nurses and care givers) completed the validated questionnaire. Descriptive statistics and correlation analyses were applied, using SPSS Statistics 24. Our study reveals that over half of the respondents possess an occupational certificate and majority of employers organize regular in-service training at workplaces. Among respondents, who claimed that in-service trainings are not regular, still stated that they generally receive safety and ergonomic related trainings, trainings for working with special equipment. However, only quarter of respondents have an access to occupational safety trainings, focusing on specific risks at work. Based on the results of the study, authors emphasize the need of integrating human factors in safety management system in nursing homes with a special focus on adequate safety training in order to develop necessary skills and knowledge of workers. This would enhance employees' ability to cope successfully with the elderly and people with special needs, to provide safe and high-quality care as well as confidence and the knowledge how, successfully manage conflicts in order to keep good relationships at work.

**Key words:** health care, workplace safety, training, competences.

**ACKNOWLEDGEMENTS.** This research received funding by Tallinn Health Care College (project Proactive safety management in health care no 1-16/61) in cooperation with Tallinn University of Technology.

## **V LIVESTOCK ENGINEERING**

## Effect of thermal environment on body temperature of early-stage laying hens

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**Abstract.** The thermal comfort condition of early-stage laying hens can be verified by means of physiological variations. The mean surface temperature and cloacal temperature are important parameters to demonstrate the effect of the thermal environment on the birds. The objective of the present study was to correlate homeostasis and stress with physiological responses (mean surface temperature and cloacal temperature) of lightweight laying hens of the Lohmann LSL Lite line aged from one to forty-two days when submitted to different thermal environments. A total of 864 birds with the same age, origin and uniform body weight were randomly distributed in four climatic chambers. The characterization of the different environments was as follows: thermal comfort temperature (33.0 - 19.0°C), two cold stress levels (28.0 - 17.0°C and 25.0 - 17.0°C) and one level of heat stress (38.0°C - 22.0°C). The experiment was performed in a completely randomized design in the subdivided plots scheme, with four treatments in the plots and the evaluations (days) in the subplots. The means were compared using the Tukey test, adopting the 5% probability level. The birds maintained the physiological responses, based on cloacal and surface temperatures, within the normal range for all evaluated treatments during the period between 01 and 42 days of life. The surface temperature of the birds varied as a function of the air temperature of each breeding environment, with lower surface temperatures for mild cold and moderate cold treatments.

**Key words:** environmental conditions, poultry, surface temperature, layer chicks.

**ACKNOWLEDGEMENTS.** To CAPES, CNPq, FAPEMIG and the LOHMANN DO BRASIL.

## The role of field beans in nutrition of Boer goat

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**Abstract.** A study on the effective using of field beans to Boer mother goats feeding was carried out on a farm whose main activity is the production of goat meat. Since the Boer goat breed is still very rare in Latvia, there is a lack of experience in the feeding of meat goat. Goat productivity was analyzed according to the birth weight of goat kids and kids live weight at 50 days, as well as the average live weight gain of kids per day up to 50 days old. For control group goats a relatively high energy shortage (14% of the daily requirement) and protein deficiency (29% of the daily requirement) were observed in feed ratio. Adding fodder beans and maize into the feed, it is possible to optimize feed ratio for energy and protein supply. Experimental activities had shown that by the inclusion of field beans and maize in feed ratio of goat's mothers, the average increase in live weight of kids up to 50 days old was by 58.2% higher ( $P < 0.05$ ) than that of kids in which goats' mothers received only oats as concentrated feed. By the optimization of feed ratio, it is possible to achieve a higher milk productivity of goat mothers and hence larger live weight gain for kids, which reduces the feed costs by up to 9% for 1kg of live weight. By optimizing the breeding and feeding of mother goats and kids, it is possible to achieve greater animal fast-growing, hence, more efficient and cost-effective management.

**Key words:** Boer goat, live weight, gain.

**ACKNOWLEDGEMENTS.** Financial support for the research project was provided by Latvia Ministry of Agriculture.

## The influence of dietary inclusion of peas, faba bean and lupin as a replacement for soybean meal on pig performance and carcass traits

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**Abstract.** The effect of peas, faba bean and lupin seed inclusion in growing and finishing pig diets was evaluated. The control diet included soybean meal at 15%, but in the trial groups diets peas were 15 or 28%, faba bean 20 or 25%, lupin seed 12 or 15%, completely replacing soybean meal. Diets formulated to be isoenergetic for ME and with the same crude protein content. The faba bean and, especially, lupin seed meal inclusion in pig diets for growing period significantly reduced ADG ( $P = 0.02$  and  $0.01$ ), and G : F was also significantly influenced ( $P = 0.02$ ) for pigs in lupin seed meal groups. There were no effects on finisher pigs average daily gain, inclusion peas or faba bean, daily gain were, respectively  $892 \pm 19$  and  $915 \pm 11$ ,  $867 \pm 12$  and  $828 \pm 11$ , except lupin seed meal ( $P = 0.04$ ) inclusion. There were no significant effects on carcass quality and to pork chemical content, but pigs fed the diets with peas 28% and faba bean 25% had less of lean meat content, greater backfat thickness and internal fat than other groups which have a similar results. The muscle chemical content show that inclusion of pulses increased the total fat content in pork. In conclusion, results from this experiment suggest that pigs fed peas and faba bean have equal or slightly lower growth performance and carcass traits than pigs fed soybean meal, except lupin seed meal.

**Key words:** peas, faba bean, lupin, growing and fattening pigs, nutrition.

**ACKNOWLEDGEMENTS.** This research was part of the project "Pulses as alternative protein feeds instead of soybean meal, their production, agricultural and economic evaluation in Latvia conditions" funded by Ministry of agriculture, Republic of Latvia, but the chemical content of pork is supported by second project "VPP- 20142017 AgroBioRes Project No. 3 LIVESTOCK".

## Improvement of monitoring of cattle in outdoor enclosure using IQRF technology

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**Abstract.** Monitoring of cattle in the outdoor enclosure is a very important issue. Currently, the increasingly stealing cows and other cattle from the pasture. For businesses that manage it, this is a very lossy business. For thieves, the electric fences, which are currently the most widespread, are easily surmountly. And the owner does not have a chance early on to learn the fact theft of cattle. For this reason, a system for monitoring cattle on outdoor enclosure using IQRF (intelligent local network topology) technology has been developed. We have been dealing with this issue for a long time and the biggest problem was the monitoring of only the inner part of the enclosure. Previously, there was an overlap of monitoring in the area beyond grazing. This problem has been solved by using a shielded base for mounting IQRF receivers.

**Key words:** IQRF technology, wireless transmission, interference, livestock.

**ACKNOWLEDGEMENTS.** It is a project supported by the CULS IGA TF “The University Internal Grant Agency” The Examination of the Influence of Blended Biofuels on Operating Parameters of CI Engines, 2017:31150/1312/3116.



## The relationships between different genotype dairy cow body condition score, milk urea content and milk productivity.

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**Abstract.** Analysis of cow body condition score (BCS) and milk urea content its relation with can be useful indicators in dairy farms for determination of cow health, productivity and, most important, feeding efficiency and protein metabolism. In our study were used data from cows that were located in Latvia University of Agriculture research and study farm “Vecauce” and milked in automatic (voluntary) milking system. The BCS were determined with “DeLaval” 3D body condition scoring cameras every day after milking. After each milking time system calculated cow individual milk productivity. The average milk yield in farm goes over 10 000 kg per lactation. In study group cows were fed with partially mixed ration (PMR) and the concentrated feed was given to them in the milking robots and individual feeding stations. In study we analysed daily milk yield, milk protein, fat, lactose and urea content as well as somatic cell count from Holstein Black and White (HBW), Latvian Brown & Holstein Red and White (LB&HRW) and dairy breed crossbreed (XP) cows which calved in year 2016 and 2017. In total we analysed data about 1038 BCS and control day milking results. The obtained results are given as least mean squares. Significantly lower average BCS had HBW breed cows –  $3.05 \pm 0.016$ , but BCS of LB&HRW and XP cow breed groups in between them had no significant differences, accordingly average BCS were  $3.17 \pm 0.020$  and  $3.11 \pm 0.019$ . Control day milk test results were distributed in 4 groups depending on BCS results during the lactation. Significantly higher daily milk yield were observed in cow group with BCS from 2.5 to 2.9 ( $44.4 \pm 0.53$ kg) points, but the lowest milk yield ( $29.1 \pm 0.38$ kg) were obtained from cows with BCS  $>3.5$  points ( $p < 0.05$ ). Milk fat, lactose content (%) and somatic cell count did not differ between cows with different BCS, but higher milk protein content was in cow group with the highest BCS –  $>3.5$  points. The highest milk urea content ( $34.8 \pm 0.52$  mg dL<sup>-1</sup>) were observed in cow group with BCS ranging from 2.5 to 2.9 points. During lactation the cow BCS changed significantly. Eight days after calving the average BCS was  $3.23 \pm 0.066$  points. Starting with 3<sup>rd</sup> BCS evaluation time that in average happened in 58<sup>th</sup> day of lactation, until 5<sup>th</sup> milk control (the 120 days in lactation) average BCS was within range of 2.97 to 2.93 points. Dairy cow body condition started significantly increase from 9<sup>th</sup> up until 12<sup>th</sup> milk control time. BCS during the lactation had negative, moderately close and significant correlation with the control day milk yield ( $r = -0.501$ ). Significant negative correlation was obtained also between BCS and the milk urea content.

## Efficiency of the use of field beans in fattening lambs

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**Abstract.** The breeding and feeding of self produced pulses to livestock is one of the important directions of research for reducing the production costs of livestock products. Experiment on the effective using of the field beans to lambs for fattening was arranged in three replications using the Latvian Dark-headed breed male lambs. The mixture of concentrated feed consists of 50% of bean and 50% of oat. Lambs 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. The fattening period lasted from 37 to 94 days, on average  $63 \pm 3.6$  days. The average live weight gain per day was  $247.4 \pm 13.85$  g, and live weight increased on average by  $15.3 \pm 0.94$  kg. Significantly higher ( $P < 0.05$ ) growth rate during fattening period reached lambs of 3rd group, where lambs started fattening above 27 kg of live weight, reaching a  $276.8 \pm 26.26$  g daily live weight gain. The quality of the obtained carcasses is an average, and score for musculature is from R to O class, but the average score for fat deposition is from 3 to 4 points. The mixture of field beans and oats provided 19.3% of crude protein and 11.5 MJ of metabolizable energy per 1kg of dry matter, and its unlimited feeding provided medium lamb's growth rate. The level of feed conversion was 7.56.

**Key words:** beans, lamb, fattening, slaughter, carcass.

**ACKNOWLEDGEMENTS.** Financial support for the research project was provided by Latvia Ministry of Agriculture.

## The European performance indicators of broiler chickens as influenced by stocking density and sex

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**Abstract.** The aim of this study was to investigate the influence of different stocking densities on the growth performance of Ross 308 broiler chickens up to six weeks of age. A total of 216 one-day broiler chicks were randomly assigned to three treatment groups based on the stocking density: Low (LSD)=14 chickens/m<sup>2</sup>, Medium (MSD)=18 chickens/m<sup>2</sup> and High (HSD)=22 chickens/m<sup>2</sup>, with four replications. Higher body weight gain (TWG) was observed for the low (2043.89g) and medium (2008.03g) compared to the high (1901.51g) density. The study revealed that chickens of the LSD treatment consumed significantly ( $P < 0.01$ ) more feed compared to the HSD chickens. High stocking density (22/m<sup>2</sup>) tended to improve feed conversion ratio compared to medium (18/m<sup>2</sup>) and low (14/m<sup>2</sup>) stocking density, but the differences were not significant ( $P > 0.05$ ). From the results of this study it can be concluded that broiler chicks can be stocked up to 22 chickens/m<sup>2</sup>, as far as required standards are assured.

**Keywords:** broiler chickens, feed intake, growth, sex, stocking density.

## Criteria of design for deconstruction applied to dairy cows housing: a case study in Italy

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**Abstract.** This work aims at presenting the design process of a new barn for dairy cows. Project embraces several concepts that are rather new to the dairy industry and will deeply affect its environmental, economic and social sustainability. The barn will be built on a green field site located in Cervasca (CN) in the region of Piedmont. Building has been designed applying the emerging principle of "design for deconstruction" extensively. A series of constructive solutions was developed allowing for complete end-of-life disassembly and reuse of building materials. Structural system will consist of locally sourced timber connected by steel joints. Foundations will be realized by means of chestnut wood piles driven into the ground. The employment of an alternative housing system for dairy cows based entirely on cultivated pack will allow limiting the use of cast-in-place concrete, which is largely employed in conventional dairy barns. The cultivated pack needs a large space per cow leading the building to be particularly extended. The large covered area combined with the high snow load of the building site posed several challenges. Accumulation of snow on the roof would increase dramatically the structural load and therefore construction costs. Therefore, the building will consist of several 12m-large modules with 4m free space between them. Given the unusual shape of the barn and the limited use of concrete for flooring, the development of efficient systems for livestock management required the study of dedicated solutions. A first module, already realized to collect useful information for final design, is described.

**Key words:** design for deconstruction, sustainable building, cattle housing, cultivated pack barns, compost dairy barns.

**ACKNOWLEDGEMENTS.** Authors acknowledge Cascina Bianca for their participation and support of this study. We thank Livio Bima, farm manager at Cascina Bianca, for sharing his invaluable experience.

## Productive performance of broilers at the final stage of breeding submitted to different levels of metabolizable energy in different thermal environments

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**Abstract.** The Brazilian poultry industry is an activity in constant development due to the high indices of productive efficiency. The accelerated evolution of poultry production has allowed to obtain early and very efficient broilers able to convert different foods into animal protein. However, due to this intensive breeding system, a series of metabolic and management problems appeared, with emphasis on thermal stress. The objective of this work was to evaluate the physiological responses of broiler chickens in the final stage of breeding (21 to 42 days of life), submitted to two thermal conditions, one representative of the thermoneutrality situation (T1) and one giving a situation of cyclic stress by heat (T2). For each experimental thermal condition, the birds were submitted to different levels of metabolizable energy of 3,050, 3,125, 3,200, 3,275 kcal.kg<sup>-1</sup>. At 28, 35 and 42 days, the birds and the feed leftovers were weighed to measure the performance variables: CR (feed intake), GP (weight gain) and CA (feed conversion), viability of the rearing (Vb), productive efficiency index (PEI).

As conclusions, the GP was 13.6% higher for the birds maintained at the thermoneutrality situation T1. The PEI was 32.5% higher for the birds maintained in T1 condition, when compared to those kept in T2. However, both in thermoneutral and in heat stress conditions, the increase in the level of metabolizable energy in the diet did not influence the performance and the productive efficiency index of broiler chickens aged between 21 and 42 days of age.

**Key words:** broilers, feed, metabolizable energy, productivity, thermal stress.

ACKNOWLEDGEMENTS. AmbiAgro, CNPq, CAPES and FAPEMIG.

## Typological analysis of the sustainability of dairy cattle farming in the Chelif valley (Algeria)

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**Abstract.** To identify production systems that could increase local milk production in a sustainable manner, a study was conducted on 135 dairy farms in the three main plains of the Chelif Valley, Algeria. These have been evaluated for environmental, social and economic sustainability based on the IDEA (Farm Sustainability Indicators) method.

The Principal Component Analysis identified 4 different types dairy production systems, namely Type 1: Medium-size dairy farms with cereal crop production; Type 2: Small-size dairy farms; Type 3: Medium-size dairy farms diversified crop production, and Type 4: Large-size dairy farms with diversified crop production.

Comparative analysis of ecological sustainability showed better results for medium-size dairy farms with cereal crop production ( $52.3 \pm 10.17 / 100$  points) and for large-size dairy farms with diversified crop production ( $51.6 \pm 10.38 / 100$  points), while the economic sustainability was better for medium-size dairy farms with diversified crop production ( $51.6 \pm 19.20 / 100$  points). On the other hand, social security was the weak point for all farm types.

On the regional level, it appeared that agri-environmental scores were better in Middle and Low Chelif valley while the best economic performances were recorded in High Chelif valley. On the regional level, it appears that the scores of agri-environmental scales are better in the middle and low Chelif while the economic performances are comparable between the three localities.

**Key words:** Algeria, dairy farming, IDEA, sustainability, typology.

## **Poultry farming solutions for a sustainable development of marshlands areas of South Iraq**

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**Abstract.** The Department of Agricultural, Food and Forestry Systems of University of Florence carried out cooperation projects in the South Iraq, funded by Italian Ministry of Foreign Affairs and International Cooperation, focused on the development of rural areas. All the proposed interventions were designed taking into account some key points, such as the development of sustainable farming systems, the protection of the environment, the empowerment of women role. Among the main activities, a particular importance is given to the simple solutions for poultry breeding that represents an important economic resource for many farmers and a source of food for a large segment of the population. Therefore the main aim of the project was to define new building solutions to apply in the area of marshlands. A mobile poultry shelter was designed and built to meet the demand for meat and eggs from a typical rural family. This shelter was designed to be used for extensive breeding, with animals free to graze outside during the day. A suitable self-building methodology was applied to obtain results from farmers without specific skills for wood construction thanks to which they learn the appropriate way to build poultry shelters. As conclusion, poultry breeding can be spread in the area of marshlands using the simple self-building structures presented in the study.

**Key words:** marshlands, poultry shelter, rural development, self-building.

**ACKNOWLEDGEMENTS.** Project funded by Italian Agency for Cooperation and Development (AICS). The authors express gratitude to Dhi Qar Governorate and Dhi Qar Agriculture Directorate, and to all the other Iraqi Institutions involved in the project.

## Implementation of practical solutions to improve buffalo breeding development in rural areas of South Iraq

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**Abstract.** Buffalo breeding is widely spread in rural areas of southern Iraq, especially in marshlands. In the Provinces of Basrah, Dhi Qar and Maysan the buffalo represents the main source for survival of local people in marshlands. The paper shows the situation in these areas, remarking the main critical points for buffalo breeding development. A survey in 24 buffalo farms was carried out by the Department of University of Firenze to verify the situation of buffalo farming in southern Iraq (years 2014-2016). In particular the study shows problems related to the shortage of food for animals, to the lack of suitable structures and infrastructures, to the poor herd management by farmers. In the paper the main critical points, which compromise the success of the breeding, are pointed out, with particular reference to animal welfare, animal health and labour (care of animals and risks for workers). Solutions to mitigate the scarce results are indicated. In particular some practical interventions carried out during a project funded by Italian Agency for Cooperation and Development are presented and discussed. Such interventions refer mainly to the application of feeding racks, systems for a safe capture of the animals, plants and equipment for heat protection. As conclusion, also in difficult and poor areas like Iraqi marshes, a correct design and a right application of simple constructive and plant solutions, with little employment of technological resources, coupled with a good training of farmers, can give a contribution to solve problems in buffalo breeding.

**Key words:** buffalo, livestock housing, marshlands, Iraq.

**ACKNOWLEDGEMENTS.** Project funded by Italian Agency for Cooperation and Development (AICS). The authors express gratitude to local people taking part to the activities of the project, to Dhi Qar Governorate and Dhi Qar Agriculture Directorate, and to all the other Iraqi Institutions involved in the project. A particular thank is addressed to Mr. Imad Ali Hayif for the important support given during all the phases of the project.



