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# I AGRICULTURAL ENGINEERING

## Experimental analysis of iot based camera si-ndvi values for tomato plant health monitoring application

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**Abstract.** This paper reveals an IoT based camera design to capture SI-NDVI parameters and describes first obtained data analysis regarding luminary spectrum impact on readings in real greenhouse application. For experimental comparison, measurements of Encore, Strabena, Audiance, Bolzano, Forticia and Chocomate tomato plants, both for the "best" and the "weakest" plant sample, using IoT based camera solution and portable leaf spectrometer. First experimental results show that this approach can be applied for tomato plant monitoring, and reveals some ideas about possible precision improvements.

**Key words:** SI-NDVI, tomato plant, industrial greenhouse, precision agriculture, IoT.

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## Theory of grain mixture particle motion during aspiration separation

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**Abstract.** The practice of separating grain mixtures with the use of the difference in the aerodynamic properties of their components has proved that the process of separating mixtures in the aspiration separator is the most promising one with regard to the improvement of quality and intensification of production. The authors have developed a new improved design of aspiration seed separators, in which the work process of separating seed material is performed with the use of vibration processes. In this seed material separator, the constant force air flow that acts on the sail members on the central pipe of the separator, when seeds are fed for processing, generates self-excited oscillations in the pipe, which produces centrifugal forces of inertia in the seed feeding system. As a result of the mentioned effect, the propelling force in the process under study substantially increases, accelerating the seeds of different fractions, which differ in their masses, to different velocities. The motion paths of the seed particles change accordingly, heavier particles moving closer to the vertical axis of the aspiration channel, which provides for increasing the efficiency of separation of the seeds of different fractions from each other. In this paper, a new mathematical model is developed for the motion of a seed mixture material particle in the operating space of the separator's aspiration channel. The mathematical modelling of the process of vibration and aspiration separation has indicated that the separation of the motion paths of the medium and heavy fractions takes place within the range of 20-40 mm; the flying speed of the particles is equal to 3.2-8.0 m·s<sup>-1</sup>, respectively; and their acceleration is equal to 1.8-3.3 m·s<sup>-2</sup>, which provides the necessary conditions for the accurate and high quality separation into the required fractions. In view of the found differences between the kinematic characteristics of the separated fractions of the grain mixture, the diameter of the pipeline for the medium fraction is to be within the range of 90-100 mm, for the heavy fraction – 50-70 mm.

**Key words:** air flow; aspiration separator, material particle, seed, mathematical model.

## The theory of vibrational wave movement in drying grain mixture

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**Abstract.** This paper outlines a theory that involves the vibrational wave transportation of bulk grain during the course of passing that grain under an infrared radiation source, in a working thermal radiation drying chamber, and using a vibrational wave transporter belt that has been developed by the authors of this paper. The main outstanding feature of the proposed design is the presence of mechanical off-centre vibration drives which generate the vibration in the working rollers at a preset amplitude and frequency, thereby generating a mechanical wave on the surface of the flexible transporter belt which ensures the movement of bulk grain along the processing zone which itself is being subjected to infrared radiation. A calculation method was developed for the oscillation system that is used in conjunction with the vibrational transportation of the grain mass, in order to be able to determine the forces that may be present in the vibrational system and to prepare the differential calculations for the movement of the vibrational drive's actuators, utilising for this purpose Type II Lagrange equations. The solving of the aforementioned integral equations on a PC yielded a number of graphical dependencies in terms of kinetic and dynamic parameters for the vibrational system described above; the analysis of those dependencies provided a rational structural, along with kinetic and dynamic indicators. According to the results that were taken from theoretical and experimental studies on the functioning of the developed infrared grain dryer combined with a vibrational exciter, stable movement for its working roller takes place if the angular velocity of a drive shaft is changed within the range of between 50-80 rads<sup>-1</sup>, whereas the amplitude of the indicated oscillations falls within the range of 3.0-4.0mm. It has been discovered that a rational speed when transporting soy seeds during infrared drying falls between the range of between 0.15-0.60cms<sup>-1</sup>, whereas the amplitude of the indicated oscillations falls within the range of 3.0-4.0mm. An increase of this parameter within the stated limits increases the time that it takes to achieve the stage in which a constant drying soy speed is reached by more than 2.5 times (from 205 seconds to 520 seconds), stabilising the figure at a level of 520 seconds, which makes it possible to recommend a range of transport speeds of between 0.15-0.40cms<sup>-1</sup> under infrared radiation for the seeds in order to achieve the required moisture content with a single pass of the produce on the wave transporter. With that in mind, the power consumption levels for the vibrational exciter do not exceed 50W, while the angular velocity of the drive shaft's rotation falls within the range of between 100-120 rads<sup>-1</sup>. The results of the experimental study that has been conducted indicated that a rational transportation speed for the soy seeds on the wave transporter under infrared radiation is between 0.15-0.40cms<sup>-1</sup>