## Effect of Automatic Feeding Station use on fattening performance in lambs and intake activity periods

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**Abstract.** Implementation of precise farming technology is very important for productivity increasing of livestock. One of the highest components of the production costs is feeding expenses. An automatic concentrate feeding stations (AFS) can ensure economic feed distribution and intake registration for animals individually. The aim of this research was to study the possibility and benefits of using AFS in fattening of lambs. Results show that during all the research average number of daily visits to AFS per lamb were  $13 \pm 0.2$  visits, average daily live weight gain per lamb was  $254 \pm 15.7$  g. For 1 kg lamb live weight gain 5.35 kg concentrate was used. More intensively activity periods of lambs was noted during following hours of day time: 02:00 - 02:59 , 08:00 - 09:59 and 19:00 - 20:59. Significant ( $P \leq 0.05$ ) moderate positive correlation ( $r = 0.470$ ) was found between average daily number of visits to the AFS per lamb and total amount of concentrate consumed during the research per lamb. Significant ( $P \leq 0.05$ ) strong negative correlation ( $r = -0.806$ ) was found between average daily number of visits to the AFS per lamb and average amount of concentrate consumed during one visit.

**Key words:** sheep, feed intake, live weight gain, feeding station.

## Molecular Genetics Analysis of Milk Protein Gene Polymorphism of Dairy Cows and Breeding Bulls in Latvia

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**Abstract.** Milk protein is the most valuable component of milk from a dietary point of view. More than 95% of ruminants' milk proteins are coded by six structural genes: two whey proteins ( $\alpha$ -lactalbumin and  $\beta$ -lactoglobulin) and four caseins ( $\alpha_{S1}$ - and  $\alpha_{S2}$ -caseins,  $\beta$ -casein,  $\kappa$ -casein). The object of the research was the genetic polymorphisms of milk protein genes in populations of cows and breeding bulls of milk producing breeds in Latvia. The aim was to promote cow breeding in Latvia by developing and testing molecular genetics analyses for future quantity and quality analysis of the dairy cows' population in Latvia, based on the research of genes encoding milk protein polymorphism. In methodology the molecular markers were chosen which would be suitable for characterization of polymorphism of five milk protein genes in the population of dairy cows reared in Latvia. As a genetic method chosen the Restriction Fragment Length Polymorphism (RFLP) method and most analysed alleles of milk proteins. Using data of 719 DNA samples of dairy cows, the analysis of Latvian cows' population was carried out through six SNP of five milk protein genes: *CSN1S1* c.-175A>G, *CSN2* – c.4451A>C, *CSN3* c.11625C>T and c.11661A>C, *LAA* c.15A>G and *LGB* c.3106T>C. The results of PCR-RFLP analysis showed, as it was expected, that all genotypes were found in the populations.

**Key words:** milk proteins, dairy cattle, polymorphisms, Latvian population.

**ACKNOWLEDGEMENTS.** The results are part of D. Smiltina, Dr. agr., PhD Thesis. We thank Latvian Science Board for financial support to our investigations through grant Nr. 09.1461. The study financed by the ESF Project "Support for doctoral studies in LLU" No/2009/0180/1DP/1.1.2.1.2/09/IPIA/VIAA/0117 agreement No. 04.4-08/EF2.D1.13.

## Diagnosis of air quality in broilers production facilities in hot climates

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**Abstract.** The objective of this study was to evaluate air quality of industrial farms of broilers production, located at Zona da Mata region, Minas Gerais, Brazil. The environmental air quality was evaluated during the last rearing week, between 35 and 42 days of life of broilers. Facilities with beds constituted by two types of substrates were evaluated: coffee husks (6 reuse cycles) and shavings (4 reuse cycles). A total of 30 facilities (3 per each of the 10 reuse cycles) were investigated. Air quality was diagnosed by determining air temperature and relative humidity and by ammonia and carbon dioxide concentrations. Air temperature and relative humidity were not affected by reuse cycles in coffee husks bed, but these variables were affected by reuse cycles in shavings bed. Ammonia and carbon dioxide concentrations increased linearly according to the reuse cycles for both types of bed. The maximum concentrations of ammonia and carbon dioxide were 25 ppm and 1,348 ppm in facilities with bedding of coffee husks and 10 ppm and 1,075 ppm in facilities with bedding of shavings, respectively. Air quality of facilities using coffee husk bed tends to be worse when compared to facilities using shavings bed due to the higher values of ammonia and carbon dioxide concentrations, as observed in this study. In conclusion, regardless bedding type, increases in reuse cycles tend to decrease air quality inside the facility, since a linear increasing in ammonia and carbon dioxide concentrations can be observed in relation to the number of bed reuse cycles.

**Key words:** air pollutants, air quality, gas concentration, livestock, poultry.

**ACKNOWLEDGEMENTS.** The authors thank the sponsors CAPES, CNPq and FAPEMIG.

## Energy consumption of milking pump controlled by frequency convertor during milking cycle

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**Abstract.** The article deals with selected parameters affecting the energy consumption of a vacuum pump in a milking system during the whole milking cycle in variants with and without regulation by a frequency convertor. When put into practice, the latest research of creation, control and stabilization of vacuum in milking devices allows dairy farmers to obtain a vacuum system that ensures maximum stability of milking pressure, which is a basic requirement affecting the health of dairy cows. The choice of vacuum system prioritizes in particular high performance, maximum operational reliability, minimum maintenance, long service life, environmental friendliness and economy. The vacuum pump was a Roots vacuum pump with a rotary piston which is typical for this use. Use of a frequency convertor significantly affected the efficiency of this pump for control of vacuum pressure level and pump performance by varying the rotation frequency according to the actual airflow requirement. Using this control system, only as much vacuum pressure is produced as necessary. By measurement of an experimental setup, it was found that the average power requirement of a setup with a control valve was 3.8 kW compared to 1.7 kW in the case of the variant with frequency convertor. Measurements and calculations have shown that this system is capable of saving more than 50% of electric energy.

**Key words:** milking cycle, vacuum system, vacuum pump, frequency convertor, energy consumption.

**ACKNOWLEDGEMENTS.** Supported by the Internal Grant Agency of the Faculty of Engineering, Czech University of Life Sciences Prague, Czech Republic, Project No. 2015:31170/1312/3115.

## Technical economic assessment of liquid manure transport and incorporation hose technologies

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**Abstract.** Comparison of three different techniques for transporting and introducing liquid manure into the soil will be performed. In the first variant of the liquid manure transport from the storage to the fields, and for the delivery of liquid manure to its application to the soil the hoses will be used. The second variant is characterized by the fact that the liquid manure is transported to the field via transport tanks. And in the third variant universal tractor units with tanks, sliding wings and tubular distributors of contributed liquid manure will be used. Such units do not only transport liquid manure, but also contribute it into the soil. It is found that the technology of the hose and operating application labour costs of maintenance are 1.5-2 times smaller in comparison with other process variants.

## **VI PRECISION AGRICULTURE**

## Potential reuse of Sphagnum peat after biosorption-desorption of Zn(II)

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**Abstract.** In this study, continuous biosorption-desorption cycles in a fixed-bed column were performed to evaluate the sphagnum peat potential reuse as biosorbent material to remove Zn(II) ions from aqueous solutions. Biosorption-desorption studies revealed that the sphagnum peat as biosorbent could be regenerated using 0.1M HCl as eluting agent with more than 70% recovery in four successive biosorption-desorption cycles. The results showed that the sphagnum peat should be used as an alternative, effective and low-cost biosorbent for Zn(II) ions removal from polluted aqueous solution.

**Key words:** biosorption-desorption process, fixed-bed column, zinc, sphagnum peat.

**ACKNOWLEDGEMENTS.** This work has been funded by IPP3: INNO INDIGO Programme Project B-LIQ „Development of an Integrated Process for Conversion of Biomass to Affordable Liquid Biofuel”, No. ES/RTD/2017/18 (PVS ID 2802).

## Identification of wet areas in forest using remote sensing data

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**Abstract.** Aim of this study is to evaluate different remote sensing indices to detect spatial distribution of wet soils using GIS based algorithms. Area of this study represents different soil types on various quaternary deposits as well as different forest types. We analyzed 25 sites with the area of 1 km<sup>2</sup> each in central and western part of Latvia. Data about forest type, soil characteristics, ground load-bearing capacity, thickness of peat layer and presence of reductimorphic colors in soil was collected during field surveys in 228 random points within study sites. ANOVA test for comparing means of different soil wetness classes and binary logistic regression for evaluating the accuracy of different remote sensing indices to model spatial distribution of wet soils are used for analysis. Main conclusion of this study is that for quaternary deposits and soil texture classes different algorithms for soil wetness prediction should be used. Data layers for predicting soil wetness in this study are various modifications and resolutions of digital elevation model like depressions, slope and SAGA wetness index as well as Sentinel-2 multispectral satellite imagery.

**Key words:** DEM, satellite imagery, quaternary deposits.

**ACKNOWLEDGEMENTS.** The study is implemented within the scope of the Forest Sector Competence Center project No. 1.2.1.1/16/A/009.



## Environmental risk assessment studies of new plant protection products elaborated from coniferous trees bark

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**Abstract.** Nowadays there still are different chemical pesticides applied in plant protection. Plant pathogens induce considerable economic losses in agricultural production industry; therefore, more attention should be paid to the development and implementation of environmentally friendly techniques. Since 2010, we are working on the development of new environmentally friendly plant protection products against pathogenic fungi and bacteria causing diseases of crop plants. Several plant protection products on the base of coniferous trees biomass were produced in cooperation between the Latvian State Forest Research Institute "Silava" and the Institute of Biology, University of Latvia. General aim of the research was to develop new environmentally friendly plant protection product, usable in organic farming and integrated pest management. The specific aim of this study was to evaluate risk assessment of new plant protection products elaborated on the base of coniferous trees bark. Various products from processing of pine (*Pinus sylvestris* L.) and spruce (*Picea abies* (L.) Karst.) bark were tested. Different solvents (ethanol, butanol, sodium carbonate, sodium hydroxide and water) were used for extraction. Extracts were formulated and applied in field experiments. Two formulations, which showed anti-fungal activity *in vitro* and in field trials on fruit crops (strawberries, raspberries) were selected for risk assessment studies. The impact of formulation treatment on crop plants and soil biological activity were tested. We analysed also residues of active substances accumulated in crop plants and soil. The application of new formulations did not show negative effect on the chlorophyll content and fluorescence in plant leaves. We observed an increase of coumaric acid in raspberries after treatment by preparations. We did not find the negative impact of selected preparations on soil respiration, soil microbial biomass and soil fermentative activity. The effects on invertebrate fauna will be further explored.

## Evaluation of the RTK receiver's capability of determination the accurate position

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**Abstract.** The main aim of this experiment was to compare low-cost RTK receiver, that possible can be used for precise agricultural application, another that is currently used for these applications and the third one that suits for static measurement the most and gives the reference point for results comparison. The main idea of this research was to compare the measured positions during static measurement of RTK receivers. Were discovered that the receiver Trimble 750 was not able to work in fix mode (mode when the RTK receivers are capable to measure the most accurately) for the whole time. This fact affects the results from whole measurement and showed that errors were a little higher than producers specifies. The low-cost receiver u-Blox C94-M8P showed satisfying results when in most cases it was capable to solve the problem of ambiguity integer phases. The main parameters in this work that were counted and summarized were: accuracy, precision, RMS error, system status ratio and number of satellites.

**Key words:** localization, positioning, survey-ing, accuracy, precision, agriculture, RTK, VRS.

**ACKNOWLEDGEMENTS.** This study was supported by GA no. 2017/31160/1312/3123 with topic “Evaluation of Determined Position Accuracy by RTK Receivers”.

## Enrichment of field crops biodiversity in conditions of climate changing

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**Abstract** Gradual introduction into the culture of new species requires introduction of appropriate technologies of their cultivation, with taking into account varietal characteristics, species adaptation to the conditions of cultivation, analysis of yield and quality formation characteristics, taking into account content of biologically valuable components, depending on technological factors and environmental factors. The dynamics of the weather changes in the Right-bank Forest-steppe of Ukraine during the period is analyzed. Identified cultures: lentil (*Lens culinaris*), chick-pea (*Cicer arietinum*), chufa (*Camelina sativa*); triticale (*Triticale*); millet (*Panicum miliaceum*); sorghum (*Sorghum bicolor*); white mustard (*Sinapis alba*); brown mustard (*Brassica juncea*); coriander (*Coriandrum sativum*). that, due to biological and technological characteristics, are suitable for introduction into production. Installation of the elements of adaptive technologies for the cultivation of scarce field crops. Developed elements of adaptive cultivating technology for species, introduced into the field culture, contribute to reducing the influence of uncontrolled factors on productivity formation, the role of species increasing, sustainable development of formed agrocenoses, improving the quality of raw materials and food safety.

**Key words** : less common crops, weather conditions, adaptive technology, yield.

## Research on the mineral composition of cultivated and wild blueberries and cranberries

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**Abstract.** European cranberry (*Vaccinium oxycoccos* L.) and European bilberry (*Vaccinium myrtillus* L.) are among the most popular wild-harvested fruits in Latvia, traditionally used in folk-medicine and food. The commercial cultivation of American cranberry (*Vaccinium macrocarpon* Ait.) and highbush blueberry (*Vaccinium corymbosum* L.) was successfully started during last 20 years. With a berry production increase due to considerable hectareage of plantings and growing consumer interest in health-improving foods cultivated blueberries and cranberries have found a place in a daily intake as an excellent source of phenolic and nutritive compounds, vitamins and minerals. As the chemical composition of *Vaccinium spp.* has an important implication on human health, detailed information on the nutritional content of berries are of special importance. The aim of this study was to compare the contents of twelve biologically essential elements (N, P, K, Ca, Mg, S, Fe, Mn, Zn, Cu, Mo, B) in berries of four *Vaccinium* species: cultivated and wild blueberries (*Vaccinium corymbosum* and *Vaccinium myrtillus*) and cranberries (*Vaccinium macrocarpon* and *Vaccinium oxycoccus*). Together 136 (leaf and berry) samples were collected from 7 main cranberry and blueberry producing sites and 17 native woodland areas and bogs in Latvia. A comparison of wild and cultivated species showed similar concentrations for the macroelements K, Ca and S in cranberry and N, P in blueberry fruits. While statistically significant differences were found for N, P and Mg in case of cranberries and Ca, K, Mg and S for blueberries. The research revealed statistically significant differences of most micronutrients in cultivated and wild berries. Plant leaf and fruit analysis revealed the organ-specific distribution of mineral elements in all species studied. In most of the cases, leaf analysis supported concentration differences in fruits.

**Keywords:** *Vaccinium myrtillus*, *Vaccinium corymbosum*, *Vaccinium oxycoccus*, *Vaccinium macrocarpon*, mineral composition of fruits.

## Solution for remote real-time visual expertise of agricultural objects

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**Abstract.** In recent years automated image and video analyses of plants and animals have become important techniques in Precision Agriculture for the detection of anomalies in development. Unlikely, machine learning (i.e., artificial neural networks, support vector machine, and other relevant techniques) are not always able to support decision making. Nevertheless, experts can use these techniques for developing more precise solutions and analysis approaches. It is labour-intensive and time-consuming for the experts to continuously visit the production sites to make direct on-site observations. Therefore, videos from the site need to be made available for remote viewing and analysis. In some cases it is also essential to monitor different parts of objects in agriculture and animal farming (e.g., bottom of the plants, stomach of the animal, etc.) which are difficult to access in standard recording procedures. One possible solution for the farmer is the use of a portable camera with real-streaming option rather than a stationary camera.

The aim of this paper is the proposition of a solution for real-time video streaming of agricultural objects (plants and/or animals) for remote expert evaluation and diagnosis. The proposed system is based on a Raspberry Pi 3, which is used to transfer the video from the attached camera to the YouTube streaming service. Users will be able to watch the video stream from the YouTube service on any device that has a web browser. Several cameras (USB, and Raspberry Pi camera) and video resolutions (from 480p till 1080p) are compared and analysed, to find the best option, taking into account video quality, frame rates, and latency. Energy consumption of the whole system is evaluated and for the chosen solution it is 645mA.

**Keywords:** precision agriculture, video streaming, visual observations.

**ACKNOWLEDGMENT.** Scientific research, publication and presentation are supported by the ERA-Net SusAn Project „Improving pig system performance through a whole system approach (PigSys - 2817ERA08D)” funded by the Latvian State Education Development Agency, subordinated to the Ministry of Education and Science and by the German Federal Ministry of Agriculture and Nutrition, represented by the Federal Agency of Agriculture.

## Biostability of cotton fibers with different natural colors and selection

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**Abstract.** Biodamageability is one of the weak sides of the cotton-plant fiber. Economic loss from the cotton damage caused by microorganisms is significant. Toxic chemical compounds are used to preserve the cotton fiber. This has a negative impact on environment and cotton consumers. The degree of the cotton biodamage depends on selection variety, types of cultivation, storage conditions and other factors. One of the directions in cotton planting is selection of the boll-stained cotton. It was established that naturally colored cotton of different varieties has high biostability. It allows to product hypoallergenic, eco-friendly textile and reduces impact on the environment. The purpose of the work is stability evaluation for microbiological damage of different cotton varieties including those naturally colored during long-term storage in different temperature and humidity conditions. The research lasted for 10 years. The species composition of the cotton microflora was determined, the impact of fiber on microorganisms and dynamics of samples biodamage was studied in the work. The results obtained show preservation of microflora viability on cotton fiber when storing it under normal conditions for a long-term period. With an increase in temperature and humidity necessary for microorganisms' growth, the fiber destruction processes are amplified. It was established that cotton damage degree depend on the regimes and terms of its storage as well as color of the fiber. Nature-colored cotton is more resistant for microorganisms, some varieties inhibit the growth of mold fungi.

**Key words:** biostability, cotton fibers.

**ACKNOWLEDGEMENTS.** The authors Express their deep gratitude to his supervisor Professor Ermilova I. A. for the sharing of knowledge and warm attitude, Professor, Botanical Institute of V. L. Komarov E. V. Lebedeva for your outstanding work on the identification of microorganisms.

## Assessment of soil electrical conductivity using remotely sensed thermal data

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**Abstract.** Detection of heterogeneity (crop, soil, etc.) gained a lot of importance in the field of site-specific farming in recent years and became possible to be measured by different sensors. The thermal spectrum of electromagnetic radiation has a great potential today and experiments focused on describing a relation between canopy temperature and various vegetation characteristics are conducted. This paper was aimed to examine the relation between canopy temperature and electrical conductivity as one of staple soil characteristics. The related experiment was undertaken in Sojovice, Czech Republic, within an agricultural plot where winter wheat was grown in 2017 growing season. The examined plot was composed of three sub plots and 35 control points were selected within this area which the data were related to. A canopy was sensed by UAV (eBee carrying thermoMAP (FLIR TAU2) camera). Soil conductivity data were collected by terrestrial sampling using EM38-MK2 Ground Conductivity Meter in 1 m depth and 2 m sampling point distance. This dataset was later interpolated using the kriging method. The correlation analysis results showed a strong negative correlation between conductivity and thermal data ( $-0.82$ ;  $p < 0.001$ ). When comparing conductivity with NDVI representing the aboveground biomass, there was an opposite trend but also strong result ( $0.86$ ;  $p < 0.001$ ). Correlation coefficient of thermal data and NDVI comparison was  $-0.86$ ; ( $p < 0.001$ ). These preliminary results have a potential for further research in terms of soil characteristics studies.

**Key words:** precision agriculture, winter wheat, heterogeneity, UAV, kriging.

**ACKNOWLEDGEMENTS.** This study was supported by Faculty of Engineering of Czech University of Life Sciences under the internal grant IGA 2017:31160/1312/3118. The section of data acquisition was conducted under financial support from project of Ministry of Industry and Trade TRIO FV10213. The section regarding terrestrial experiments was supported by Ministry of Agriculture of the Czech Republic CRI RO0418.

## Effect of I<sub>2</sub>/KI water solution to wheat seeds imbibition assessed by image analysis

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**Abstract.** Water plays key role in a seed germination due to its participation in starting of many metabolic processes that accompany the seed germination. Rate of water uptake into seeds is a usual basis for determination of the three germination phases. The water uptake into seeds during their germination was investigated by many researchers who used various methods (e.g. magnetic resonance micro-imaging, near-infrared hyperspectral imaging and visualization with I<sub>2</sub>/KI solution (Lugol's iodine)). The method of using I<sub>2</sub>/KI water solution for this purpose is quite popular for its relatively applicability. In this paper we compared the seed surface area projection and shape development of the seeds imbibed in the I<sub>2</sub>/KI solution and in the pure water via image analysis. It was found that the presence of the I<sub>2</sub>/KI in water changes the increase of seeds volume during germination and the effect is different during the initial imbibition and during the next germination phases. The seed shape development is similar for both variants, pure water and I<sub>2</sub>/KI solution.

**Key words:** imbibition, germination, image analysis, water diffusion.

**ACKNOWLEDGEMENTS.** This work was supported by the Internal Grant Agency of the Czech University of Life Sciences Prague, Project No. 31120/1312/3110, (2017)



## The influence of cultivar, weather conditions and nitrogen fertilizer on winter wheat grain yield

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**Abstract.** Winter wheat (*Triticum aestivum* L.) is one of the most productive and significant cereal species in Latvia used for food grain production. The aim of the research was to evaluate winter wheat grain yield depending on nitrogen fertilizer rate, crop-year (meteorological conditions) and cultivar and determine the impact and interaction of research factors on grain yield. Field experiments with winter wheat cultivars ‘Bussard’ and ‘Zentos’ were conducted at the Latvia University of Agriculture, Study and Research farm Peterlauki during a three year period (2009/2010, 2010/2011 and 2011/2012). Nitrogen (N) was applied (N60, N90, N120, N150 kg ha<sup>-1</sup>) in spring after resumption of vegetative growth. Assessment of both winter wheat cultivars showed that crop-year, cultivar, nitrogen fertilizer, crop-year × cultivar had a significant ( $p < 0.05$ ) impact on grain yield. Nitrogen fertilizer did significantly ( $p < 0.05$ ) affect the grain yield of winter wheat, treatment with N90 showed of yield increase, compared to N60, while further use of increasing amounts of N fertilizer did not increase grain yields significantly. Results suggest, that winter wheat grain yield by 34% depended on cultivar, by 33% on crop-year (weather conditions), and by 13% on crop-year × cultivar. Influence of the nitrogen fertilizer effect was small – 3%. Medium strong positive correlation was found between HTC in the vegetation period from winter wheat heading to grain ripening.

**Key words:** grain yield, nitrogen fertilizer, hydrothermic coefficient.

**ACKNOWLEDGEMENTS.** The research was supported by the national research program “Agricultural resources for sustainable production of qualitative and healthy foods in Latvia” (AgroBioRes), project No. 1 “Sustainable use of soil resources and abatement of fertilisation risks (SOIL)”.

## Effect of Nitrogen Fertilization on Winter Wheat Yield and Yield Quality

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**Abstract.** Wheat (*Triticum aestivum* L.) is the most common cereal, which is grown in Latvia. Nowadays, farmers are trying to get high grain yields in line with food quality, at the same time trying to minimize production costs and to use environmentally friendly technologies. The objective of this experiment was to clarify the impact of nitrogen fertilization on winter wheat yield and yield quality under two soil tillage systems and after two forecrops. Trials were conducted at the Research and Study farm 'Peterlauki' of Latvia University of Agriculture (56° 30.658' N and 23° 41.580' E). Researched factors were (1) crop rotation (wheat/wheat and oilseed rape (*Brassica napus* ssp. *oleifera*)/wheat), (2) soil tillage (traditional soil tillage with mould-board ploughing at a depth of 22 – 24 cm and reduced soil tillage with disc harrowing at a depth below 10 cm), (3) nitrogen fertilizer rate (altogether eight rates: N0 or control, N60, N90, N120(90+30), N150(90+60), N180(90+60+30), N210(90+70+50), and N240(120+60+60)), and (4) conditions of the growing seasons 2014/2015, 2015/2016 and 2016/2017. The results indicate that winter wheat yield has been significantly affected by soil tillage, nitrogen fertilizer rate ( $p < 0.001$ ) and forecrop ( $p < 0.05$ ). Three-year research confirmed significant yield increase until the nitrogen fertilizer rate N180. Significantly higher average grain yield was obtained under traditional soil tillage. Nitrogen fertilizer affected significantly all tested yield quality indicators ( $p < 0.001$ ). Increase of nitrogen fertilizer rate secured significant increase of winter wheat grain quality indices, except starch content, after both forecrops and in both soil tillage variants. Values of yield quality indicators increased significantly enhancing N-rate from N150 up to N210

**Key words:** nitrogen fertilization, grain quality, winter wheat, soil tillage.

**ACKNOWLEDGEMENTS.** Research was financed by the project 'Determination of maximal fertilizer norms for crops' which is carried out within the framework of 'State and European Union investment for encouragement in agriculture', but the paper is prepared thanks to funding of the State research program 'Agricultural Resources for Sustainable Production of Qualitative and Healthy Food in Latvia: project No. 1 'Sustainable Use of Soil Resources and Abatement of Fertilisation Risks (SOIL)'

## The indigenous arbuscular mycorrhizal fungal colonisation potential in potato roots is affected by agricultural treatments

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**Abstract.** There is an urgent need to develop novel approaches to enhance sustainable agriculture while not reducing crop yields. Arbuscular mycorrhizal (AM) fungi establish symbiotic associations with most crop plants improving plant performance and soil health. This study investigated the extent of colonisation of potato roots by indigenous AM fungi in the arable soil under conventional and organic farming systems. Potato roots had greater AM fungal colonisation levels under organic than conventional farming, though in general, root colonisation levels were extremely low in both farming systems. Potato root AM fungal colonisation was lower with higher soil P content and higher with higher annual C input. Trap plant root AM fungal colonisation was considerably higher than in field potato roots and showed that soil mycorrhizal inoculum potential was higher in organic than in conventional farming. Thus, the positive impact of manure application in organic fields to the potato AM fungal colonisation can be explained by previous higher total annual C fresh organic matter input and lower soil P content under treatment. Furthermore, the natural AM fungal abundance in the soil was sufficient to colonise trap plant roots, suggesting a low mycorrhizal dependence of the studied potato cultivar.

**Key words:** Cropping systems, Glomeromycota, management practices, *Solanum tuberosum* L.

**ACKNOWLEDGEMENTS.** The study was supported by the Estonian Science Foundation grant No 9432, the European Regional Development Fund (project RESIST 3.2.0701.11–0003), Institutional research funding grants IUT36-2 and IUT20-28 of the Estonian Ministry of Education and Research.

## Comparison of Two Sowing Systems for CTF Using Commercially Available Machinery

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**Abstract.** The crop establishment belongs to crucial technology operations. The quality of sowing is the basis for obtaining efficiency of production. Controlled Traffic Farming (CTF) is a technology which prevents excessive soil compaction and minimizes compacted area to the smallest possible area of permanent traffic lanes (PTL). There were two sowing systems compared, namely row and band sowing when growing winter barley. Sowing parameters as well as all other field operations were identical for both compared systems. Measurements were conducted at an experimental field on non-compacted and traffic lane areas where CTF system was introduced in 2009, with 64% of compacted and 36% of non-compacted soil. Six crop parameters were analysed. Generally, it can be concluded that the band sowing performed better in yield (by 9.3% in non-compacted area; by 3.8 % in traffic lane), ear number (by 5.2 % in non-compacted area; by 10.1% in traffic lane) and grain number (by 6.3% in non-compacted area; by 8.1% in traffic lane) as well as crop height (by 6.6% in non-compacted area; and by 2.4% in traffic lane). The only parameter performing worse was TGW with decrease of 6.6% in non-compacted area and decrease 2.8% in traffic lane for band system. Differences in number of grain per ear were negligible.

**Key words:** band sowing, drill, CTF, soil compaction, cereals.

**ACKNOWLEDGEMENTS.** This article was prepared in the framework of a research project funded by the European Union entitled: 'ITEPAG: Application of information technologies to increase the environmental and economic efficiency of production agro-system' (ITMS no. 26220220014) and 'Building the Research Centre AgroBioTech' (ITMS no. 26220220180). The authors are grateful to staff at the University Farm in Kolinany (Slovakia) for technical and operational support to conduct this research.

The authors are grateful to staff at the University Farm in Kolinany (Slovakia) and company TOKO AGRI in Rudice (Czech Republic) for technical and operational support to conduct this research.

## Influence of soil tillage on oats yield in Central Bohemia Region

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**Abstract.** The paper describes results of the field experiment with two technologies of oats crop stand establishment. First technology is conventional technology and second is no-tillage technology. The article describes an experiment which was conducted in years 2013-2017. The experiments were located in Nesperská Lhota at Central Bohemia region. Altitude of selected field is 460 m. The experimental field is covered by a light cambi-soil. The differences between the two technologies stand establishment are discussed. Statistical evaluation was performed on both methods in the parameter number of tillers per m<sup>2</sup> and yield. Crop yield is the basic indicator of agricultural production and usually affected by quality of soil tillage. One of the parameters affecting the yield is tillage (technology, working tools, depth, turning of soil etc.). Tillage depends mainly on the depth of processing and other quality parameters. An examination of the crop yield is necessary in terms of sensitivity, depending on agro-technical conditions. Among those can be included processing plant soil nutrition and plant protection. It's always necessary commemorate, in these experiments can't be excluded some parameters like locality or meteorological parameter influences. Field trial was conceived as multi-year experiment with minimal changes of agro-technical conditions. During the experiment, the positive effect of conventional technology on crop yields was found. This difference was reflected in the number of tillers and in total yield. The measurement shows the beneficial effect of the loosening of soil on the state of the oat crops. The results of experiment show that, the average yield in 5 years observation was 2.11 t.ha<sup>-1</sup> for no-till technology and 4.22 t.ha<sup>-1</sup> for conventional technology of tillage.

**Key words:** no till technology, conventional technology, yield evaluation.

## Field Bean (*Vicia faba* L.) Yield and Quality Depending on Some Agrotechnical Aspects

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**Abstract.** Despite growing interest about field beans (*Vicia faba* L.), only few researches have been carried out in Baltic countries on the possibility to increase field beans' yield and quality depending on different agrotechnical measures. Field trial was carried out in 2015, 2016 and 2017. Researched factors during all years were: A – variety ('Laura', 'Boxer', 'Isabell'), B – seeding rate (30, 40 and 50 germinate able seeds m<sup>-2</sup>), C – treatment with fungicide (with and without application of fungicide). Beans' yield (t ha<sup>-1</sup>) and yield quality characteristics were detected in the trial. Temperature and moisture conditions were mostly suitable for high yield formation of field beans in all three trial years. In all three trial years, field bean yield has been significantly affected by all factors. The highest yield ( $p = 0.001$ ) was provided by variety 'Boxer' in all years (6.10 – 7.74 t ha<sup>-1</sup>). Thousand seed weight (TSW) was significantly affected by variety and fungicide application. From agronomical point of view, crude protein level was not importantly affected by seeding rate changes or fungicide application. Volume weight was affected significantly by increased seeding rate only in 2016. Fungicide application also did not affect volume weight significantly during the whole trial period. Field bean yield increased by each year, but the main tendencies in all years were the same: higher yield and TSW was provided by variety 'Boxer', but higher protein content and volume weight – by 'Isabell'. Seeding rate increase gave positive impact on yield. Fungicide application affected field bean yield, but did not affect its quality significantly.

**Key words:** field beans, agrotechnology, fungicide application, seeding rate, variety.

**ACKNOWLEDGEMENTS.** Research was carried out by the financial support of RSF "Pēterlauki" of LLU.

## Germination and growth of primary roots of inoculated bean (*Vicia faba*) seeds under different temperatures

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**Abstract.** Temperature stress strongly affects legumes, rhizobia, and the efficiency of legume-rhizobia interaction. An experiment in 2016 was developed to test the seed germination in Petri dishes using different microorganism inoculation under several temperature treatments (4, 8, 12 and 20°C). The goal of this study was to test the effect of rhizobium inoculation under low root zone temperature, and to examine whether the addition of mycorrhiza fungi could enhance rhizobia resistance to abiotic stress and improve faba bean (*Vicia faba*) germination. Four faba bean cultivars were selected for the experiment ('Lielplatone', 'Fuego', 'Bartek' and 'Karmazyn'). Four different seed inoculation variants were included in this experiment – 1) with rhizobium inoculation; 2) with a commercial preparation containing mycorrhiza fungi; 3) inoculation with both rhizobium and the mycorrhiza fungi preparation; 4) control variant. The number of germinated seeds, the length of the primary root and the primary root weight ratio were determined. The effect of inoculation was found out to be dependent not only on the temperature treatment, but it also significantly varied between the bean cultivars. Variants where seeds were inoculated with both mycorrhiza and rhizobia resulted in the highest results (length and weight ratio of primary roots), comparing with other inoculation variants, regardless of temperature. Variants where seeds were treated only with rhizobia mostly showed the lowest results – both length and weight ratio of primary roots, especially under treatment of 4°C. Faba bean inoculation with only rhizobia might not be efficient, when sowing seeds under a low temperature stress. Inoculation with both rhizobia and mycorrhiza fungi could be a potential solution, when the root zone temperature is still below the optimal temperature.

**Key words:** rhizobia, mycorrhiza, abiotic stress, low root zone temperature, legumes, *Vicia faba*.

**ACKNOWLEDGEMENTS.** This project is supported by EU 7th frame EUROLEGUME project (Enhancing of legumes growing in Europe through sustainable cropping for protein supply for food and feed).

## Evaluation of different lighting sources on the growth and chemical composition of lettuce

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**Abstract.** Experiment were carried out in Latvia University of Agriculture in plant growth room. Lettuce *Lactuca sativa* L. var *foliosum* cv. 'Dubacek' and *L. sativa* L. cv. 'Michalina' were grown under 4 types of lights (luminescence lamps, commercial light emitting diodes (LED) lamps (V-TAC premium series – for plant growing) and two different Lumigrow LED strips - dominant wavelength- blue or red with 14 h photoperiod and total photosynthetic active radiation (PAR)  $100 \mu\text{mol m}^{-2} \text{s}^{-1}$  in all variants. Plant weight, length, amount of leaves were measured. Content of chlorophylls, carotenoids, phenols, flavonoids in lettuce was determined three times per vegetation period. In experiments were found that higher lettuce yield was under commercial LED (V-TAC premium series), but these plants contain less soluble sugars, pigments and phenols. Better plant quality was obtained with luminescence lamps. These lettuces have higher sugar, phenols and flavonoids content. Lettuce growth under blue dominate LED (LEDb) was delayed, but these plants contain higher chlorophylls content. The differences in plant growth, response to light and biochemical content between cultivars were detected.

**Key words:** LED lamps, *Lactuca sativa*, pigments, phenols, flavonoids.

**ACKNOWLEDGEMENTS.** Study was supported by European Regional Development Fund project "New control methods for energy and ecological efficiency increase of greenhouse plant lighting systems (uMOL)", Grant Agreement Nr. 1.1.1.1/16/A/261.



## Soil sampling automation using mobile robotic platform

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**Abstract.** Land based drone technology has considerable potential for usage in different areas of agriculture. Here a novel robotic soil sampling device is being introduced. Unmanned mobile technology implementation for soil sampling automation is significantly increasing the efficiency of the process. This automated and remotely controlled technology is enabling more frequent sample collection than traditional human operated manual methods. In this publication universal mobile robotic platform is adapted and modified to collect and store soil samples from fields and measure soil parameters simultaneously. The platform navigates and operates autonomously with dedicated software and remote server connection. Mechanical design of the soil sampling device and control software is introduced and discussed.

**Key words:** soil sampling, unmanned ground vehicle, autonomous navigation.

**ACKNOWLEDGEMENTS.** This research was supported by funding of PRIA, project no. L160160TIPT “Autonoomse mullaproovide kogumise seadme väljatöötamine”.

## **VII PRODUCTION ENGINEERING**

## Testing of ISM band at remotes for unlocking vehicles

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**Abstract.** Every modern car has a remote control for wireless unlocking. Wireless drivers for unlocking the vehicle using frequency in the ISM bands. ISM bands are unlicensed bands. They are usually used for industrial, medical and scientific purposes. The question is whether wireless transmission parameters are sufficient and do not violate defined range of ISM band. Another important aspect is the security of the wireless transmissions and any other signal interference. The problem of interference plays an important role in ensuring the quality and safety of wireless communications, especially when wireless networks can be found everywhere. The issues of remote control vehicles is very important due to the resulting security of a guarded vehicle. One of the major risks that may occur are data transmission that the signal is blocked by another signal and the end user does not notice. In this case, does not lock the vehicle nor ensuring its securing security system. Tests which were performed accurately determined the bandwidth of broadcast remote control for each vehicle. Vehicles for which the tests were conducted are standard vehicles used to frequent occurrence. These are the following types: Alfa Romeo, Hyundai, Mercedes, Škoda and Toyota. Subsequently, the analysis was performed of transmission compared with standard broadcast of jammers. All test drivers worked in the band ISM433. These tests clearly demonstrated that not every manufacturer strictly observes ranges of ISM band. This may affect traffic on surrounding licensed bands.

**Key words:** Remotes, vehicle, wireless transmission, interference, measuring.

**ACKNOWLEDGEMENTS.** It is a project supported by the CULS IGA TF “The University Internal Grant Agency” (Analysis of the risks associated with the transmission of large data and data from sensor networks through wireless transmission in ISM bands).

## Influence of face lighting on the reliability of biometric facial readers

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**Abstract.** At present, there is an increasing need to protect workplace entry and specially guarded premises. In addition to standard access systems on a chip cards are getting to the fore of biometric identification systems such as readers for fingerprint, biometric scans faces and others. Biometric readers face still improve, but still have a lot of blind spots, thanks to which their reliability and user-friendliness decreases. One such problem is the light intensity in the room where the reading device is located. The varying intensity of the light in the room causes a different illumination of the person's face. It emphasizes or suppresses the main points of the face that needed for user authorization, and the whole identification process is prolonged and difficult. The reliability value is significantly different from the value given by the manufacturers. It is very important to highlight on this problem and begin to address it by altering the current production engineering.

**Key words:** light intensity, measuring, False Acceptance Rate, identification, facial features.

**ACKNOWLEDGEMENTS.** It is a project supported by the CULS IGA TF 2015 “*The Study of Alternative Energy Resource Utilisation Under Rural Conditions*” CZU 2017:31150/1312/3122.

## Mechanical behaviour of Sugar palm (*Arenga pinnata*) fibres

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**Abstract.** The tensile strength of Sugar palm (*Arenga pinnata*) fibres was examined. Fibre samples were prepared and tested up to the point of rupture with a deformation rate of 0.05 min<sup>-1</sup>. The tensile device (Labortech, MPTest 5.050, Czech Republic) were used to determine the tensile force. The aim of the paper was to describe a mechanical behaviour of Sugar palm (*Arenga pinnata*) fibres. Measured values can be used as a basis for further research on the application of Sugar palm fibres.

**Key words:** tensile force, agriculture material, deformation energy.

**ACKNOWLEDGEMENT.** This paper has been supported by Internal Grant Agency of Faculty of Engineering – Czech University of Life Sciences Prague – IGA 2018: Impact of technical and economic parameters of agricultural product drying in Indonesia with regard to quality of production and economic impact on local market.