**Key words:** drying, grain, kinetic and dynamic parameters, model, quality, transportation.

## Theory of motion of grain mixture particle in the process of aspiration separation

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**Abstract.** The paper describes the development of a mathematical model for the motion of a seed mixture particle in the aspiration channel of the separator after the particle passes the cone-shaped spreader and enters the workspace of the aspiration channel in the pneumatic dynamics and vibration unit devised by the authors. The unique feature of the proposed new design is the presence of the central pipe with sail members in the aspiration channel. The sail members in the air stream generate the self-oscillatory mode of motion of the central pipe, which results in the efficient separation of the grain seed mixture into the required fractions. On the basis of the prepared equivalent schematic model, the differential equations of the motion of a seed mixture particle in the process of aspiration separation have been generated. Basing on the results of the PC-assisted numerical modelling of the motion paths, on which the material particles (seeds) of the heavy and medium fractions travel, it has been established that they move on different courses, and the course of the heavy fraction seeds is such that, after they pass the cone-shaped spreader and advance further in the air stream through the space of the aspiration channel, they move closer to the pipe of the aspiration channel. Also, their velocities and accelerations are greater than the same kinematic parameters of the medium fraction seeds. The seeds of the light fraction move upwards under the action of the air stream and leave the aspiration separator at its top.

**Key words:** air flow, aspiration channel, grain seed mixture, material particle, separation.

## Theoretical and experimental research into impact of threshing tools in combine grain harvesters on quality of cereal crop seeds

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**Abstract.** The theoretical and experimental research into the micro-damaging of cereal crop seeds in the process of their harvesting by combine grain harvesters in relation to the strains, forces and stresses imparted to them by the threshing tools has been carried out. The propagation of deformations and cracks in the seeds as well as the nature of their strength and the damage that is sustained, when the critical load is applied, have been investigated. It has been established that the onset of cracks, the direction of their propagation and their quantity in the bodies of grain seeds depends in the majority of cases on the direction of action of the external forces and the specifics of the seeds' internal biological properties. It has been established that the strength of the grain seed is, apart from the arisen cracks, also under the significant effect of the microtraumas in the germ, endosperm as well as the seed coat and shell. Theoretical calculations have been carried out on the PC and the effect that the drum and rotor threshing apparatus have on the deformation and damage sustained by cereal crop seeds has been substantiated. The said calculations and the obtained graphic relations support the results of the experimental investigations and prove that the macro- and especially micro-damage sustained by the seeds of winter wheat and rye is different, when they are threshed with the use of different types of threshing apparatus, which has a considerable impact on the final quality of the harvested cereal crop seeds. The results obtained in the experimental investigations, field and laboratory tests on the topic of the effect of mechanical loading on the sustained damage and quality of seeds indicate that the damage rate accounted for the work processes of the reaping and postharvest treatment of the cereal crop heaps of different winter wheat varieties with the use of rotor threshing apparatus is 3.1% as compared to the drum threshing apparatus – 6.4%, that is, 2 times lower. The total amount of the seeds with microtraumas collected in the hopper after threshing amounts to 23.0% and 54.0%, respectively, which is a significant difference. Similar results have been obtained in the experimental investigations on the effect of the equipment on the sustained damage and quality of seeds in the cleaning, chemical treatment and sowing of cereal crops.

**Key words:** damage, deformation, drum and rotor threshing apparatus, grain, quality, seed, strength.

## **Electric infrared heating panels as an alternative source of heating for greenhouses**

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**Abstract.** The aim of this article is to show the possibilities of supplementary heating of greenhouses. There was used for this research an electric infrared heating panel ITA 700. The average total power was 630.8 W in laboratory measurements, of which 504.3 W has been transferred by the front part of the panel, of which 267.2 W has been transmitted by radiation. The total radiation efficiency of the front part was 42.4%. Similar measurements have been carried out in an experimental greenhouse (length 24 m, width 3.5 m). Approximately 448 W of average total power 603.7 W has been transferred by the front part of the panel, of which 159 W has been transferred by radiation. The total radiation efficiency of the front part was 26.3%. Differences between measured surface temperatures confirmed the influence of panel radiation on the flower bed. The average temperature in the soil (9°C) shows that the influence of heating is mainly on the surface of the flower bed, where it could protect cultivated plants during the lowest temperature period. The obtained results can be useful for choosing suitable panel parameters for the placement in small horticultural or hobby greenhouse.