## Conceptual ‘Cradle to Gate’ Analysis of GHG Emissions from Wood, Agricultural Plant and Synthetic Fibres

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**Abstract.** Industrialization and fossil resource use has brought unprecedented anthropogenic carbon dioxide emissions. Use of synthetic fibre materials and unsustainable plant cultivation practices contribute to greenhouse gas emissions. The global market share of polyester fibre (synthetic fibre made from fossil resources) exceeded the share of cotton fibre (natural fibre) for the first time in 2000 and since then polyester has remained the most popular fibre. The demand for textiles keeps increasing. In Northern Europe locally made fibres from wood, hemp and flax could substitute fossil based fibres decreasing the global GHG emissions and helping local economies to prosper. Multi-criteria analysis method TOPSIS was used to carry out a conceptual research evaluating GHG emissions from wood, agricultural plant and synthetic fibre acquisition under two scenarios: fossil fuels are used as energy sources & industrial fertilizers are used; and renewable energy sources are used & industrial fertilizers are not used. Results show that wood and plant fibres have smaller GHG emissions than synthetic fibres in both scenarios. Factors affecting emission performance are analysed.

**Key words:** fibre, wood fibre, hemp fibre, flax fibre, synthetic fibre, carbon dioxide, multi-criteria analysis, TOPSIS.

**ACKNOWLEDGEMENTS.** The work has been supported by the National Research Program “Energy efficient and low-carbon solutions for a secure, sustainable and climate variability reducing energy supply (LATENERGI)”.

## Quality assessment of laser clad HSS coatings with deep penetration into base material to obtain a smooth gradient of properties in coating-substrate interface

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**Abstract.** The present research is dedicated to the study of influence of coaxial laser cladding (CLC) process parameters onto values of alloying components content in the coatings, morphology as well as the influence of post-cladding heat treatment on the quality and mechanical properties of coatings. The research is based on a hypothesis that applying of first layer of coatings onto steel substrate with keyhole in penetration allows achieving smooth gradient of properties of the coating-substrate system. As a result it may provide a smooth distribution of the internal residual stresses in interface as well as the better resistance to external stress during cyclic load in tool operation processes: metal forming, stamping etc. Experimental work was carried out using CLC system, which consists of industrial robot Kuka and 1kW IPG Yb-fiber laser, integrated to the coaxial powder supplying cladding head. The regularities of formation of High Speed Steel AISI M2 cladding coatings created by different regimes were studied by deposition onto EN 41Cr4 and C80U steel substrates. The quality of achieved coatings has been evaluated by examination of morphology of transverse cross-sections, coatings geometrical features, elemental composition and microhardness distribution inside coatings. Additionally detailed assessment of coating thickness and content of alloying elements using statistical methods has been performed. As a result of the research done the degree of influence of chosen CLC process parameters onto quality characteristics were estimated. The most appropriate cladding regime for used method was proposed.

**Key words:** coaxial laser cladding, HSS coating, keyhole in penetration, quality.

## Tools for building production and woodworking made from the perforated steel wastes

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**Abstract.** The rising of efficiency of the building and construction production is an actual task. One of the possible ways to ensure higher efficiency is using innovative tools and facilities of small-scale mechanization, which increase productivity and enhance working condition. Most observable influence of such strategy is on concrete works, plastering and earthworks. Another important tendency in production engineering, building and construction production is recycling of the technological wastes, which sufficiently reduce cost of the products and improve ecology. The goal of the present paper is to offer new possibility for recycling of the technological wastes, i.e. perforated steel tapes achieved after stamping of fine parts, by producing from mentioned perforated tapes the building tools and facilities of small-scale mechanization. In particular the technological wastes of the JSC "Ditton" (Daugavpils, Latvia) – perforated steel tapes – received after stamping of the elements of supply chains for different apparatus was used in this research. The prototypes of the scrapers for the finishing building work, as well as cutting edges and circular coronas for the woodworking were elaborated and offered in this work. The influence of the material, geometrical characteristics of the tape, shape of the perforated holes and other factors on the functional properties of the proposed tools was investigated and represented in paper. The results of approbation of elaborated prototypes of the tools are offered. It was proven, that proposed innovative tools could be used effectively in building production and woodworking.



## Extraction of oil from rapeseed using duo screw press

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**Abstract.** This study was focused on the analysis of optimize the pressing process of rapeseeds (*Brassica napus L.*) using screw press. For pressing of oil a screw press Farmer 20 – duo (Farmer 20, Farnet a.s., Ceska Skalice, Czech republic) was used. The screw rotation speed 10, 20, 30, 40, 55 and 65 rpm was used. Oil recovery efficiency and specific mechanical energy were decreased when the seed material troughput was increased. It has been found that the optimal operation point for screw press Farmer 20 - duo was at 20 kg/h rapeseed throughput. The specific mechanical energy at the optimal operation point was 0.61 kWh/kg<sub>oil</sub>. Maximum oil recovery efficiency 82.6 % was found at the lowest screw speed.

**Key words:** Farmer 20, oil recovery efficiency, pressing energy.

**ACKNOWLEDGEMENT.** This paper has been supported by Internal Grant Agency of Faculty of Engineering – Czech University of Life Sciences Prague – IGA 2018: Impact of technical and economic parameters of agricultural product drying in Indonesia with regard to quality of production and economic impact on local market

## Evaluation of reed biomass use for manufacturing products, taking into account environmental protection requirements

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**Abstract.** In many countries reed is considered as invasive or unnecessary plant, because it is spreading rapidly, causing decrease in biodiversity and creating unacceptable living conditions for many bird species in their natural habitats. Due to environmental considerations it is necessary to cut reed, to decrease their over exceeding growth. Reed burning or leaving for decomposition on fields, that has been practiced until now, creates additional carbon dioxide air pollution. Therefore, the question on what to do with cut reed has become vital from environmental protection perspective. In addition, this question applies to bioeconomy principles in compliance with their use in national economy, which makes it clear, that solutions for the use of reed biomass for production have to be found. But any production process can leave a negative effect on surrounding environment. Further to product production, economic motivation, possible market and availability of resources are primarily essential to see whether it is worth to produce the product at all. Therefore, reed biomass use possibilities in production have to be analysed as a complex question, taking into account environmental and climate, economic and technological aspects. In this study, solutions to perspective reed biomass use are evaluated, considering environmental protection requirements. For this task, multi-criteria analysis method TOPSIS is used, which includes 11 environmental and climate, economic and technological criteria. Evaluation includes both – already existing and new products that are divided in 3 sectors: power industry, construction and other products. Results of the research clearly state, which of reed biomass made products are perspective, taking into account not only traditional economic and technological aspects, but also environmental and climate aspects.

**Key words:** reed, multi-criteria analysis, TOPSIS, bioeconomy.

**ACKNOWLEDGEMENTS.** The work has been supported by the Latvian Fund for Nature research “Innovative technological solutions for the use of reed biomass and evaluation of their effectiveness”.

## Sapropel processing approaches towards high added-value products

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**Abstract.** Sapropel is an organic sediment from fresh water bodies that is widely distributed in the northern regions of the world. The distribution and unique properties of sapropel make it an important natural resource that can be used in agriculture, horticulture, forestry and farming directly as obtained. The aim of this study was to investigate the extraction possibilities of sapropel and potential applications of its extracts. Humic substances constitute an important ingredient of sapropel, and they can be extracted by mild alkaline extraction. Humic substances from peaty sapropel have significant differences in composition and properties, thus demonstrating the impact of precursor biological materials on the properties of humic substances formed in the humification process.

**Key words:** sapropel, extraction, agriculture, humic substances, biological activity.

**ACKNOWLEDGEMENTS.** The research "Sapropel processing approaches toward high added-value products" was conducted within the framework of an effective collaboration project between the University of Latvia and LUMINOUS Ltd.

## Effect of rubber powder from waste tyre rubbers on mechanical properties of one-component polyurethane putty

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**Abstract.** The utilization of adhesives in technical practice is varied. Adhesives serve for a creation of strength bonds on the one hand, and on the other hand e.g. for cementing. The aim of the research is a modification of one-component polyurethane putty RPS 45 used in automotive industry to increase strength properties in an adhesive bond. An interaction between a filler in the form of rubber powder micro-particles and one-component polyurethane adhesive was investigated by means of SEM analysis. Sealing is a primary property of this putty. Sealing putties usually reach very small strength which can be increased by an admixture of the filler. In order to keep elastic properties, micro-particles of the rubber powder gained from tyre recycling process were used as the filler. An aspect of a loading speed of the adhesive bond is essential at the practical application at which the adhesive bond can be failed in adhesive or cohesive layers. The adhesive bond can be perceived in terms of its function as a complex of three layers, i.e. an adhesive bonded material, the interaction between the adhesive and the adhesive bonded material and the adhesive layer itself. There are often states in the practices when the adhesive bonds are exposed to the loading which can be either a static or a dynamic one. That is why the research is focused not only on the evaluation of the influence of the modification of the one-component polyurethane adhesive, but also on the influence of the loading speed of the adhesive bond. Tested speeds set on a universal testing machine Zwick/Roell Z150 were 2, 50 and 100 mm.min<sup>-1</sup>. The results of mechanical tests proved a positive influence of the filler on the strength  $\sigma_m$  higher by  $42.68 \pm 6.96\%$  and the elongation at break  $\varepsilon_b$  higher by  $12.2 \pm 20.95\%$ . On the contrary, the stress at yield  $\sigma_y$  was decreased.

**Key words:** Loading speed, particle filler, strength, stress at yield, elongation, SEM, recycling.

**ACKNOWLEDGEMENT.** Supported by Internal grant agency of Faculty of Engineering, Czech University of Life Sciences in Prague (no. 31140/1312/313115).

## Lake blue clay - sapropel - flax shive briquettes for water absorption and desorption

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**Abstract.** Latvian lakes are rich in sapropel sediments and below the sapropel layer there is another valuable natural resource, namely blue clay. Flax shives are formed in large quantities as a waste in flax processing factories. The problem involves processing and rational use of these resources. The paper studies the obtaining of briquettes from flax shives using sapropel and lake clay as a binding material. Briquettes are intended for use in cases when problems with regular plant watering occur. For example, provision of plants with water in greenhouses, indoor spaces for a long period of time without human presence. Briquettes are placed into the soil next to the plant roots. Briquettes are initially moistened and absorb a significant amount of water (moisture content to be expressed in comparison to the sample's dry weight 250-380%). The presence of clay in them contributes to slow drying of briquettes and provides a long lasting supply of moisture to the plant roots. The paper deals with the issues of the optimal composition of components and the amount of pressure for the production of briquettes, as well as water absorption and desorption properties of briquettes. The aim of the study is to develop a production method of clay - sapropel - flax shive briquettes with good water absorption and desorption properties.

**Key words:** clay, sapropel, flax shives, briquettes.

**ACKNOWLEDGEMENTS.** European Regional Development Fund Postdoctoral research aid Nr.1.1.1.2/16/I/001 research application "Identification of blue clay in lakes of Latgale region and possibilities of its application, Nr.1.1.1.2/VIAA/1/16/131".



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IEGULDĪJUMS TAVĀ NĀKOTNĒ

## Production and Characterization Of Al-BN Composite Materials Using By Powder Metallurgy

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**Abstract.** Aluminum matrix composites containing 3,6,9,12 and15%BN has been fabricated by conventional microwave sintering at 550°C temperature. Compounds formation between Al and BN powders is observed after sintering under Ar shroud. XRD, SEM (Scanning Electron Microscope), mechanical testing and measurements were employed to characterize the properties of Al + BN composite. Experimental results suggest that the best properties as hardness 42,62 HV were obtained for Al+12% BN composite..

**Key words:** Powder metallurgy, Sintering, Ceramic-Metal Composites.

**ACKNOWLEDGEMENTS.** This research was supported by the University of Afyon Kocatepe project no: 17.KARIYER.158 We would like to extend our gratitude to the Scientific Research Coordination Unit.

## **VIII RENEWABLE ENERGY, AUTOMATION TECHNOLOGY & POWER ENGINEERING**

## Assessment of *Calotropis* natural dye extracts on the efficiency of dye-sensitized solar cells

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**Abstract.** This work presents the construction and testing of solar cells sensitized with natural dyes extracted from plants indigenous to the desert. *Calotropis* plants are self-sufficient as they grow in very harsh environments, and yet are not consumed by humans or livestock due to their irritating agents to the skin and eyes. The energy generators of these plants are the leaves, which are crushed and processed to produce the dye solution. Also, the *Calotropis* leaves are covered in a white powder that is thought to aid in mitigating the heat by scattering incident radiation. This powder material is examined and added to the dye as it proved advantageous for the overall cell efficiency, which reached 0.214% compared with 0.108% for cells with no powder. The produced cells are also compared with ones sensitized by spinach, another common natural sensitizer for dye-sensitized solar cells, and the performance proved to be significantly better. The fact that *Calotropis* is a non-food plant is an added advantage to utilizing it as a dye source, along with its intrinsic heat resistance that allows it to survive the harsh desert conditions all year round.

**Key words:** *Calotropis*; dye-sensitized solar cells; natural dyes.



## Crop weight measurement sensor for IoT based industrial greenhouse systems

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**Abstract.** Nowadays the industrial management systems are changing by means of implementing various Internet of Things (IoT) technologies, allowing a simple integration of sensor technologies with wireless communications and development of cloud based database solutions. The industrial greenhouse management systems are not the exception in this regard, as they are becoming more and more popular with the use of various sensors for the automation of the vegetable and other crop cultivation process. The general aim they have is to raise the level of process automation, quality, energy efficiency and other important parameters. The implemented technologies and environment of industrial greenhouse can be different for the research type laboratories, as they are focused on production, therefore this research is conducted in cooperation with tomato producing industrial greenhouse of SIA “Latgales darzenu logistika” focusing on IoT based crop weight measurement.

**Key words:** Crop, Weight measurement, IoT, Greenhouse systems.

**ACKNOWLEDGEMENTS.** Publication is created with support of European Regional Development Fund project “New control methods for energy and ecological efficiency increase of greenhouse plant lighting systems (uMOL)”, Grant Agreement Nr. 1.1.1.1/16/A/261.

## Development and testing results of IoT based air temperature and humidity measurement system for industrial greenhouse

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**Abstract.** Industrial greenhouse control systems are changing and getting new capabilities, due to the evolution of the Internet of Things (IoT) technologies, allowing wirelessly integrate various sensor technologies and create a cloud-based database and analytic solutions. Greenhouse systems typically are controlled by consuming single temperature and humidity measurement unit data (treated as an average value), this raises a question about the precision of such approach for application in a large industrial greenhouse. In this article IoT based temperature and humidity measurement system uMOL architecture is described and first measurement results of multi-point data collection with high resolution compared to existing single-point measurements.

**Key words:** Temperature, humidity, wireless data, IoT, Greenhouse automation systems.

**ACKNOWLEDGEMENTS.** Publication is created with support of European Regional Development Fund project “New control methods for energy and ecological efficiency increase of greenhouse plant lighting systems (uMOL)”, Grant Agreement Nr. 1.1.1.1/16/A/261.

## A case study of collection systems efficiency comparison for paper and biodegradable municipal solid waste

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**Abstract.** The need to increase municipal solid waste recycling rates has led to the study and analysis of recycling schemes from perspectives of technical issues. This paper compares two waste collection systems operating in Vysočina region in the Czech Republic: a paper (including cardboard) municipal solid waste collection system and biodegradable municipal solid waste collection system. The both collection systems were introduced on the entire site of one selected urban area at different times. The emphasis is put on evaluation of individual separate collections development from 2014 to 2016. Analysis of the technological operation and performance of collections are observed and evaluated by measuring a range of waste collection system indicators. Especially the efficiency of separate collections of both types of municipal solid waste is compared to their relative representation in rest of municipal solid waste, which is produced at the side of surveyed area. The changes in representation of these types of waste in rest of municipal solid waste show, which collection systems are more successful from the perspective of implementation of the directive on landfill. The results also describe why systems could be more successful in view of well-chosen or inappropriately selected technological parameters of material separation. A possible statistically significant impact of paper waste production on relative amount of the paper part in rest municipal solid waste has been shown too.

**Keywords:** municipal solid waste, rest municipal solid waste, biodegradable municipal solid waste, biodegradable municipal solid waste collection, paper and cardboard waste collection, material compositions.

**ACKNOWLEDGEMENTS.** The work has been supported by the Internal Grant Agency of Czech University of Life Sciences Prague, Project: Analysis of efficiency of sorting usable components of municipal solid waste in municipalities of the Czech Republic.

## Stabilization of persistent organic pollutants (POP) in flue gases in a biological waste incinerating facility

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**Abstract.** The article focuses on a technology of flue gases stabilization in biological and hospital waste incinerating facility. Hazardous particles and compounds formed in flue gas during the process of thermal waste degradation need to be stabilized according to an enacted legislation. The aim of the research is to examine technological process of polychlorinated dibenzodioxins and polychlorinated dibenzofurans (PCDD/F) elimination in flue gas. PCDD/F is group of persistent organic pollutants which are resistant to environmental degradation and are highly toxic for the environment in very small amounts. Experiments were performed in semi operation hospital waste incinerating plant with heating power 1.5 MW and capacity 250 kg. h<sup>-1</sup> of incinerating material. It was observed that formation of PCDD/F exponentially grows with increasing concentration of chlorides in the flue gas, but formation varies based on type of congener. The highest concentration was measured for HxDF, 17,522 pg.Nm<sup>-3</sup> and HpDF, 16,334 pg.Nm<sup>-3</sup> at chloride concentration of 867 mg.Nm<sup>-3</sup>. However, concentration of PCDD congeners didn't exceeded 4,000 pg.Nm<sup>-3</sup> for the same level of chlorides in flue gas. Two types of activated carbon Chezacarb and NORIT were tested for capability to stabilize PCDD/F in flue gas. Results show that refining effect for both sorbent are very similar. It was observed that 0.1 g of activated carbon should be applied per 1 Nm<sup>3</sup> of flue gas in regard to reduce 3-4 ng.Nm<sup>-3</sup> PCDD/F under required emission limit.

**Key words:** PCDD, PCDF, hospital waste, activated carbon.

**ACKNOWLEDGEMENTS.** The article was financially supported by the Internal Grant Agency of the Czech University of Life Sciences Prague, Czech Republic, Grant No. 20173002.

## **Increasing solar energy usage for dwelling heating, using solar collectors and medium sized vacuum insulated storage tank.**

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**Abstract.** This article describes a method for increasing the solar heat energy share in the heating of a dwelling. Solar irradiation is high in summer, in early autumn and in spring, but in the same time the heat demand of dwellings is low. The article describes a solution for storing solar heat energy in summertime and calculations of the heat energy balance of such a storage system. The solar heat energy is stored in a thermally insulated water tank and used in the heating period. Heat is also stored into the ground if necessary, using the ground loop of the heat pump, if the water tank's temperature rises above a certain threshold. The stored heat energy is used directly for heating if the heat carrier temperature inside the tank is sufficient. If the temperature is too low for direct heating, then the heat pump can use to extract the stored energy. The calculations are based on the solar irradiation measurements and heating demand data of a sample dwelling. The seasonal storing of solar heat energy can increase solar heat energy usage and decrease heat pump working time.

**Key words:** Long-term storage tank, solar heat energy, solar collector, single family house.

**ACKNOWLEDGEMENTS.** This research was supported by the Estonian Centre of Excellence in Zero Energy and Resource Efficient Smart Buildings and Districts, ZEBE, grant 2014-2020.4.01.15-0016 funded by the European Regional Development Fund.

## Improving energy efficiency of biotechnical agricultural systems – scientific and organisational issues

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**Abstract.** The production process of an agricultural and industrial complex (AIC) includes processing of big areas of fertile soil that receive sun-generated electromagnetic energy. This is one of the peculiarities of the AIC, determined by the fact that the AIC produces primary (plant-based) food. The plants use part of the sun-generated energy to synthesise biological energy, which forms the nutrition value of the product and which is measured by a rational (relative) factor per unit of area. A plant community is a biological system where each plant is a biological element. The amount of fuel energy (which is anthropogenic unlike sun-generated energy) consumed by an AIC company to produce plant-based food is determined by the energy efficiency of the technical elements (fuel cells, both mobile and immobile) included in the consumer energy system (CES). Crops also supply food for livestock farming, which is the second biological branch of AIC and produces the second type of food, meat and poultry. Animals and poultry are raised using daily feed flow as the source of energy. As the energy consumption and the energy efficiency (expenses and return on investment, respectively) are determined by the technical part of the consumer energy system, it is necessary to find the dependence between the CES and biological systems (crop farming and animal farming) in the food production process.