**Key words:** convection; heat transfer; low temperature; measurement; radiation; soil.

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## **Design of modified movement planning system as a component of an intelligent planning system for robot manipulator**

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**Abstract.** Different fields of industry and in-service support widely use robots, mechatronic and robotic technology systems in their activities. This is related to growing functionalities that result from using more advanced control systems the development of which is based on available achievements in the technical measures of computing. Therefore, the subject of study in this article was movement of a robot manipulator in using a fuzzy logics and neural network, and the goal of the study was to develop methods for designing combined intelligent planning and control systems for robot-manipulator movement in static dynamic environments based on the combined use of fuzzy logic apparatus and artificial neural networks to reduce the possibility of robot-manipulator's joints colliding into unknown obstacles located in its operating area. Based on this, the robot arm model has been developed after calculating in the article the missing parameters of the experimental robot manipulator in order to analyze the peculiarities of using the fuzzy logics device as well as the specifics and challenges of using neural network. As a result of the study performed in the article, significant data were obtained based on which a method was offered for an intelligent system for planning robot manipulator movement in static environment using a fuzzy blocks, which was characterized by the use of neural network corresponding each block, and localization of each solution to the task of planning robot manipulator movement in each specific situation, which enables to improve the accuracy and efficiency of movement planning.

**Key words:** static environment, intelligent planning system, neural network, robot manipulator, fuzzy logic.

## Thermal performance of a solar hybrid dryer for conilon coffee (*coffea canephora*)

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**Abstract.** The study was aimed at design and development of an energy efficient hybrid solar dryer suitable for drying of organic Conilon coffee placed in the town of Seropédica, Rio de Janeiro, Brazil. The energy efficiency and the drying efficiency were the evaluation criteria for thermal performance of the hybrid solar dryer during the coffee drying. Temperature and relative humidity (RH) of the drying and ambient air, solar radiation intensity and coffee weight loss were monitored during the drying process. The process occurred over six consecutive days, the drying time was from 07:00 to 17:00 h, totalling 120 h of operation with an intermittent period (at night) of 14 h. During intermittence, the exhaust system kept off and solar collector and drying chamber sealed. The effective drying period took 60 h, with temperature and RH, respectively, of 38.3 °C and 60.6% outlet of the solar collector, 32.7 °C and 72.2% outlet drying chamber and 27.8 °C and 74.5% ambient air. The maximum temperature in the solar collector and drying chamber reached 53.8 and 41.6 °C, respectively, with an ambient air temperature of 31.6 °C at 12:00 h. These values showing temperature increase 22.2 °C in solar collector and 10 °C drying chamber. The mean variation for the reduction in RH between the drying air inside the solar collector and the ambient air was 28%, while in the chamber obtained in a range of 10.5% at 13:00 h. The solar collector and dryer chamber efficiency were 29.1 and 40.8%, respectively, while the overall dryer efficiency 43.2%.

**Key words:** organic Conilon coffee, drying, sustainable processing, energy efficiency.

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## Variation in the mass and moisture content of solid organic waste originating from a pig complex during its fermentation

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**Abstract.** The focus of the study was the fermentation of an organic waste mixture originating from a pig-rearing complex. The organic waste was processed in the laboratory-scale drum fermenter. Through the fermentation process, the fermented material was weighed by a system of four strain gauges installed under the fermenter. In our previous study, the following initial mixture characteristics were justified to have the fermentation process going – 65% to 70% moisture content and 400–600 kg m<sup>-3</sup> density. The optimal operation mode of the fermenter was identified depending on the initial mixture composition – aeration frequency of 5 min h<sup>-1</sup>; air consumption of 11.3 m<sup>3</sup> h<sup>-1</sup> per 1.7 m<sup>3</sup> of the fermenter volume; drum rotation interval – three times every 12 hours. Under this operating mode, the mass loss was 3% already on the third fermentation day and 7% – on the fifth day. As a result, the mass of the finished organic fertiliser was 9% smaller than that of the loaded mixture. The moisture content of the processed material also decreased: under the average moisture content of the loaded mixture of 68.7%, the average moisture content of the organic fertiliser was 66.4%. Based on the resulting experimental data, the mathematical models describing the dependence of the mass and moisture content of the processed material on the fermentation time were created. The study outcomes allow concluding that the solid-state aerobic fermentation is one of the promising options for the utilisation of the solid fraction of pig slurry.