**Key words:** energy saving, power consumption of production, criteria of energy efficiency, consumer power system.

## Thermal properties of historic rural building materials in Czechia

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**Abstract.** Due to the different natural conditions, various local natural building materials were used for the construction of rural residential and farm buildings in various locations in the Czech Republic. Currently, it is often a requirement for the modernization of relatively old buildings. The buildings were built with different technologies. Very often only locally available material was used. In many cases, the properties of old materials are not available in the literature. However, it is necessary to know the thermal properties of building materials for the preparation of a reconstruction design. Thermal properties of materials are the basis for determination of heat losses of buildings useful for design of heating systems. The aim of this paper is to compare the research results focused on the thermal conductivity of different old construction materials (stones and rocks) and to show examples of preserved historical agricultural buildings. The results presented in this paper are based on the measurements by the portable instrument Isomet 2104. Authors recognised significant differences between tested materials. The mean values of thermal conductivity  $\lambda_m$  of tested materials: gaize  $1.49 \text{ W m}^{-1} \text{ K}^{-1}$ , artificial marble  $1.80 \text{ W m}^{-1} \text{ K}^{-1}$ , gneiss  $2.36 \text{ W m}^{-1} \text{ K}^{-1}$ , proterozoic shale  $2.68 \text{ W m}^{-1} \text{ K}^{-1}$ , granite  $3.66 \text{ W m}^{-1} \text{ K}^{-1}$  and quartz sandstone  $6.15 \text{ W m}^{-1} \text{ K}^{-1}$ . Differences between thermal conductivity values of stones and rocks should be respected in calculation of heat balance of new or reconstructed buildings to avoid the problems of the formation of thermal bridges.

**Key words:** dynamic method, measurement, rocks, stones, thermal conductivity.

## Energy potential of densified biomass from maize straw in form of pellets and briquettes

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**Abstract.** The aim of the study was the evaluation and comparison of energy potential of briquettes and pellets produced from the maize straw and woody biomass based on various diameters of pellets. By experimental measurements a calorific value and ash content was observed. Calorific value was measured by laboratory calorimeter IKA C 6000 (IKA® Works, Inc., USA) and laboratory combustion chamber Lindberg/Blue M (Thermo Fisher Scientific, Inc., USA). Individual calorific values and ash content was observed and subsequently confronted to obtain differences with replication. The analysis showed that calorific value of pellets with diameter 6 mm ranged from 16.99 MJ kg<sup>-1</sup> to 17.80 MJ kg<sup>-1</sup>. Calorific value of pellets with 8 mm diameter ranged from 16.63 MJ kg<sup>-1</sup> to 17.20 MJ kg<sup>-1</sup>. However, compared calorific value of briquettes ranged from 14.99 MJ kg<sup>-1</sup> to 15.66 MJ kg<sup>-1</sup>. Further analysis showed that ash content of samples varied as well and it's even affected by diameter of pellets. While ash content of pellets with diameter 6 mm was observed as 4.9% of total volume in case of pellets with 8 mm it was observed at value 5.5%. Briquettes produced from maize straw have ash content at value 5.4%. In contrary, ash content of woody biomass was significantly higher, 11% of volume, specifically. At the basis of observed parameters it can be concluded that maize straw densified in form of briquettes and pellets have a great energy potential which is comparable and competitive with currently used materials for production of briquettes and pellets.

**Key words:** biomass, maize straw, briquettes, pellets, calorific value, ash content.

**ACKNOWLEDGEMENTS.** This work was supported by AgroBioTech Research Centre built in accordance with the project Building 'AgroBioTech' Research Centre ITMS 26220220180; and by the Ministry of Education of the Slovak Republic, Project VEGA 1/0155/18.



## **Influence of the road profile in different geographical areas of the Czech republic to the operational parameters of the electric vehicle**

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**Abstract.** The aim of this paper is to compare the operating parameters of the full-electric vehicle VW e-up! operated in two significantly different geographic areas of the Czech Republic. The first tested area was the lowland area in the vicinity of municipality Mělník; the second area was a hilly area near the municipality of Ústí nad Labem with frequent and very sharp altitude changes. During measurement, the operating parameters of the battery (voltage, level) and electric motor (instantaneous voltage and current) were recorded. The results show a surprisingly small difference in vehicle tank range in both compared regions because the recuperation in the hilly area was used very often. It is possible to conclude that these electric vehicles can be used for everyday commuting under conditions of different geographical areas.

**Key words:** recuperation, real-world driving, altitude, vehicle range.

**ACKNOWLEDGEMENTS.** Paper was created with the grant support of CULS 2015:31150/1312/3108 - The energy efficiency evaluation of the passenger road transport.

## Comparison of Predicted and Real Parameters of PV systems in the Czech Republic and Spain

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**Abstract.** This paper compares predicted performance by a simulation software for a given new constructed PV system of crystalline silicon technology located in Prague with 10 kWp peak power and a similar system in Spain. Simulation software used for the sake of this paper was publicly available PVGIS from the website of its creators, parameters were set to be the same like in the real PV system. The difference between the predicted and the real data was calculated and then discussed in the result section of this paper. Suggestion how to increase the accuracy of the prediction by the simulation software is in the discussion part of this paper.

**Key words:** PV systems, PVGIS, PV simulation, predicted and real data comparison.

**ACKNOWLEDGEMENTS.** I would like to thank to my supervisor in Prague prof. Martin Libra and my Spanish supervisor prof. Bernabé Soucase who was my mentor during my stay in Spain on the Polytechnical University of Valencia in the academic year of 2016/17 as a part of Erasmus+ program.

## Battery capacity drop during operation

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**Abstract.** A lithium-iron-phosphate (LiFePO<sub>4</sub>) battery is nowadays considered one of the best types of batteries. The paper deals with the evaluation of the drop in their capacity during operation. Based on the physical analysis of charging and discharging processes, a mathematical model of the battery capacity has been developed during its lifetime. The decrease in capacity during battery operation is evaluated according to the loss of active material, which gradually diminishes due to a number of different processes. The analysis of the loss of the active material is carried out, in particular, according to the depth of discharge, battery temperature, charging and discharging time, including the time when the battery is out of service. The tests were performed on the Winston Battery, Calb, Thunder Sky and Sinopoly batteries by cyclic discharging and charging at the 50%, 90% or 100% depth of discharge. Their real parameters were determined, compared to the model parameters and the parameters specified by the manufacturers and suppliers. Two automated systems were used for testing. During the test, in the tested battery with several cells, charging and discharging by a constant current were carried out automatically. Operating parameters of the tested battery were continuously scanned, recorded and evaluated by the control computer. The capacity curves during the battery operation, determined by the type of models, were compared with the results of long-term real battery tests.

**Key words:** LiFePO<sub>4</sub> battery, lifespan, capacity drop, depth of discharge.

**ACKNOWLEDGEMENTS.** Thanks for cooperation belong to Laboratory of Photovoltaic Systems Diagnostics, Faculty of Electrical Engineering, Czech Technical University in Prague and Department of Electrical Engineering and Automation, Faculty of Engineering, Czech University of Life Sciences in Prague.

## Determination of conversion relations for the use of pumps in reverse turbine operation

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**Abstract.** In small-scale hydropower, hydrodynamic pumps used in reverse mode are an important economical alternative to conventional water turbines. Efficient utilisation of these devices however requires taking into account all the specifics of the reverse pump operation and optimise the pump design for maximum utilisation of the hydro-technical potential of the deployment site. The article compares existing conversion models, describes initial theoretical assumptions and determines new conversion relations for the design of pumps as turbines (PAT) for the lowest power and specific speed category. The validity of the conversion relations is experimentally verified on a hydraulic test circuit with a radial centrifugal pump tested in both pump and turbine operation modes. The results of the verification of the new conversion relations proved better correspondence to reality within this category of machines than that reported by the previously used conversion models.

**Key words:** pump as turbine (PAT), conversion relations, specific speed, head, flowrate.

**ACKNOWLEDGEMENTS.** This research was supported by project: Activity Proof-of-Concept (No. 99130/1415/4101), Technology Agency of Czech Republic.

## Application of conversion model for designing hydrodynamic pumps in turbine mode

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**Abstract.** The use of the smallest water resources has been coming again to the centre of interest in recent years. A water engine – turbine, is the heart of these power plants. This is usually the highest expense for the investor, in terms of cost. The effort is therefore to seek investment less demanding alternatives. One of them is the use of hydrodynamic pumps in reverse turbine operation. This paper provides a methodology for conversion of parameters of the smallest power pumps (micro hydro sites) to turbine operation. The conversion model is based on the results of experimental research at the author's workplace and is suitable for pumps with low specific speeds and outputs. The pump design process for turbine mode is complemented by a practical example for a specific deployment site. This example also serves to verify the accuracy of the conversion model.

**Key words:** pump as turbine (PAT), conversion model, specific speed, efficiency.

**ACKNOWLEDGEMENTS.** This research was supported by project: Activity Proof-of-Concept (No. 99130/1415/4101), Technology Agency of Czech Republic.

## Factors influencing use of fuelwood and its environmental impacts in Tapanuli Utara regency, North Sumatra

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**Abstract.** Deforestation and forest degradation, after burning of fossil fuels, is considered as the second leading cause of anthropogenic greenhouse emissions (accounting for over 17% of global carbon dioxide emissions) and has become an important issue concerning climate change mitigation. The provision of wood energy is generally thought to be a major contributor to forest loss. In Indonesia, more than half of the rainforest there, the third-largest swath in the world, has been felled in just a few years. Furthermore, permission has been granted to convert the majority of what remains into palm or acacia plantations. The logging and burning of forests to clear land for cultivation has made Indonesia one of the largest emitters of greenhouse gases. Therefore, the objective of this study was to assess the current level and influencing factors of the use of fuelwood among the rural population as well as the consequent environmental impacts in the target area in North Sumatra. The questionnaire survey using randomly selected households (n = 196) was administered in Tapanuli Utara regency from July to August 2014; followed by several field visits from August to September 2016. Obtained data were analysed with descriptive statistics and cross tabulation. The results indicate that fuelwood is a significant source of energy in the target area. For 31% of respondents it is the major energy source and for 64% it is a supplementary source. The high rate of use of wood as fuel corresponds to the poor financial situation of respondents and the easy accessibility of wood, but only from the surrounding area (own garden or adjacent land). Wood resources are often very distant (on average over 1,000 metres) as a consequence of high deforestation. This study reveals that there is a non-sustainable trend of forest conversion resulting in high land degradation in Tapanuli Utara regency.

**Key words:** rural household; energy sources; Indonesia; Developing countries.

**ACKNOWLEDGEMENTS.** This research was supported by the Internal Grant Agency of the Czech University Life Sciences Prague [20173005]. Furthermore, it was supported by the Internal Grant Agency of the Faculty of Tropical AgriSciences [20185010].

## **IX VEHICLES & FUELS**

## Investigation into the Performance Characteristics of Electric Automobiles by Means of a Data Logger

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**Abstract.** Fossil fuel deposits are constrained in the world. Various alternative energy sources are introduced in vehicles to limit the depletion of fossil fuel reserves and to reduce environmental pollution. One of the alternative energy sources is electricity. The use of electric automobiles has begun in the Baltic States too, yet accurate performance parameters of the automobiles, which could sometimes differ from the technical characteristics specified, are not always known. Road testing an electric automobile was performed using a data logger that recorded the battery's voltage, current, temperature and the automobile's speed. These parameters allowed computing changes in the electric automobile's power output under various driving regimes, e.g. acceleration or braking. Road testing the electric automobile was done under two driving regimes – urban and non-urban – on a certain route. The experiment represented a full cycle road test, with the batteries fully charged, that lasted until the batteries were discharged to a minimum level, which was limited by the battery management system (BMS). The experiment identified the maximum current as well as the effectiveness of the regenerative braking system.

**Key words:** electric vehicle, energy consumption, current, voltage, driving regime, cruising.



## Experimental research on compatibility of mineral and biobased hydraulic oils

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**Abstract.** The use of biobased hydraulic oils becomes more popular in the different industries, but especially in agriculture machinery. This is stimulated by the fact that significant amount of hydraulic oils effluence in the environment and therefore leaves a negative impact to the ecosystem. Besides of that, the part of sold hydraulic oils grows and now forms approximately 15% of total oil consumption amounts worldwide (Nagendramma & Kaul, 2012). The aim of this research was to study the compatibility of the commercially produced mineral and biobased hydraulic oils, identify viscosity of a different mixtures in the entire work temperature range, as also changes of anti-frictional properties. Two different oils and three mixtures were tested. Special hydraulic experimental apparatus was established for visual observation of fluid properties. Sliding friction bench was used for the comparison of friction properties. The results showed that change of the working pressure and temperature of the hydraulic oil in the various mixtures of mineral and biological hydraulic oils do not change its original appearance. It was observed that the highest viscosity  $71 \text{ mm}^2 \text{ s}^{-1}$  and worst anti-friction properties is for the 50% mix of mineral and biological hydraulic oil at  $20^\circ\text{C}$  ambient temperature.

**Key words:** biobased, mineral, hydraulic oil, compatibility.

## **An assessment of stratification of exhaust gases from gasoline and diesel engine**

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**Abstract.** Research the aim of which was to find out stratification of main exhaust components outside the tailpipe of the vehicle was realized in Alternative Fuels Research Laboratory of Latvia University of Agriculture using two commercially produced testing vehicles (diesel and gasoline) and exhaust gas analytical system AVL SESAM FTIR. Additionally there was created a gas testing camera allowing to measure concentration of exhaust gas components in different heights and windless conditions. Regulated and unregulated emissions from gasoline and diesel engines were measured and discussed. Results obtained during the measurements showed main stratification of toxic components from both engine types from 0.6 to 1.1 m from the ground making a risk to get some health problems by inhalation, especially for children. Main components (NO<sub>x</sub>, CO, HC) of exhaust gases of gasoline engines stay in the air for about 15 minutes in height of 1.0 m from the ground level, while methane and acetylene stay in the air for a 15 minutes in height of 0.6 m from the ground level.

**Key words:** exhaust gases, stratification, diesel, gasoline, engine.

## Effect of sunflower and rapeseed oil on production of solid particles and performance of diesel engine

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**Abstract.** The development of biofuels for compression ignition engines is heading primarily to utilization of vegetable oils. Combusting of 100% vegetable oil in unmodified CI engine is usually not possible due to higher viscosity of the vegetable oil. In order to use 100% vegetable oil in CI engine the oil needs to be preheated, esterified or hydrotreated. Alternatively, in order to use raw vegetable oil in CI engine without preheating it is possible to use vegetable oil – diesel fuel blends or vegetable oil – butanol – diesel fuel blends in order to lower the viscosity of the fuel. The contribution focuses on comparison of the effect of sunflower and rapeseed vegetable oils on operational parameters of the turbocharged compression ignition engine, especially on production of solid particles. The measurement was carried out according to standardized NRSC test cycle. 5% and 20% concentration of vegetable oils in diesel fuel were used as a test fuels for the measurement while the diesel fuel was used as a reference. The count and size of solid particles were measured by means of EEPS particle analyser. Based on the measured values it can be stated that the slight increase of performance parameters occurred with strong effect on emissions production, especially on production of solid particles.

**Key words:** Combustion engine, biofuels, diesel fuel, particulate matter, vegetable oil, fuel blend.

**ACKNOWLEDGEMENTS.** The paper was created with grant support CULS CIGA 2017 – 20173001 – Utilization of butanol in compression ignition engines of generators and CULS IGA 2017: 31190/1312/3119 – Analysis of the impact of biofuels on the pressure profile in the combustion chamber of turbocharged diesel engine.

## Combustion Property Analyses with Variable Liquid Marine Fuels in Combustion Research Unit

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**Abstract.** The quality of ignition and combustion of four marine and power plant fuels were studied in a Combustion Research Unit, CRU. The fuels were low-sulphur Light Fuel Oil (LFO, baseline), Marine Gas Oil (MGO), kerosene and renewable wood-based naphtha. To meet climate change requirements and sustainability goals, combustion systems needs to be able to operate with a variety of renewable and ‘net-zero-carbon’ fuels. Due to the variations in the chemical and physical properties of the fuels, they generally cannot simply be dropped into existing systems. The aim of this research project was to understand how changes in fuel composition affect engine operation. The focus was on how various properties of the fuels impact on the combustion process – especially ignition delay and in-cylinder combustion. The goal of the research project was to allow broad fuel flexibility without any or only minor changes to engine hardware. Before the engine tests, the CRU forms an easy and cost-effective device to find out the engine suitability of the fuel. The results showed that the ignition delay decreased expectedly with all fuels when the in-cylinder pressure and temperature increased. The differences in the maximum heat release rates between fuels decreased in high-pressure conditions. MGO had the shortest ignition delay under both pressure and temperature conditions. Based on the CRU results MGO and kerosene are suitable to use in compression-ignited engines like the reference fuel LFO. In contrast renewable naphtha had a long ignition delay. If naphtha is used in a CI engine, the engine must be started and stopped with, e.g. LFO or MGO.

**Key words:** Diesel engines, alternative fuels, ignition delay, heat release rate.

## Diagnosics of hydraulic fluids used in aviation

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**Abstract:** Diagnostics is a maintenance industry that monitors performance, parameters, and follow-up. Diagnosing hydraulic fluids means comparing the parameters of the used hydraulic fluid sample to the parameters of the clean fluid. It is also essential to monitor the limit values either by the aircraft manufacturer or by the manufacturer of the hydraulic fluid. This means that the manufacturer recommends the limitations of the liquid parameters. The measurements of the fluid samples give an overview of the liquid quality. Most businesses focus on so-called proactive maintenance. The main senses and objectives of proactive maintenance are: lubricant sample analysis, lubricant status, machine status, next step recommendation, database saving and trend analysis. This article focuses on the quality of hydraulic fluid focused in aviation. The aim of the article was to determine the properties of the hydraulic fluid used in the A320 aircraft family, determine the interval of its exchange. Monitoring the state of the hydraulic fluid could contribute to the timely detection of the problem, thus avoiding a failure of the device or the system as a whole. The tracking proposal is an integral part of this article.

**Key words:** particle analysis, control interval, kinematic viscosity, hydraulic fluid, cleanliness code.

**ACKNOWLEDGEMENTS.** Paper was created with the grant support – CZU 2017:31150/1312/3122 – The study of alternative energy resource utilization under rural conditions.

## Exhaust particle size distributions of a non-road diesel engine in an endurance test

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**Abstract.** The main objective of this study was to find out how the non-road diesel engine running period of 500 hours affects the exhaust particle size distribution. By means of an engine exhaust particle sizer (EEPS), particle number was measured before the endurance test and after 250 and 500 hours of engine operation. The size distributions were determined at full and 75% loads both at rated and at intermediate speeds. The soot, gaseous emissions and the basic engine performance were also determined and lubricating oil was analysed a few times during the running period. A blend of low-sulphur fossil diesel and soybean methyl ester (B20) was used as fuel in the 4-cylinder, turbocharged, intercooled engine which was equipped with a diesel oxidation catalyst (DOC) and a selective catalytic reduction (SCR) system. All emissions were measured downstream the catalysts. During the 500 hours of operation, the particle number increased considerably within an approximate size range of 7 to 30 nm. Between the initial and final measurements, no notable differences were observed in the particle number emissions within a particle size range of 50 to 200 nm. The copper content of lubricating oil also increased significantly during the 500 hours' experiment. One possible reason for the substantial increase in the nucleation mode particle number was assumed to be copper, which is one of the metallic elements originating from engine wear. The engine efficiency was almost equal, and the differences both in smoke and hydrocarbon emission were negligible throughout the 500 hours' experiment.