**Key words:** organic waste, slurry, organic fertiliser, fermentation, mass, moisture content.

## **Airflow profile study of a compost dairy barn using a low-cost 3D-printed anemometer network**

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**Abstract.** Mechanical ventilation is commonly used for environmental thermal regulation inside closed-field agricultural production systems. Analyzing the air distribution inside these facilities and the correct operation of the fans can be a challenging. This could be determined using cost prohibitive techniques as particle image velocimetry or deploying large wind sensors networks on-site. To avoid this limitation without a lack of measurement accuracy, this research was focused on developing and test a low-cost anemometer network based in low cost propeller's anemometers, built using fused 3D-printed and open-hardware platforms. Four propeller anemometers with three to six blades were simulated using the 6-DOF method of ANSYS computer fluid dynamics software. Similar results were obtained for all the simulated models with minor differences. Anemometers were tested in an open circuit wind tunnel before to be evaluated in two open compost dairy barn building using high-volume low-speed and low-volume high-speed fans. Data were analyzed by employing contour maps, descriptive statistics and correlation. The results show that the anemometer network determines the fan's wind profile for wind speeds over  $0.7 \text{ m s}^{-1}$  and it was possible to determine the facilities spots with ventilation problems. The proposed anemometer network and methodology are a good alternative to analyze the operating conditions of the tested agricultural facilities and optimize its performance.

**Key words:** Ventilation optimization; CFD; wind tunnel; Arduino; sensor network; directional anemometer; compost barn.

## **II AGRICULTURAL ECONOMICS**

## **Sustainability indicators in cooperative management of recyclable materials**

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**Abstract.** Following the promulgation of the National Solid Waste Policy in 2010, legal provisions, government programs and sectoral agreements have been implemented, but without the expected efficiency in relation to recycling. It should be noted that Cooperatives of Recyclable Material Pickers (CRMP) should play a leading role in this regard, but they do not have adequate management to be economically, socially and environmentally sustainable, depending on assistance to maintain the activity. Aiming to elucidate this issue, in this paper was made an institutional diagnosis of the category of waste pickers using the Gramacho region in the city of Duque de Caxias (Rio de Janeiro) as a case study. It was carried out an evaluation of the historical context of the neighbourhood, and it was drawn up a semi-structured questionnaire in 12 of the 17 cooperatives in the region. The data were interpreted through a SWOT matrix and the Venn diagram. A matrix was proposed and elaborated with 15 sustainability indicators specific to the CRMC reality in order to evaluate and monitor the management of cooperatives. After collecting the primary data, it was possible to validate the matrix of indicators with indexes of cultural, economic, political and ecological sustainability of the cooperatives. It was found that the matrix of indicators facilitated the understanding of the data and the comparison between the indicators. This tool can help decision-making, creation of action plans and identification of demands by the cooperative waste pickers themselves, without the presence of an analyst or technician.

**Key words:** matrix of indicators, planning, pickers, solid waste.

**Acknowledgements.** We thank all the cooperatives that agreed to participate in the project.

## Typology of small producers in transition to agroecological production

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**Abstract.** Agroecology is now emerging as the fundamental science to guide the conversion of conventional production systems to more diversified and self-sufficient systems. The agroecological transition is defined as the gradual change that farmers undergo to adapt and move from more conventional towards agroecological farming principles, encompassing technological, societal, institutional and organisational changes in the food system. To analyze a transition process, it is initially necessary to understand how agroecosystems work (their structure and processes), and the different ways human beings intervene an ecosystem in order to transform it for productive purposes. Farm systems typology and classification techniques are used to guide strategic lines of research, sectorial policies, and promote sustainable development in response to farmer's needs. Determining multidimensional classification methods in agricultural systems is necessary, considering both the variables inherent to the production system and those of an external nature that indirectly impact the development and long-term sustainability of production systems. One of the purposes of this research was to characterize agricultural production based on sustainability systems and environmental, social, and economic indicators. The study was carried out based on data collected from 71 farm surveys, considering the social, economic, environmental, and technological dimensions. Multiple correspondence and cluster analysis were done. Three types of production systems were obtained: Group I, organic producers in transition; Group II, conventional producers in transition to organic production; and Group III, conventional producers interested in organic production. Producers need to focus on processes that allow them to improve their skills to develop human talent and social capital in terms of integration, collaborative work, trust, political and cultural capital, so that they can make progress easily and start implementing agroecological, infrastructure, and natural resources management practices, while improving their living standards. The information yielded by a typology process allows for us to know the current state of agricultural production systems based on the implementation of agroecological practices; thus facilitating the preparation and implementation of participatory plans and/or integrative proposals that promote agrofood sustainability.