**Key words:** particle number, exhaust aftertreatment, B20, blend fuel, soybean methyl ester.

**ACKNOWLEDGEMENTS.** The Novia University of Applied Sciences allowed us to use the engine laboratory for this study. The authors wish to thank Dr. Jonas Waller, Mr. Holger Sved and Mr. John Dahlbacka for this possibility. In addition, the authors wish to thank Ms. Katriina Sirviö for her assistance during the measurement campaigns and Mr. Tobias Eriksson for operating the engine daily. The authors also thank Mr. Toomas Karhu from Turku University of Applied Sciences for his assistance during the measurements after 500 hours of engine operation.

## The operational parameters and emissions of portable generator after long-term operation on n-butanol

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**Abstract.** The utilization of biofuels in spark ignition and compression ignition engines is the trend of the recent time. The great expectations are inserted into n-butanol as a fuel, especially for spark ignition engines. The short time use of n-butanol in the SI (spark ignition) combustion engine does not make a big problem (start of the cold engine, change of the air-fuel ratio). The purpose of this contribution is the effect of long-term use of n-butanol as a fuel for SI engine. For this purpose the small portable generator was used. The harmful emissions, fuel consumption and power of the generator was measured then the generator was operated for 300 hours on 100% n-butanol with 80% of nominal load and the measurement was repeated. The generator was loaded with adjustable electrical resistance. As a reference fuel the petrol BA 95 with no bio-component was used. During the operation on n-butanol no technical problems occurred with the generator. After 300 hours of operation on n-butanol the performance parameters slightly decreased with little impact on production of harmful emissions components.

**Key words:** biofuel, petrol, emission, fuel consumption, spark ignition.

**ACKNOWLEDGEMENTS.** Paper was created with the grant support – CULS CIGA 2017 - 20173001 – Utilization of butanol in compression ignition engines of generators.

## Flash points of gasoline from Kukersite oil shale: Prediction from vapor pressure

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**Abstract.** The flash point of liquid fuels, especially of light distillates such as gasoline or naphtha, is an important parameter for the handling of such materials. In this work, flash points and volatility characteristics (vapor pressure, boiling point) of a number of shale gasoline samples with different volatilities were measured. The shale gasoline fractions were produced from Kukersite oil shale using solid heat carrier retorting technology. Several existing correlations for calculating flash points of hydrocarbons and petroleum fractions are evaluated, and the absolute average deviations were found to be between 1.1 to 20.9 °C. New, easy-to-use correlations are proposed for estimating flash points for oil shale based gasolines from volatility characteristic that are readily available. The correlation proposed in this work are based on the vapor pressure at 20 or 37.8 °C (100 °F), Reid vapor pressure (37.8 °C) or boiling point. The average absolute deviations for these correlations were 0.82 to 0.93 °C, meaning they are comparable to or better than existing methods developed for petroleum oils, which mostly use boiling point as the input parameter, when applied to gasoline from Kukersite oil shale.

**Key words:** oil shale, gasoline, flash point, closed cup, correlations, vapor pressure, Reid vapor pressure, boiling point, alternative fuel, mineral oil.

**ACKNOWLEDGEMENTS.** The authors are grateful to Prof. Vahur Oja from Tallinn University of Technology for his help with this article. Support for the research was provided by National R&D program 'Energy' under project AR10129 'Examination of the Thermodynamic Properties of Relevance to the Future of the Oil Shale Industry' (P.I. prof Vahur Oja).



## Properties of local produced animal-fat based biodiesel and its blend with fossil fuel

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**Abstract.** In the near future, more emphasis must be put on reducing greenhouse gas (GHG) emissions in road transportation, house heating, agricultural activities, marine transport etc. This study concentrated on the use of alternative fuels in engine-driven applications of non-road machineries and decentralized energy production. Today, the engines are mainly designed for crude oil derived fuels and liquid renewable fuels are blended with crude oil based fuels to fulfill the requirements of renewable energy usage. Due to the environmental reasons on one hand and to the agricultural needs, on the other hand, different blends of bio- and fossil fuels are becoming more popular. In Europe, the maximum FAME content in diesel fuel is 7 vol% according to the EN 590:2013 but higher percentages are also available and targeted around the world. For example in the United States, the 20% blend fraction is becoming more common. For these reasons, B20 fuels were chosen to be investigated in this study. Special emphasis was put on improving blending issues since fuel blending may cause some operating risks. The main aim was to research widely the properties of animal-fat based methyl ester (AFME) and B20 fuel blend produced from it. AFME is a waste based fuel and produced in Ostrobothnia region, Finland. The aim was to find out in which engine applications the fuels are feasible and investigate if the fuels fit in the quality of automotive fuel Standards. According to the results, AFME is a feasible option to increase self-sufficient energy production in Ostrobothnia.

**Key words:** Biofuel, blending, FAME, AFME, diesel fuel, B20.

**ACKNOWLEDGEMENTS.** The authors would like to acknowledge Merchant Gustaf Svanljungs foundation for donation to this study. The authors also wish to thank the companies Feora and Neste for delivering the studied samples. **Funding:** This work has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 634135.

## Kinematic viscosity studies for medium-speed CI engine fuel blends

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**Abstract.** Engine-driven power plants, run by diesel fuel or gas, will be needed for peaking power to keep the electricity grids stable when the production of renewable electricity, e.g. utilizing wind or solar power, is increased. The choice of the alternative, renewable fuels for engine-driven power plants and marine applications is at the moment quite narrow. The amount of renewables of all liquid fuels is at present less than 2%. Biodiesels, FAMES, have been studied for long time and apparently, despite of the problems they may have, they are still in the great interest. One important increment to the category of alternatives is fuels that are produced from e.g. oil wastes, i.e., recycled fuels. They are not renewable, but recycling of potential energy raw materials is still one step forward in increasing the suitable and more sustainable options.

To utilize the blends in medium-speed engines for power production, accurate knowledge of the physical and chemical properties of fuel blends is very important for the optimization of engine performance. The determination of the fuel kinematic viscosity is needed to create proper fuel atomization. The injection viscosity affects directly the combustion efficiency and the engine power. Consequently, this study focused on measuring kinematic viscosity curves for seven fuel blends, as well as the neat fuels used for blending. The temperature range was 10-90°C. The fuels used for blending were rapeseed methyl ester, animal-fat based methyl ester, hydro-treated vegetable oil, light fuel oil and marine gas oil produced from recycled lubricating oils.

**Key words:** Fuel viscosity, viscosity curve, alternative fuels, fuel blends, power plant, renewable energy.

**ACKNOWLEDGEMENTS.** The authors would like to acknowledge Ab Feora, STR Tecoil and UPM Biofuels for the fuel samples. This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 634135.

# **X FOOD SCIENCE & TECHNOLOGY**

## Shrinkage effect on diffusion coefficient during carrot drying

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**Abstract.** Many studies have been previously carried out on the carrot drying and the undergoing processes. The developed mathematical models provide an opportunity to gain an understanding of this complex process and its dynamics. But they are simplified and based on a number of assumptions, including calculation of diffusion coefficient values. In one of the previous studies, the authors of this study determined that the diffusion coefficient is linearly dependent on the moisture concentration with the assumption that the sample's geometric shape does not change. The aim of this study is to determine the dependence of the diffusion coefficient on the moisture concentration taking into account the change in sample thickness during the drying experiment. The experiments were carried out with carrot slices of three different thicknesses: 5mm, 10mm and 15mm thickness on the film infrared dryer at temperature 40°C. During the experiments, measurements of the weight and thickness of the slices were performed. Using the experimental data the average thickness and diffusion coefficient of slices was calculated depending on the moisture concentration. Obtained results show that thickness depends linearly on the moisture concentration. Using experimental data and obtained average values of samples thickness, the values of diffusion coefficient was calculated. The results indicate that diffusion coefficient value depend linearly on moisture concentration. Their values are close and tend to zero when the concentration decreases if the thickness changes are taken into account during the experiment.

**Key words:** carrot, diffusion coefficient, drying, thickness.

## Production and investigations of antioxidant rich beverage: utilizing *Monascus purpureus* IHEM LY2014-0696 and various malts

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**Abstract.** Antioxidant evokes numerous health benefits to the consumer as well as stabilisation of the beverages flavours. Therefore, this paper provides detailed information on the application of *Monascus purpureus* IHEM LY2014-0696 in combination with various malts in brewing antioxidant rich beverage (ARB). Starter culture Angkak was prepared by solid state bioprocessing (SSB). Single infusion method of mashing was used. Physicochemical parameters, volatile compounds, DPPH (2, 2-diphenyl-1-picrylhydrazyl) radical scavenging activity and fermentability of the wort were evaluated. Distillation procedure based on pycnometry technique was used to quantify the alcohol content (%ABV). Fermentability of the wort was found to be  $97.6 \pm 0.46\%$  whilst %ABV was equal to  $5.42 \pm 0.03$ . It was observed that ARB showed a strong DPPH radical scavenging activity of  $1.00 \times 10^{-4} \text{ mol} \times \text{equ}$  ( $R^2 = 0.91$ ) whereas  $3.43 \times 10^{-5} \text{ mol} \times \text{equ}$  ( $R^2 = 0.81$ ) for wort. The strong antioxidant activity (AOA) is thought to be caused by pigments produced by *M. purpureus* IHEM LY2014-0696 and other compounds originated from the malts and hops utilised in brewing ARB. A total of 4 volatile compounds were identified in the present study. Incidence of microbial load ranged from  $2.14 \pm 0.04 \times 10^7$  and  $0.8 \pm 0.1 \times 10^5$  for *M. purpureus* IHEM LY2014-0696 and bacterial respectively was observed in the ARB. This study contradicts some previous ones, as the ARB brewed did not take the red pigment produced by the *M. purpureus*. Panellists generally expressed their acceptance for the ARB as they assessed it as a new product, moreover, taking account its health benefits.

**Key words:** Volatile compounds, Fermentability, Angkak, Solid state bioprocessing, Pigments.

**ACKNOWLEDGEMENTS.** The work was carried out with the financial support of the Ministry of Education of the Russian Federation within the framework of the basic part of the state task, Project No. 4.9514.2017 / 8.9.

## Bioactive compounds in herbal infusions

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**Abstract.** Herbal teas are very popular and known as important source of biologically active compounds. Some of popular Latvian herbal teas: Calendula (*Calendula officinalis* L.), Matricaria chamomilla (*Matricaria chamomilla*), Lady's-mantle (*Alchemilla vulgaris* L.), Jasmine (*Jasminum officinale* L.), Yarrow (*Achillea millefolium* L.) and Linden flowers (*Tilia spp.*) were selected for analysis. This study was carried out with the aim to investigate the effect of extraction time (10, 15, 20 min) on the content of total flavonoids and total phenols as well as antioxidant activity of herbal tea extracts. The infusions were prepared by usual domestic preparation technique using ground air-dried plant materials and boiling deionized water ( $0,055 \mu\text{S cm}^{-1}$ ) for extraction. Content of total flavonoids, total phenols and antioxidant activity was determined spectrophotometrically. Dry matter content was determined in lyophilized herbal infusions. The obtained results indicated that extraction time did not affected the content of biologically active compounds in the herbal infusions significantly ( $P>0.05$ ). The highest level of flavonoids was found in Jasmine and Lady's-mantle infusions (average  $104.98 \pm 9.21$  mg quercetin equivalent  $100 \text{ g}^{-1}$  and  $115.28 \pm 5.25$  QE mg  $100 \text{ g}^{-1}$  respectively), while the lowest was determined in Matricaria chamomilla extract - (average  $70.10 \pm 4.68$  QE mg  $100 \text{ g}^{-1}$ ). Lady's-mantle tea contained the largest amount of total phenols (average  $4126.62 \pm 26.24$  mg gallic acid equivalents  $100\text{g}^{-1}$ ), the lowest - Calendula tea  $1828.04 \pm 10.37$  mg GAE  $100 \text{ g}^{-1}$ ). Data analysis showed a close linear positive correlation between the content of total flavonoids and total phenols in herbal infusions ( $R^2=0.872$ ;  $r=0.934$ ) with the probability of 99%. In general, all samples tested in this study, demonstrated high level of antioxidant activity (from 75.04 to 91.54 mmol Trolox equivalents  $100 \text{ g}^{-1}$ ). Results of the present experiments demonstrated that content of dry matter in analysed herbal teas was significantly different ( $P<0.05$ ).

**Key words:** herbal infusion, phenols, flavonoids, antioxidant activity.

## Effect of germination and extrusion on the phenolic content and antioxidant activity of raw buckwheat (*Fagopyrum esculentum* Moench)

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**Abstract.** The aim of the research was to determine the total phenolic content, antioxidant activity and phenolic compounds in raw and germinated common buckwheat grain and their extruded products in order to estimate the effect of germination and extrusion on the total phenolic content, antioxidant activity and phenolic compounds in buckwheat. A total of 10 buckwheat samples were analysed, where the raw buckwheat grain was the control sample, four samples were germinated and then extruded. The total phenolic content was determined using the Folin-Ciocalteu assay. The antioxidant activity was determined using a micro plate assay and phenolic compounds with Liquid Chromatography –Time of Flight Mass Spectrometer method.

The results showed that germination of buckwheat significantly affected the total phenolic content, antioxidant activity, radical scavenging activity and content of phenolic compounds. The decrease of the total phenolic content, antioxidant activity, radical scavenging activity and the content of some phenolic compounds depended on germination time – 48 h of germination provided greater concentrations at the end of a 24 h germination period, whereas the content of some phenolic compounds like rutin, quercetin and vitexin increased substantially after germination, besides, the increase of phenolic compounds depended on the germination time. In total 26 different phenolic compounds were detected in raw and germinated buckwheat samples and only one compound with an *m/z* value 385.1282 was unidentified. The data of extrusion revealed a significant decrease of total phenolic content, antioxidant activity, radical scavenging activity and phenolic compounds content in buckwheat samples ( $P < 0.05$ ). In the extruded buckwheat samples novel phenolic compounds like 4-hydroxybenzoic acid, homovanillic acid, catechin, ferulic acid, and hyperoside were detected.

**Key words:** buckwheat, germination, extrusion, phenolics, antioxidant activity.

**ACKNOWLEDGEMENTS.** This research was supported by National Research Programme AgroBioRes (2014–2017) and the project ‘Strengthening Research Capacity in the Latvia University of Agriculture’.

## The measurement of energy consumption during milling different cereals using the sieve analyses

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**Abstract.** This paper deals with the measurement of energy consumption required for disintegration of different cereals depending on the desired fineness of obtained grist. The energy consumption necessary for milling was compared with the results of a sieve analysis before and after the disintegration process. The obtained results were compared with energy expended during the disintegration of cereals and were analysed to determine the coefficients of the ratio of fineness of milling/energy consumption. They was found to have good conformity. Special attention was paid to the RRSB distribution for determination of statistic average particle size and specific area of malt grist. Specific area of grist particles from different cereals was determined by calculation of the limited area and x axis in diagrams, this effort is necessary for optimisation of the disintegration process with impact on the quality of final food.

**Key words:** cereals, two roller mill, hammer mill, sieve analysis, electric energy consumption.

**ACKNOWLEDGMENT.** The authors have the honor to thank their colleagues J. Volf, J. Frýdl and M. Křížek, from the Department of Electrical Engineering and Automation, Faculty of Engineering, Czech University of Life Sciences Prague for helping to measure power consumption during experimental activities.



## Study of potential PCR inhibitors in drinking water for *Escherichia coli* identification

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**Abstract.** In the last few decades, the polymerase chain reaction (PCR) has become one of the most powerful molecular biological tools. However, the PCR is an enzymatic reaction and therefore sensitive to inhibitors which may occur in drinking water samples. In this work, the possible inhibition effect of chlorine, humic acids, and iron for real-time PCR (qPCR) efficiency was studied and the environmental sample from drinking water treatment system before iron removal was selected and analysed. The results demonstrated that the highest concentrations of humic acids (5 mg l<sup>-1</sup> and 1 mg l<sup>-1</sup>) and iron (4 mg l<sup>-1</sup>) inhibited the PCR reaction while no effect of chlorine was observed. The analysis of the environmental sample with spiked *Escherichia coli* cells demonstrated reduction efficiency of the average threshold cycle (C<sub>t</sub>) values compared with control dilution series determining the possible inhibition for qPCR assay.

**Key words:** Polymerase chain reaction, inhibitors, chlorine, humic acids, iron, *Escherichia coli*.

**ACKNOWLEDGEMENTS.** This work has been supported by Riga Technical University funding for doctoral students and National Research Programme No. 2014.10-4/VPP-3/21 'Multifunctional Materials and composites, photonicS and nanotechnology (IMIS<sup>2</sup>)', Project No. 4 'Nanomaterials and nanotechnologies for medical applications', Subproject No. 4.7. (2014-2017). The authors gratefully acknowledge Kristina Tihomirova and Viktorija Denisova for their assistance in humic acid and chlorine concentration measurements.

## Development of gluten-free sourdough bread technology with rowan powder

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**Abstract.** A new technology of gluten-free bread with gluten-free sourdough and rowan powder (botanical species *Sorbus aucuparia*) was developed. The new technology allows to improve organoleptic characteristics, structure, texture, microbial spoilage resistance and shelf life of gluten free bread. The gluten-free dry microbial composition with lactic acid bacteria was developed as a starter for sourdough. The lactic acid bacteria *L. brevis E38* was experimentally selected for dry microbial composition on basis of its antagonistic activity against ropy bread disease pathogens (*B. subtilis* and *B. licheniformis*). The dependence of the accumulation of acetic acid and lactic acid in the sourdough on the microbial composition during fermentation was revealed. A gluten-free sourdough technology involving new starter, rice and soy flour in a ratio of 0.2:2:1 was developed. It was shown that the use of soy protein slows down the fermentation process in the sourdough. The increase of acidity in the 7.5–9.5 times in the dough with a sourdough and rowan powder compared to the dough without the sourdough was established. Sourdough usage allowed to increase the compressibility of the crumb in 1.8–2 times, the specific volume of 19.0% and a porosity of 9.8% and 11.5% and to improve sensory characteristics perceived by consumers. It was proved that the microbial composition with a lactic acid bacteria *L. brevis E38* usage inhibits the ropy disease and mould development in bread. The results of present study showed that addition of sourdough and rowan powder can be used to improve the quality of gluten-free bread.

**Key words:** gluten-free bread, lactic acid bacteria, dry microbial composition, rowan powder, quality, molding, ropy disease.

### 3D image analysis of the shapes and dimensions of several tropical fruits

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**Abstract.** Three dimension virtual models of Avocado (*Persea americana*), Salak (*Salacca zalacca*), Dragon fruit (*Hylocereus undatus*), Mango (*Mangifera indica*), Coconut (*Cocos nucifera*) using 3D scanner Intel RealSense were determined. Calculated models based on arithmetic and geometric diameter were also determined. From statistically analysis implies that virtual models on significance level 0.05 are significantly different with calculated values based on arithmetic or geometric diameter.

**Key words:** virtual, model, scanner, physical properties.

**ACKNOWLEDGEMENT.** This paper has been supported by Internal Grant Agency of Faculty of Engineering – Czech University of Life Sciences Prague – IGA 2017: 31130/1312/3111.