**Key words:** sustainability, organic agriculture, rural development.

**Acknowledgements.** The authors would like to thank the research department of the University of Cundinamarca for the financial support for the execution of this research.

## Feasibility study of the grinding process of grain materials

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**Abstract.** For a comparative assessment of the effectiveness of various types of grinders of grain materials, various approaches are used. As the main criterion, the correspondence of the crushed material according to the particle size distribution can be taken as an indicator of the reliability of the grinding process. A comparative assessment of rotary crushers is carried out using the technical and economic indicator  $E_g$ , which is the ratio of total costs to the implementation of a given amount of work. Under the reliability of the grinding process, we have accepted the condition that the particle size distribution will comply with the requirements for agricultural feeding animals, which is possible while maintaining a rational gap between the stator and rotor riffles. The contradiction manufacturing techniques for the experiment are divided into: option No. 1 – steel 3 (HRC 10–12), option No. 2 – steel 45 (HRC 15–17), option No. 3 – hardened steel 45 (HRC 45–50), option No. 4 – steel 45 hardened and having a thin-film coating of FPH (finish plasma hardening), microhardness of 13 GPa. If reliability of the grinding process equal to 80%, wear on the fourth option, the cost was 1171 rubles/ton, which is 16% lower than the cost of the first version of the production of a rotor crusher equal to 1405 rubles/ton, respectively, this all speaks of the possible use of the proposed options for various forms of ownership of agricultural enterprises.

**Key words:** grain crushing, rotary crusher, working clearance, finished product quality, reliability of the grinding process, cutting element, wear resistance, feasibility.

**Acknowledgements.** The authors would like to acknowledge rector of FSBEI HE 'Stavropol State Agrarian University' V. Truhachev and the chairman of agricultural production cooperative 'Kazminsky' in the Stavropol Territory of Russian Federation S. Shumsky for comprehensive support in conducting research work.

## The impact of herd health on the efficiency of dairy farms

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**Abstract.** Maximization of profit is one of the main interests of any farmer. Profit depends on managerial decisions and many economic factors, but also on the health of the herd. Thus, it is important to study how different factors related to herd health impact farms' economic performance. The objective of this paper is to determine how herd health influences farm technical efficiency by comparing Estonian farm data from two periods, the years 2012 and 2017. Typically, the major herd health issues are related to udder problems, followed by reproduction issues and limb disorders. We used the FADN (Farm Accounting Data Network) database and data from Estonian Livestock Performance Recording Ltd. The two-stage mathematical approach was chosen as the research method. In the first stage the DEA (Data Envelopment Analysis) was used to estimate farms' technical efficiency. The output-oriented VRS (Variable Returns to Scale) approach was applied to the data of 64 farms. In the second stage, we used the FRM (Fractional Regression Model) to define which the technical efficiency drivers were among herd health and economic factors. The study revealed that major changes have occurred between the two periods analysed. The main herd health factors influencing farms' technical efficiency are the somatic cell count (SCC) and age at first calving.

**Key words:** dairy farms technical efficiency, herd health, DEA, FRM.



## **A simple tool for resource availability optimization: A case study of dairy whey supply for single cell protein and oil production in Latvia**

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**Abstract.** Single cell proteins (SCP) and oils (SCO) are promising alternatives for replacing conventional feed ingredients in animal and aquaculture fish feeds. The production costs of SCP and SCO need to be reduced by using inexpensive substrates (production by-products) suitable for cultivation of protein and oil producing microorganisms. This article reviews the availability of milk processing by-product – whey in Latvia, in 2019. Additionally, a simple production plant location optimization model is proposed, where no prior knowledge of location optimization or experience with dedicated software is required from the user. The case study demonstrated that the model is valid, and it can be used as a simple tool for resource acquisition from multiple sources to single production plant.

**Key words:** availability analysis, biomass supply chain, dairy waste, location optimization, whey.

**ACKNOWLEDGEMENTS.** The work has been supported by ERAF project KC-PI-2017/60 ‘Supercritical Omega-3 oil from production by-products’ managed by the Investment and Development Agency of Latvia (LIAA). Thanks to Central Statistical Bureau of Latvia for providing us with detailed data without which the creation of this publication would not have been possible.

## The spatio-temporal trend of rapeseed yields in Ukraine as a marker of agro-economic factors influence

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**Abstract.** The paper demonstrates the applicability of several statistical methods to the analysis and interpretation of the average rapeseed yield data. It proves our hypothesis that the general trend of rapeseed yield variations in Ukraine during 1991-2017 occurred due to agro-economic and agro-technological factors, which are the determinants of the revealed general trend. The temporal trend of rapeseed yield in most administrative districts can be described by a fourth-degree polynomial, namely, its characteristic points enabled us to describe and interpret the dynamics of rapeseed yields. The absolute term of the polynomial shows the initial conditions of the process, and its mapping allows us to identify the areas with the most favorable soil-climatic conditions for the rapeseed cultivation. Indicators of the maximum rate of growth and decrease of yields are the markers of stability of agro-ecosystems to the external influences. Therefore, the mapping of the maximum rate of decline and increase of yields reveal areas in which yields respond rapidly (increasing / falling) to the changes in agro-economic and agro-technological conditions, as well as areas where yields are more stable and change gradually. Thus, the form of the yield trend is determined by the influence of agro-technological and agro-economic factors, whose contribution to the fluctuation in rapeseed yields varies from 53% to 90%.

**Keywords:** yield, rapeseed, trend, dynamics, variability, agro-economic factors, agro-technological factors.

## **III BIOENERGY**

## Separation of reducing sugars from lignocellulosic hydrolysate: membrane experiments & system dynamic modelling

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**Abstract.** Separation of fermentable sugars after hydrolysis of lignocellulosic biomass plays a vital role in second-generation biofuel production. Byproducts and solid fractions generated during pretreatment and hydrolysis can have adverse effects on fermentation efficiency. Previous studies have shown that a maximum of 40% (w/w) of sugar yield can be obtained by sequential UF and NF permeate recovery. This study aimed to introduce a multi-step membrane filtration process to recover fermentable sugars while removing inhibitory bi-products. Fermentable sugar recovery was investigated using a recirculation flow between various stages of separation. The experimental results demonstrated that by introducing NF permeate recirculation to the UF unit a sequential UF/NF system can achieve 60% (w/w%) recovery of reducing sugars. Based on the experimental results, a “Simultaneous ultrafiltration and nanofiltration model” was developed using system dynamics. The model was used to predict the final sugar concentration and sugar yield using sugar permeability in each membrane as the dynamic variability. The model predicts that high sugar permeability (or selective permeability) through the ultrafiltration mostly affects the efficiency of the system, which still is a challenge.

**Key words:** lignocellulosic biomass, fermentable sugars, membrane separation, system dynamic modelling.

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## **Sorghum dry biomass yield for solid bio-fuel production affected by different N-fertilization rates**

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**Abstract.** The objective of this study was to examine the effect on the dry biomass yield of two different sorghum hybrids (H1 and H2) under five different N-fertilization levels (0, 70, 140, 210 and 280 kg ha<sup>-1</sup>) in a soil which was formed by lacustrine deposits of Karla Lake and is characterized from the downward movement of calcium carbonate from the surface horizons due to leaching (*Fluventic Xerochrept*) during 2017. The results demonstrated a significant effect ( $P < 0.05$ ) of fertilization only for one hybrid. Biomass yield ranged from 22.2 to 37.5 t ha<sup>-1</sup>. For both hybrids, sorghum accumulated a high amount of biomass in stems. Dry stem/total biomass ratio was rather constant throughout the different fertilization treatments achieving 81.6 and 77.5 % for the first (H1) and the second hybrid (H2), respectively. The second hybrid (H2) had a higher percentage of leaf biomass (20.1 vs. 13.8 %) than the first (H1), but lagged behind in seed production (2.4 vs. 4.6 %). Biomass dry matter partitioning and total dry weight are important selection criteria for energy crops, due to different gross calorific value and ash content but also because of the different economic importance they may have e.g. the seed is also used as animal feed. The above high biomass yields of sorghum, confirming the high potential of this crop, should be taken into serious consideration regarding land use planning, but further investigation for the gross calorific value and the ash content is needed as well as biomass characteristics that are quite important in case to improve the combustion process