## Determination of the tension limit forces of a barley malt and a malt crush in correlation with a load size

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**Abstract.** This article deals with determination of selected parameters of barley malt (whole grain and crushed grain). The barley malt is besides water, hops and brewer's yeast, one of the basic ingredients necessary for the production of traditional Czech pilsner type of beer. The aim of this research is to determine limit force and internal friction angle with depending on the size of the load. The assessed malt crush was produced using a 2-roller malt mill. The 2-roller malt mill is based on the principle of grinding the material in a milling gap between two milling rollers, which is a very commonly used production of the malt crush. By determining the tension limits of the barley malt and the malt crush in correlation with the load, we can obtain very important parameters that inform us of the bulk material behavior, particularly with respect to the storage method (storage shape, height of the stored material layer, and the removal method from the storage, etc.), and to the transport (route gradient, transport speed, etc.). The determination of the tension limits has a direct link with cohesion of the bulk material and thereby contributes to establishing of the basic parameters of the bulk material, such as - the friction angle. The measurement for the angle of internal friction determination were performed on a prototype device. The principle of measurement on a mobile prototype devices is, the upper square chamber slides down the lower square chamber. Barley malt (whole grain and crushed grain) were loaded from 100 g to 5000 g. The results of measuring were statistically analyzed with software Statistica 12.

**Key words:** food industry, barley malt, malt crush, bulk material, friction angle.

**ACKNOWLEDGEMENTS.** The measurements were made on the device "Mobile device for shear soil testing" utility model number 29836, authors CHOTĚBORSKÝ, R., LINDA, M., NÝČ, M. <http://www.upv.cz/cs/>. 29836. 04.10.2016.

Thank doc. Ing. Rostislav Chotěborský, Ph.D. and Department of Material Science and Manufacturing Technology for borrowing the device.

## Alcohol free beer as carbohydrate-electrolyte solution for sportsmen

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**Abstract.** Generally Beer is regarded as an ideal thirst quencher. Especially alcohol free beer is promoted among athletes as fitness drink or suitable for sportsmen. Rules for real sport drinks were given for the first time by the “Report of the Scientific Committee on Food on composition and specification of food intended to meet the expenditure of intense muscular effort, especially for sportsmen of the European Commission.” Two factors that have been considered to contribute most to the onset of fatigue in exercise are the depletion of the body's carbohydrate reserve and the onset of dehydration, as a consequence of the loss of water and electrolytes in sweat. Fitness drinks have to meet these requirements. Ron Maughan of St Andrews University UK already proved that beer has a positive water balance of 800 mL L<sup>-1</sup> beer. We have shown that most alcohol free yeast clouded beers are isotonic when analyzed by HPLC and Ion chromatography to determine the content of mineral salts and carbohydrates. But the results also showed that for use as „real sport or fitness drink” the sodium content is too low. For so called „carbohydrate-electrolyte solutions” (C.E.S.) which could replace the loss of electrolytes including sodium the EC advises a range from 335 - 1470 kJ Carbohydrate L<sup>-1</sup> CES drink and sodium concentrations of 20-50 mmol L<sup>-1</sup> (460 - 1150 mg L<sup>-1</sup>). We showed that it is possible to reach the level of sodium recommended by means of the addition of different sodium salts or combinations of them. 5 different sodium salts and combinations of the salts were added to alcohol-free, yeast-clouded beer. These spiked beers were blind tested for flavor impairments. Salts tested were sodium chlorid, sodium citrate, sodium lactate, sodium hydrogencarbonate and sodium carbonate. Blind tasting was performed according DIN 10959 with increasing concentrations of salts. Samples were classified as sensory not perceivable, perceivable and disturbing taste. The blind tasting of the spiked beers showed that at sodium concentrations of 20 mmol most salts were perceivable but no “disturbing” taste disturbing. A mixture of sodium citrat and sodium hydrogencarbonate had the highest detection threshold. As the taste was described as sweet or citric and not as disturbing such sodium enriched alcoholic beers might be offered to consumers as carbohydrate-electrolyte solutions to substitute the losses of water and electrolytes after sport activity.

## Effects of processing conditions on physical parameters of triticale flakes

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**Abstract.** Consumer interest in breakfast cereal flakes has increased during the last few years. Various technologies, used to produce flakes, significantly influence their quality parameters and shelf-life stability. The main purpose of the present research was to investigate how different processing methods affect the physical parameters of triticale flakes. For obtaining the flakes, cleaned whole triticale grains were treated using the following technologies: dry processing (hot air), steam processing and soaking with subsequent steaming. For preparing the flakes different kilning methods and traditional flaking rolls were used. Traditionally made rolled and dried whole grain triticale flakes were analysed as a control sample. Using standard methods, the flakes' moisture content, water activity, microstructure, swelling capacity and colour changes were analysed. The gap settings of flake rollers do not influence significantly ( $P < 0.05$ ) changes of starch during processing. However, the starch granules were fully transformed into sugars in the flake samples with greater thickness. Non-significant ( $P < 0.05$ ) steaming and hot air drying (toasting) conditions' effects were observed on the changes of the starch granules during processing. Strong correlation was determined during the analysis of water activity and moisture content. The moisture content of the ready- to-eat flakes varied from 2.54% to 10.66%, and the water activity value was from 0.108 to 0.494. Compared with traditionally processed flakes (control sample) the colour of the flakes prepared using other technologies changed significantly, the  $\Delta E$  values varied from 9.587 to 18.554. The colour of the soaked-steamed-rolled-hot air dried samples was similar but those significantly differed from the colour of soaked-dried-rolled-hot air dried flake samples. The soaked-dried-rolled-hot air dried flakes were darker compared with other analysed flake samples.

**Key words:** triticale flakes, technology, quality.

**ACKNOWLEDGEMENTS.** The present research leading to these results in accordance with the contract No. 1.2.1.1/16/A/004 between "Latvian Food Competence Centre" Ltd. and the Central Finance and Contracting Agency (11.11.2016), has been conducted by "Felici" Ltd. with the support from the European Regional Development Fund (ERDF) within the framework of the project "Latvian Food Industry Competence Centre".



INVESTING IN YOUR FUTURE

## Effect of drying technologies on bioactive compounds maintenance in pumpkin by-products

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**Abstract.** During the pumpkin processing large amounts of waste material as a combination of pumpkin peel, seeds and the flesh between seeds has produced. Therefore it is important to investigate the possibilities for using the pumpkin residues. **The aim** of this research was to investigate the effect of different drying technologies on maintenance of bioactive compounds in pumpkin by-products. Two pumpkin residue products of Hubbard group pumpkins were used to obtain pumpkin powder: residue products formed in the process of extracting industrial pumpkin purée by heating it in a heat exchanger and treating through a sieve of pulpier; residues resulting from pumpkin juice extraction process mechanically pressed from fresh, chopped pumpkins. In order to be able to choose the most suitable drying technology pumpkin by-products were dried in the microwave-vacuum, convective (at 40, 50, 70 and 80 °C) and freeze-drying type dryers. For all samples total carotenes, the ascorbic acid, total phenols content (TPC) and antiradical activity (DPPH<sup>·</sup>, ABTS<sup>·+</sup>) were determined by using standard methods. The highest total carotenes content was retained in freeze-dried pumpkin powders. The most suitable drying method for obtaining pumpkin powder with the highest ascorbic acid, total phenolic content and antiradical activity is drying in convective type drying at +80 °C temperature.

**Key words:** pumpkin residues, ascorbic acid, total phenols, carotenoids, drying technologies.

**ACKNOWLEDGEMENTS.** To contract No SB/L – 1/17 (3.2-10/2017/LLU/25-02.05.2017) with company ‘SKAI BLTIJA’.

## Sonochemical Effects on Food Emulsions

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**Abstract.** Acoustic cavitation of food emulsions is widely applied as the main processing method to improve the quality of a finished product and its organoleptic characteristics, as well as to increase production performance.

To identify the optimal modes of ultrasonic emulsification, we propose a model of emulsion droplet breakup in an acoustic cavitation field, which allows us to determine the dependence of emulsion droplets' diameter on exposure time and intensity of action. The developed models enabled us to pioneer complex research of the dependence of emulsion droplets' diameter on time given the maximum radius of cavitation bubbles and physical properties of liquid phases in the emulsion composition. We carried out the first complex theoretical and practical research of how shapes and positions of absolutely fixed boundaries influence the propagation of oscillations in a activating liquid medium (food emulsion). To verify the adequacy of the obtained theoretical models, we studied the dependence of emulsion droplets' breakup rate (by the example of a model water/oil emulsion) on the exposure time and the intensity of ultrasonic action. The calculation results revealed that the results of a series of experiments and the results obtained with the use of the developed mathematical model are consistent. Based on the theoretical data obtained, we designed an industrial flow- type acoustic cavitation device aimed at acting on food emulsions; it differs from analogous devices in that it has within it a cylindrical wave acting through solid walls of the tunnel for transmitting processed liquid.

**Key words:** ultrasound, cavitation, model, food emulsion, sonochemistry.

**ACKNOWLEDGEMENTS.** This article was written with support from the Government of the RF (Resolution №211 of 16.03.2013), Agreement № 02.A03.21.0011, and subsidies for the fulfillment of a fundamental part of a state order under Project № 40.8095.2017/BCh, Project № 19.8259.2017/BCh, Project № 15-58-45028.



## Influence of Technological Parameters on Chemical Composition of Triticale Flakes

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**Abstract.** Triticale is hybrid crop developed by crossing wheat (*Triticum*) and rye (*Secale*) and in last years it become more popular for food applications, including flake production. Different approaches are developed to improve flakes technology by applying different cooking, rolling, toasting parameters resulting in high quality products. All these technologies influence also nutrition quality of product due to the different stability of these compounds during mechanical and thermal treatment. The aim of current experiment was to investigate the influence of technological parameters on chemical composition of triticale flakes. In current experiment triticale grains and triticale flakes obtained by different technologies was tested. For evaluation of the influence of technological parameters, different flaking and rolling parameters were tested. For all samples were determined composition of basic nutrients (fats, proteins, fibres, sugars, ash), minerals (Ca, Mg, K, Zn, P), vitamins, total phenolics and antioxidant activity. Triticale has high nutritional quality, containing significant amounts of protein, fibres, vitamins and minerals. Technological processes significantly influence cereals composition, but it depends on parameters tested. Control sample showed lower results and hierarchical cluster analyses showed that samples 1/3/1, 2/1/2/1, 2/1/3/1, 2/1/4/1 are similar in composition of bioactive compounds. Results showed that for selection of the best method for flaking physical and/or sensory properties should be taken in account.

**Key words:** triticale, flakes, technology, chemical composition.

**ACKNOWLEDGEMENTS.** The present research leading to these results in accordance with the contract No. 1.2.1.1/16/A/004 between "Latvian Food Competence Centre" Ltd. and the Central Finance and Contracting Agency (11.11.2016), the study is conducted by "Felici" Ltd. with support from the European Regional Development Fund (ERDF) within the framework of the project "Latvian Food Industry Competence Centre".

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## Changes in the nutritional value of breakfast cereals containing germinated spring grain flakes during storage

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**Abstract.** The aim of current research was to assess the nutritional value of breakfast cereals containing germinated spring grain flakes and its changes after 6 month storage. Three types of breakfast cereals were prepared and packaged in two types of Standup pouches - Pap50g/Alu7/Pe60 (AL), Pap40g/PELD20/PE40 (PE). For the accelerated shelf life test the samples were stored at  $35 \pm 2^\circ\text{C}$  and dietary fibre, protein, fat, B-group vitamins, sugars, total phenol content and DPPH, ABTS+ radical scavenging activity were determined. Developed breakfast cereals have high nutritional value and all are high in fibre and thiamine. Additionally, sample S2 is source of protein, riboflavin, niacin, and S3 – is source of riboflavin and high in niacin. Comparing total phenolic content and antioxidant capacity of tested samples S3 showed the highest values. Storage and selected packaging influenced stability of nutrients, and for S1 and S2 AL showed better results whereas for S3 – PE.

**Key words:** breakfast cereals, nutritional value, germination, spring cereals, packaging, storage.

**ACKNOWLEDGEMENTS.** The research leading to these results has received funding from the Norwegian Financial Mechanism 2009–2014 under Project Innovative approach to hull-less spring cereals and triticale use from human health perspective (NFI/R/2014/011).

## Flavonoids and total phenolic content in extruded buckwheat products with sweet and salty taste

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**Abstract.** The aim of research was to evaluate the effect of added ingredients used for taste improvement on flavonoids and total phenolic content in extruded buckwheat products. The added ingredients were - sugar, vanilla sugar, stevia, agave syrup, cinnamon, ~~um~~ fennel, caraway, garlic powder, sweet pepper powder and salt. Six extruded buckwheat products were analysed, where an extruded buckwheat product without added ingredients was a control sample, two extruded buckwheat products were with sweet taste and three products with salty taste. Total phenolic content was determined using the modified Folin-Ciocalteu method but flavonoid content according to LC-TOF-MS method.

The highest total phenolic content ( $p < 0.05$ ) was determined in extruded buckwheat product with vanilla sugar + stevia ( $91.17 \pm 0.67$  GAE mg  $100\text{g}^{-1}\text{DW}$ ). It was almost three times higher than in the control sample. The significant differences were observed in extruded buckwheat products with ~~um~~ fennel + salt + agave syrup ( $41.5 \pm 0.12$  GAE mg  $100\text{g}^{-1}\text{DW}$ ) and sweet pepper powder + salt + agave syrup ( $42.39 \pm 0.80$  GAE mg  $100\text{g}^{-1}\text{DW}$ ) comparing to other extruded products ( $p < 0.05$ ). The highest content of rutin and quercetin ( $p < 0.05$ ) was established in extruded buckwheat product with garlic powder + salt + agave syrup, whereas the highest content of catechin and epicatechin – in extruded buckwheat product with vanilla sugar + stevia. The extruded buckwheat product with ~~um~~ fennel + salt + agave syrup in addition contained luteolin, kaempferol and isoquercitrin. The results of research showed that some added ingredients used for taste improvement can significantly influence the total phenolic content and flavonoid content.

**Key words:** buckwheat, extrusion, flavonoids, total phenolic content.

**ACKNOWLEDGEMENTS.** This research was supported by National Research Programme AgroBioRes (2014-2017) and the project 'Strengthening Research Capacity in the Latvia University of Agriculture'.

## Comparative analysis of chia seeds (*Salvia hispanica L.*) oil obtained by different methods

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**Abstract.** Having a unique composition of fatty acids, vegetable oils are estimated by scientists from different countries in terms of their impact on public health. Based on research, vegetable oils are considered as essential components of the human diet. A number of authors consider chia seeds (*Salvia hispanica L.*) as an excellent source of high-quality oil with a unique composition. Chia seeds oil is of particular importance as a source of such polyunsaturated fatty acids as omega-3 and omega-6 in a ratio of 3 to 1 respectively. However, as scientifically proven, the method of oil production directly affects its qualitative and quantitative characteristics. Research in the field of chia seeds oil production is limited and has a strong scientific interest.

The purpose of this study is to compare the properties of chia seed oils obtained by different methods. The raw material used for obtaining oil under laboratory conditions was chia seeds (*Salvia hispanica L.*) for the food purposes of the 2017 year harvest by Adovel Inversora, Uruguay.

The study considers the possibility of using various methods to produce chia seeds oil, including various organic solvents extraction, cold pressing, and supercritical CO<sub>2</sub> extraction. The influence of oil production methods on the yield of oil and its qualitative composition was studied. The biological value of the lipid component of chia seeds oil obtained by various methods was received. The qualitative characteristics of chia seeds oil, including iodine, peroxide and acid numbers, the number of saponification were investigated. The optimal method of oil production from chia seeds was chosen according to the evaluation of the complex study indicator.

In the future, the results of this research are likely to be used to investigate the therapeutic properties of chia seeds oil produced in the most rational way.

## Development of the composition and technology of the frozen dessert without sugar, using sesame flour

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**Abstract.** The article presents the results of the analysis of the entry dose of stevioside, topinambur syrup, sesame flour and the type of stabilizer added to the milk ice cream formula, theoretically calculated, using solids according to GOST 31457-2012 for development of a functionally oriented dessert with low content of fat and without sugar. It has been established that the entry dose of the stevioside and the topinambur syrup in an amount of 0.03 and 5% respectively to the mixture mass of the frozen dessert allows us to get the product with pleasant flavor and scent. The use of the PGX-1 stabilizer (Germany) with an entry dose of 0.4 to the mixture mass allows us to get the product with the best indicators for whipping, thawing resistance, density and uniformity of consistency. It has been determined that the entry dose of sesame flour added to the mixture mass varies from 1.5 to 2 %. It is expedient to put it into the normalize mixture after the process of homogenization before milling, pre-brewing with water in the ratio of 1:10 for 15 – 20 minutes to humidity (80±1) %. It has been found that the expiration date of the frozen dessert without sugar with the use of sesame flour is 6 months at a temperature of – 18°C.

**Keywords:** frozen dessert, topinambur syrup, stevioside, stabilizer, sesame flour, prophylactic and functional products.

## Possibility of using powdered sea-buckthorn in the development of bakery products with antioxidant properties

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**Abstract.** The article examines ways of increasing the antioxidant capacity of bakery products (BP) by adding powdered peel, powdered seeds, and powdered marc produced from sea-buckthorn berries. Three different versions of BP were developed with the maximum addition of the following powders: from the peel (3%), from the marc (5%) with the content of sugar 14.5%; from seeds (5%) with the sugar content of 5%, and potato flakes content of 5%. BPs with addition of sea-buckthorn powders were baked at two temperature regimes: 200°C and 220°C. The content of phenolic compounds, flavonoids, ascorbic acid was determined in the powder from sea-buckthorn, in the crust and crumb of BP. The antioxidant activity of BP was determined by two methods: by the chemiluminescence, and by their reaction with the DPPH-radical. Cyclic amides (lactams) were determined in BP's crust and crumb with the use of the IR spectroscopy method. AOA of powdered sea buckthorn depended on the amount of phenolic compounds and ascorbic acid in them: peel > marc > seeds. Antioxidant properties of BPs decreased in the following order were aligned the following way: BP with marc > BP with peel > BP with seeds. They displayed higher AOA than was theoretically calculated, depending on the amount of powders in the recipe. Increase of the baking temperature led to the loss of phenolic compounds and vitamin C, as well as to the formation of poly lactams. BP baked at the temperature regime of 200°C displayed the greatest AOA.

**Key words:** sea buckthorn, peel, seed, marc, bakery products, antioxidant activity, lactams.

## Investigation of microflora of the Shubat - Kazakh National fermented dairy product produced from camel milk

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**Abstract.** In certain countries of the world, camel milk is used for food in equal amount as cow's milk. Shubat is the national food product in Kazakhstan produced from camel milk. Traditionally shubat is obtained by spontaneous fermentation of camel's milk under the influence of native microflora. The objects of the present investigation are the camel milk from the southern region of Kazakhstan and the shubat which is produced from spontaneous fermentation of camel milk. The aim of the search are to study the microflora of the camel milk, which causes its spontaneous fermentation. During the experiment, the dynamics of acid accumulation by the change in active acidity (pH) and titratable acidity ( $^{\circ}$  T) was determined in the ranges of 3.8 to 4.2 and from 25.4 to 29.3, respectively. This was made from camel milk in the process of spontaneous fermentation. Shubat is the result of lactic and alcoholic fermentation, the last of which causes the finished product an increased acidity and a high degree of gassing. To enumerate and identify microorganisms causing spontaneous fermentation, shubat was sown into the following nutrient media: MRS, MPA, and Czapek's medium, where the temperature was maintained at 36  $^{\circ}$ C, 30  $^{\circ}$ C and 30  $^{\circ}$ C respectively for 48 h. As a result of this study, the prevailing microflora of the shubat was detected. It is arguable that the microflora of camel milk, which causes its spontaneous fermentation, mainly contains yeast (*Candida kefir*, *Debaryomyces hansenii*, *Pichia anamala*, *Saccharomyces cerevisiae*, *Rhodotorula rubra*.) and lactic acid bacteria (*Lactobacillus plantarum*, *Lactobacillus kefir*, *Leuconostoc mesenteroides* ssp. *Dextranicum*). It should be taken into account that the shubat is formed as a result of spontaneous fermentation of thermally unprocessed camel milk and thus, it was necessary to investigate it from the stand-point of safety. The result of the study constitutes the fact of absence of pathogenic microorganisms, such as *Salmonella*, *Shigella*. In the future study, the identification of individual strains of bacteria will allow us to simulate a starter microflora for the production of safe camel milk based fermented product on an industrial scale. This study will make a significant contribution to improving food safety in arid regions of Kazakhstan and other countries of the world where camel milk based products are popular.