**Keywords:** biomass, sorghum, dry weight, stems, leaves.

## **Study of transhydrogenase systems features in the mutants of the yeast *Pachysolen Tannophilus* for the production of ethanol and xylitol from agricultural wastes**

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**Abstract.** The key catabolic enzymes of D-xylose, an important structural component of different agricultural wastes, were studied in cells of mutant strains of the xylose-assimilating yeast *Pachysolen tannophilus*. The evaluation of catalytic activity and cofactor specificity of xylose reductase (EC 1.1.1.307) and xylitol dehydrogenase (EC 1.1.1.9) confirmed the dependence of intracellular catabolic pathway for D-xylose on the NAD<sup>+</sup>/NADP<sup>+</sup> ratio, formed under microaerobic conditions. The study of total activity of some NAD<sup>+</sup>/NADP<sup>+</sup>-dependent dehydrogenases revealed the metabolic characteristics of the yeast cells, which could ensure selective ethanol or xylitol production. Thus, the efficient involvement of D-xylose into the Embden–Meyerhof–Parnas pathway provided not only the high activities of xylose reductase and xylitol dehydrogenase, but also of 1-glycerophosphate dehydrogenase (EC 1.1.1.8) and lactate dehydrogenase (EC 1.1.1.27), respectively. The inhibition of activity of these enzymes led to selective production of xylitol from D-xylose. On the base of the experimental results, the principles of metabolic engineering of xylose-assimilating yeasts were formulated. The possibility of bioethanol and xylitol production from different agricultural wastes using xylose-assimilating yeasts are discussed.

**Key words:** agricultural wastes, D-xylose, mutants of the yeast *P. tannophilus*, xylose reductase, xylitol dehydrogenase, 1-glycerophosphate dehydrogenase, lactate dehydrogenase, ethanol, xylitol.

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## **A sustainable approach to boosting liquid biofuels production from second generation biomass resources in West Africa**

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**Abstract.** West African region has abundant second generation biomass resources consisting of agricultural residues, forest resources; municipal solid wastes; and animal wastes that could be harnessed to produce liquid biofuels. A number of countries in the region have developed energy policies to foster bioenergy production. Despite the national intent expressed in various countries' bioenergy policies, development of bioenergy facilities and liquid biofuels production from cellulosic sources in the region are essentially at the research and development stage. This study, through comprehensive reviews of various bioenergy policies, news reports, related journal articles and development reports, examined the reasons for the delay in the development of bio-refineries in the region. The study then articulated feasible solutions to address the challenges. Among the discovered causes of the delay are over-dependence on fossil fuels and defective energy policy implementation manifesting in the form of lack of continuity. Other issues include poor private sector's involvement and inadequate incentives necessary for private investors' participation. This study concludes that boosting liquid biofuels production in West Africa would require public-private collaboration that is built from bottom-up. Successful bioenergy facilities' development in the region would need to be community level scaled rather than being mega projects, and it would need to involve participation of communities as collaborators. In addition, to ensure sustainable production, it would be necessary to incorporate public enlightenment, and grant tax incentives to investors. Moreover, it would need to include a sustainable technology training package that would empower local engineers and technicians to not only develop bioenergy facilities that are suitable for the locality but also to maintain and improve them. Furthermore, Continuity and consistency in policy implementation and financing prioritization are essential to boosting liquid biofuel production in the West African region and to enable West African region to occupy its rightful place in the global bioeconomy.

**Key words:** Bioeconomy, bioenergy, liquid biofuels, sustainability, West Africa.

## **Biorefining of low-value streams and residuals with edible filamentous fungi**

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**Abstract:** Improved human lifestyle and industrialization has led to unsustainable linear economies with overexploitation of resources and waste accumulation. Hence, the need of a paradigm shift from linear to circular economies where wastes are considered as resources. Microbial conversion has been among the waste management strategies attracting immense research and development interest. This is related to the diversity of the microbial world that opens the possibility to convert a wide range of low-value substrates into a panoply of value-added products. For instance, filamentous fungi are able to grow on substrates of variable composition, where a nutritious macroscopic filamentous structure, easily recovered from the medium, is produced as a result of nutrient assimilation. If edible filamentous fungi are used for the valorization of municipal and industrial sidestreams, residuals and wastes, a positive impact can be attained on e.g. the establishment of circular economies and concomitantly on the environment, and on shortage concerns of protein sources due to population growth forecasts. The talk will give an overview of the type of substrates that can be used and value-added products that can be produced through fungal conversion. Examples will include sidestreams and residuals from bioethanol, dairy, fish, paper and pulp, and agricultural sectors. Emphasis will also be given to industrial integration strategies of fungal-based processes that can lead to new value-added products, increased production yields and energy savings.