## Effect of impact-activating-disintegration treatment on grain protein fraction of autumn rye

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**Abstract.** This paper studies the distribution of rye protein fractions according to their mass and amino acid composition while milling by machines with different work tools. The research was conducted on the autumn rye of harvest year 2017 with kernel moisture content of 8%. Cereals were milled in the machine of an impact-activating-disintegrating type DEZI-15 with three-row and five-row rotors which rotate at  $120 \text{ s}^{-1}$ , and in the laboratory mill with a knife-rotor work tool. The milling grain size was determined by a diffraction-type grain analyser MalvernMastersizer 2000. The average grain size obtained from three-row disintegrating rotor was  $167 \mu\text{m}$ , from the five-row rotor –  $158.1 \mu\text{m}$ , and from the laboratory knife-rotor mill –  $384 \mu\text{m}$ , respectively. The free amino acids composition in flour samples was investigated using the size exclusion chromatography method (SEC-method). The polypeptide composition of total grain protein has been determined by One-dimensional SDS-acrylamide gel electrophoresis. According to the electropherogram results obtained from all the the content of high-protein fraction of 200 kDa. The glutelin fraction with molecular weight of 116.25 kDa is definitely observed in the sample obtained from the three-row disintegrating rotor. Whereby the lowest glutelin content has been detected in the flour sample obtained from the five-row disintegrating rotor. Fractions with molecular weight of 60–75 kDa – globulin fractions - come up frequently in the sample obtained from the three-row disintegrating rotor. Prolamine fractions of 45–47 kDa are clearly observed in the flour sample obtained from the laboratory knife-rotor mill. The albumin fraction with molecular weight of 17–28 kDa are mostly observed in the samples obtained by three-row and five-row disintegrating rotors. Few LMW fractions (from 6.5 to 15 kDa) are found in samples obtained using the impact-activating-disintegrating technique, mostly – in the sample milled in the laboratory knife-rotor mill. Based on the data of free amino acid content in sample investigated it can be concluded that the impact-activating –disintegrating techniques does not cause reduction in protein biological value.

The albumin rich flour milled in the disintegrator can be used for production of functional food. Due to the low content of glutelin protein fraction the flour obtained from the five-row disintegrating rotor offers the greatest promise for production of gluten-free foods.

**Key words:** impact-activating-disintegrating technique, autumn rye, protein fractions, amino acid composition, biological value foods.



## Encapsulation of Gallic acid in solid lipid core surrounded with maltodextrin shell

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**Abstract.** Multiple phase capsules had been prepared in a single spray drying process. The main goal of the present study was to investigate whether the conversion of a portion of the modified starch (wall material used in spray drying) to resistant starch (RS) would offer added protection of encapsulated material. To achieve this, dry gallic acid (GA; a model water soluble phenol compound used in the present study) was initially dispersed in palm oil and stabilized with Polyglycerol Polyricinoleate (PGPR 4175) as an emulsifier. This dispersion was homogenized with a modified starch (MS, dextrose equivalent of 15) solution, that was previously treated with high pressure and increased temperature to achieve starch retrogradation, and then spray dried. It was possible to produce only small amounts of RS from modified starch, varying from 0.1 to 0.2% of total carbohydrate content. GA content in the lipid phase of the capsule was determined by lipid droplet size in the O/W emulsion (the feeding solution), as smaller droplets results in the significantly bigger surface area, and more intensive GA diffusion from O to W phase. Maltodextrin shell wall was able to prevent leaking of the melted palm oil form the capsule core to the surface during seating tests, preventing agglomeration of capsules. This could be very important for the storage/transportation of capsules in the uncontrolled temperature conditions.

**Key words:** gallic acid, spray drying, encapsulation, resistant starch.

## Inoculation technology for legumes based on alginate encapsulation

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**Abstract.** The main purpose of seeds inoculation is to provide the sufficient number of viable efficient bacteria that are able to actively colonize the plant roots immediately after germination. One of the promising forms of bacterial preparations is cells encapsulation in the polymer gel. Advantages of using alginate microspheres are slow, controlled release of bacteria, biodegradation in the soil and an increased shelf life. As a result of this study the effectiveness of using capsulated biopreparation was established to increase the nitrogen-fixing potential of legumes. The advantage in colonization activity is shown in comparison with other forms of the biopreparations due to the slow release of rhizobium from the capsules. The optimal composition for formulation is established which ensures the storage of biopreparation for more than 1 year. The prospect of using encapsulated biopreparations under adverse environmental conditions and for joint application with chemical pesticides and agrochemicals is analyzed.

**Key words:** biopreparations, encapsulation, sodium alginate, legume crops, inoculation.

**ACKNOWLEDGEMENTS.** This work is partially financially support by Project №14.607.21.0178 at 26.09.2017 (RFMEFI60717X0178) "Creation of microbiological preparations for expanding the adaptive potential of crops for nutrition, resistance to stress and phytopathogens". Work of E.N. Shcherbakova, A.V. Shcherbakov, S.A. Mulina, L.M. Yahina, Yu. V. Lactionov, V.K. Chebotar was supported by grant of Federal Agency of Scientific Organizations N0664-2018-0028.

## Comparison of power consumption of a two-roll mill and a disc mill

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**Abstract.** Grinding or milling is often used process, for example in the production of feed, grinding of malt in beer production, grinding of cereals on flour, etc. In order to optimize the energy intensity of the whole production process, it is necessary to know the energy consumption of individual processes. The grinding of malt influences the mashing process, the drawing-off and the boiling yield. Correct grain grinding makes the endosperm available for enzyme and physicochemical reactions during wort production. Husks affect the drawing-off process. Two-, four- or six-roll mills, in some cases a hammer mill or disc mill, are most commonly used for grinding of malt. Power consumption was monitored when light, Munich, caramel and coloring malt were grinding. A two-roll mill and a disc mill with engine speeds of 1,500 rpm and 2,800 rpm were used for grinding. The gap between the mill rollers and the mill disks was set to 0.4 mm. The fineness of the grinding was evaluated for all types of malt on all used equipment. The energy intensity of the grinding was correlated on 1.0 kg of malt and then compared.

**Key words:** malt, grinder, dispersant, electrical power, mechanical power.

## Single cell protein production from waste biomass: review of various agricultural by-products

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**Abstract.** Agricultural waste constitutes for most of the manmade waste streams. Processing of biodegradable waste materials ensures the treatment of harmful substances and allows to reduce environmental pollution. In addition, conversion of these waste materials in value-added products makes these recycling methods more economically viable. Single-cell protein is one of the value-added products that can be produced by microbial fermentation of waste materials. In this review various biodegradable agricultural by-products as substrates for production of SCP are categorized and compared.

**Key words:** single cell protein, waste biomass, agricultural by-products, resource availability, aquaculture, fish feed, fish meal.

## A study of dynamics of bitter acids and xanthohumol in hop pellets during storage

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**Abstract.** Eight varieties of hop pellets were analyzed for the contents of  $\alpha$ -acids,  $\beta$ -acids and xanthohumol according to the EBC 7.7 analytical method. The pellets were extracted with acidified mixture methanol – diethylether and analyzed using HPLC with a diode-array detector and a Nova-Pak column C<sub>18</sub>. Four series of analyses were performed: immediately after the unpacking of the pellets and then after five, seven and nine months of storage at 4°C. According to the first series of analyses, the contents were assayed as following ( $\alpha$ -acids,  $\beta$ -acids, xanthohumol resp., all in weight % in pellets): Galaxy (13.4, 8.0, 0.74), Citra (11.1, 3.0, 0.48), Tradition (8.2, 8.0, 0.58), Cascade (4.5, 5.2, 0.25), Northern Brewer (4.0, 2.9, 0.37), Sládek (3.5, 4.0, 0.48), Saaz (2.0, 3.4, 0.24), and Triskel (1.7, 3.6, 0.18). According to these results, variety Galaxy was found as the richest in all three parameters. After nine months of storage at 4°C, the weight loss of  $\alpha$ -acids ranged from 4.1% (Citra and Triskel) to 66.4% (Galaxy). The losses of  $\beta$ -acids and xanthohumol were less distinctive (from zero to 31.3% and 25.7%, resp.) and indicated good long storage possibilities of these compounds at convenient conditions (darkness, low temperature, elimination of direct influence of oxygen).

**Key words:** hop pellets, hop varieties, storage,  $\alpha$ -acids,  $\beta$ -acids, xanthohumol, HPLC.

**ACKNOWLEDGEMENTS.** The work was supported by the SGS Grant Agency of Faculty of Agrobiolgy, Food and Natural Resources, CULS Prague.

## Cadmium-induced oxidative damage and protective action of fractioned red beet (*Beta vulgaris*) root juice in chickens

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**Abstract.** Cadmium (Cd) is one of the most dangerous environmental bioaccumulative pollutants that affects many organs in humans and animals. Present investigation was conducted to evaluate the protective effect of fractioned red beetroot juice on Cd-induced oxidative stress in chickens. The named red beetroot juice fraction (BJF) was received by juice ultrafiltration. Per oral administration of BJF for 10 days followed by dietary Cd exposure (50 mg·kg<sup>-1</sup> of diet) was evaluated in the *in vivo* experiments in chickens. The prominent increase of Cd concentration in blood plasma, liver and kidney provoked the rise of oxidative processes activity in organs. BJF treatment attenuated the Cd-induced oxidative stress. The changes of oxidative stress markers - the reduction of hepatic and kidney malondialdehyde amount, the increase of glutathionperoxidase level in liver and blood catalase activity indicated the possible antioxidative influence of BJF. Chickens exposed to Cd showed no evidence of clinical toxicity, but exhibited some features of adverse action of this heavy metal. The increase of uric acid concentration in blood serum is associated with protein catabolic processes intensified by Cd affect. Suppressive effect of Cd on the immune response in chickens manifested in alteration of cell and humoral immunity parameters. The data of the most investigated oxidative stress markers, biochemical and immunological indices in Cd-exposed chickens were almost back to the values, when received BJF *per os* during 10 days. Administration of fractioned red beetroot juice to Cd-treated chickens prevented the oxidative impact of this heavy metal and provided immunomodulating effect.

**Key words:** oxidative stress, cadmium, red beetroot juice, antioxidative effect, chickens.

## Meat chemical composition of pasture pure lambs and crossbreeds

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**Abstract.** Increased customer interest of safe, healthy and environmentally friendly food consumption promote development of sheep farming industry in Latvia. Aim of the paper – explain of different pasture-fattened sheep breed and their crosses lamb meat composition traits. A study of pasture fattened lamb meat chemical composition was carried out from year 2013 to 2017. Fattening lambs were kept in breeding rams control station ‘Klimpas’ (57°50’58.8’’N 25°19’39.6’’E) pasture array. Lambs were slaughtered in a certified slaughterhouse, but analysis of meat chemical composition were conducted in laboratory of Institute of Food Safety, Animal Health and Environment (BIOR). For the analysis of the meat chemical composition were used up to 1 kg heavy *Quadriceps femoris* muscle samples. In meat were analysed following elements of its chemical composition: dry matter, protein, fat, minerals, pH, cholesterol and unsaturated fatty acids. Data analysis shows that the lambs before slaughter ranged in age from 5 to 8 months. Lamb meat obtained from the study groups had a significantly different total amount of dry matter and fat. The lowest total fat, but the highest ash content was obtained in the lamb meat of the extensive breed group. The lowest total fat and the highest ash content were obtained in the lamb meat from the extensive breed group. In meat obtained a small (in individual samples <0.10%) cis-10-pentadecenoic acid, cis-11-eicosenoic acid and myristoleic acid content. Of unsaturated fatty acids in lamb meat were represented higher amount of oleic acid, linoleic acid and elaidic acid.

**Key words:** breeds, lamb, pasture, meat, composition.

**ACKNOWLEDGEMENTS.** Latvia Republic Ministry of Agriculture founded study ‘Different sheep breed and their crossbreed suitability to quality carcass and lamb meat production’.

## Individual Product Code as a tool of control quality and management of technological processes of meat products

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**Abstract.** In the modern world the tense ecological situation has increased the problem of contamination of food and raw materials by xenobiotics of chemical and biological origin. One of the forms of the system approach to ensuring the safety of food production is the management system based on the principles of HACCP-Hazard Analysis and Critical Control Point. Evaluation, risk analysis and risk management should be integrated into the corporate governance process as one of the important components, taking into account the relevant strategy, tactics and operational implementation. It is important not only to manage the risk, but also to periodically review the risk management measures such as the prevention, reduction and compensation for damage. Not all food industry enterprises use the HACCP methodology as a model for quality and safety management. Particular attention should be paid to the meat processing industry, because meat is one of the products that is most susceptible to various types of pollution at any stage of production. In many factories and livestock complexes, the HASSP-MEAT system is already in operation. The quality of products at such enterprises, as experts say, has really increased significantly, which allows us to conclude that the development and implementation of this system is effective. As a quality control tool, the development of the PIC-Product Individual Code was considered. It is not only an in-factory system that fixes where, when raw materials were received for each product, who took it, conducted analysis and worked at every stage up to the delivery, but also a unique system feedback from the buyer. The PIC system allows to cover the entire path of moving the product from the enterprise to the store. In the process of research, a comparative analysis of the work of the enterprise was carried out based on the principles of HACCP-MEAT and traditional principles.



## Comparison of phenolic compounds and antioxidant activity of fresh and freeze-dried potatoes

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**Abstract.** Potatoes (*Solanum tuberosum* L.) contain a wide range of compounds with health benefits, and different techniques have been developed for the determination of these compounds. Freeze-drying is a common method for the preservation and preparation of samples for the analyses of bioactive compounds, but it is well known that drying influences the composition of food products. The aim of the current study was to compare phenolic compounds and antioxidant activity of fresh and freeze-dried potatoes. In the experiment 11 cultivar potatoes grown in experimental fields of the Institute of Agricultural Resources and Economics in 2016 were analysed. Potatoes were freeze-dried. Homogenized fresh and freeze-dried samples were extracted with an ethanol/water (80/20 w/w) solution. Total phenolic content (TPC) was determined using the Folin-Ciocalteu method, and the antioxidant activity was evaluated using 2,2-diphenyl-1-picrylhydrazyl (DPPH<sup>•</sup>) and 2,2'-azino-bis(3-ethylbenzothiazoline-6-sulphonic acid) (ABTS) assays. The highest TPC and radical scavenging activity were determined in cultivars 'Peru Purple' and 'Blue Congo' potatoes. Freeze-drying influenced all the tested parameters but more significantly the TPC, and for certain cultivars a reduction of more than 30% was observed. A strong correlation between TPC, DPPH and ABTS in fresh and freeze-dried samples was observed,  $r = 0.81$ ,  $r = 0.93$ ,  $r = 0.92$ , respectively. It could be concluded that the effect of freeze-drying on TPC and antioxidant activity is cultivar dependent.

**Key words:** potatoes, phenolic compounds, antioxidant activity, freeze-drying.

**ACKNOWLEDGEMENTS.** National Research Programme 'Sustainable agricultural resources of high quality and healthy food production Latvia (AgroBioRes)' (2014–2017). Project No. 4 'Sustainable use of local agricultural resources for development of quality and healthy food product development (FOOD).

## Optimisation of biologically active compounds ultrasound assisted extraction from potatoes using response surface methodology

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**Abstract.** Potato (*Solanum tuberosum* L.) is source of phenolic compounds and from plant matrixes can be extracted by several methods. In recent years ultrasound assisted extraction has become more popular due to its efficiency for recovery of phenolic compounds and antioxidants and response surface methodology is an effective tool for optimisation of extraction procedure by evaluating different variables and their interaction. The aim of the current research was to optimize ultrasound assisted extraction of biologically active compounds from potatoes by response surface methodology. For experiment purple-flesh potato variety 'Blue Congo' was selected. Control sample was extracted by stirring for 1 hour. Box-Behnken design was used for optimization of extraction conditions from fresh potatoes and as variables were selected: ethanol concentration (% v/v), hydrochloric acid concentration (molarity) and time (min). For extracts as responses total phenolic, total flavonoid, total anthocyanin content and antioxidant activity (DPPH, ABTS+ scavenging activity) were determined using a spectrophotometric methods. Significant models were obtained for anthocyanins, total phenols and DPPH radical scavenging activity. Optimisation of extraction showed that for maximising all responses optimal HCl concentration is 2.5M, ethanol concentration 79.4% and extraction time 60 minutes, resulting in following responses: 57.41 mg 100 g<sup>-1</sup> of anthocyanins, 238.52 mg 100 g<sup>-1</sup> of TPC, 24.58 mM TE 100 g<sup>-1</sup> of DPPH scavenging activity and 12.99 mM TE 100 g<sup>-1</sup> of ABTS scavenging activity. Conventional extraction method showed significantly lower results. It could be concluded that ultrasound assisted extraction is effective method for recovery of phenolic compounds and solvents and extraction time is significant parameter influencing efficiency.

**Key words:** purple-flesh potatoes, phenolics, ultrasound assisted extraction, response surface methodology, Box-Behnken design.

**ACKNOWLEDGEMENTS.** Present research has been supported by the program 'Strengthening Research Capacity in the Latvia University of Life Sciences and Technologies' project 'Effect of storage conditions and processing technology on dynamics of secondary metabolites in potatoes tubers' (Z16).

## A study of commercial $\beta$ -galactosidase stability under simulated *in vitro* gastric conditions

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**Abstract.**  $\beta$ -Galactosidase activity in milk may be affected by several factors, such as temperature, pH, milk composition, and metal ions. It is important to note that digestive proteases and gastrointestinal pH can affect enzyme activity during transit through the gastrointestinal tract. For the investigation of commercial  $\beta$ -galactosidase stability in human and animal gastric tracts, human gastrointestinal tract (GIT) models were employed, enabling prediction of enzyme activity under *in vivo* conditions. The aim of this study was to analyse and compare commercial  $\beta$ -galactosidase stability under simulated *in vitro* gastric conditions. Commercial enzymes (Ha Lactase 5200 produced by *Kluyveromyces lactis* and NOLA™Fit5500 produced by *Bifidobacterium bifidum* expressed in *Bacillus licheniformis*, Chr. Hansen, Hørsholm, Denmark; GODO-YNL2 produced by *Kluyveromyces lactis*, Danisco, Copenhagen, Denmark) were used for this study. Commercial enzymes were added to GIT models at 1 and 5 mL L<sup>-1</sup>. The enzyme activity was assessed as the percentage of lactose hydrolysis by the enzymes from *Kluyveromyces lactis* and *Bacillus licheniformis* using HPLC after digestion.  $\beta$ -Galactosidase extracted from yeast (*Kluyveromyces lactis*) and bacteria (*Bacillus licheniformis*) was found to be effective as a strategy for improving lactose tolerance.

**Key words:**  $\beta$ -galactosidase, simulated gastric conditions, lactose hydrolysis.

**ACKNOWLEDGEMENTS.** The research was supported by project ‘Strengthening Research Capacity in the Latvia University of Agriculture’. Contract No. 3.2.-10/2017/LLU/27. We acknowledge the Leprino Foods Professor of Dairy Science, Dr. David W. Everett from California Polytechnic State University, for providing advice on data interpretation.

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