**Key words:** Feed products, Filamentous fungi, low-value substrates, value-added products.



## Comparison of two perennial energy crops for biomass production at the end of their life cycle

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**Abstract.** Nowadays fossil fuels are decreasing, causing the world's interest in renewable energy sources to rapidly grow. One of the most interesting renewable and ecologically pure fuels is biomass, which is considered to be carbon neutral. Biomass is a promising source of energy, as it can be used directly as an energy resource. Its quality characteristics such as gross calorific value and ash content are of paramount importance so as to improve the combustion process. Furthermore, during the last three decades, there has been an increasing interest in the production of biomass pellets for domestic and industrial use. Alternative feed stocks will need to be sourced to meet the demand for biomass pellets. Investigation for new energy crops that produce high amounts of biomass under low inputs and of high energy efficiency are the main tasks of this field. Therefore, the aim of this study is to assess the biomass yield and the quality characteristics (gross calorific value and ash content) of two perennial energy crops (*Cynara cardunculus* L. and *Panicum virgatum* L.) growing in a typical soil (*Fluventic Xerochrept*) of the main agricultural land of central Greece. The comparison for both cultivated crops was made in order to show the results during their 8<sup>th</sup> growing year. The examined factors were the irrigation (two levels: irrigated and rainfed) and the nitrogen fertilization (two levels: 0 and 80 kg N ha<sup>-1</sup>) as well as their effect on the dry biomass yield and the gross calorific value. It was found that higher dry biomass yield was produced from cardoon (21.3 vs. 14.23 t ha<sup>-1</sup>), while the higher average gross calorific value was observed for switchgrass biomass (17.31 vs. 15.65 MJ kg<sup>-1</sup>). Finally, multiplying the dry biomass yield (t ha<sup>-1</sup>) with the gross calorific value (MJ kg<sup>-1</sup>) it was found that 334 and 245 GJ ha<sup>-1</sup> from a cardoon and a switchgrass cultivation could be produced, respectively. Cardoon has better results than switchgrass probably due to the fact that switchgrass is growing from March till October; while cardoon's growing period is from October to June and in such areas precipitation is in shortage during summer months. Both crops could achieve high amounts of energy per hectare and thus their introduction in future land use systems, for an environmentally friendly energy production should be seriously taken into consideration.

**Keywords:** cardoon, switchgrass, yield, gross calorific value, biomass.

## Implementation of EU biofuels policies at country level: a review

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**Abstract.** Presently, the transportation sector alone accounts for more than 30% of the final energy consumption in the world. This brings along an increase in the utilization of fossil fuels in the final energy mix (gas, oil and coal), the depletion of those fossil fuels, increment of the environmental impacts result of burning them, and an increase in the carbon dioxide emissions and global warming potential. As a result, great attention has been paid to sustainable, alternative and rational sources of energy for the transportation sector. Biofuels have emerged as an attractive low carbon alternative for the reduction of fossil fuels in the transportation sector. European Union plays an important role in the promotion and implementation of biofuels in its member states. It should be noted that although there is a wide range of biomass that could be used as a feedstock for the production of biofuels, this should not detract in any way the importance of compliance with European legislation on fuel quality, vehicle emissions, and air quality. The main European legislations that are directly connected to biofuel production, energy, and climate are “The Renewable Energy Directive (RED) of 2009”, that requires the EU to fulfil at least 20% of its total energy needs with renewables by 2020 and “The Fuel Quality Directive (FQD) of 2009” that requires a reduction of the greenhouse gas intensity of transport fuels by a minimum of 6% by 2020. In 2018 a new directive was implemented (RED II). This directive raised the EU targets on renewable energy from 20% in 2020 to 32% in 2030. At country level, each member state has national legislations regarding the implantation of FQD, RED, and RED II. This work aims to investigate the legal aspects associated with promotion of the use of biofuel and other renewable energy sources in transportation sector in the EU. For this, the implementation of FQD, RED and RED II in 12 European countries (Austria, Bulgaria, Croatia, Estonia, Hungary, Ireland, Latvia, Lithuania, Malta, Portugal, Slovakia and United Kingdom.) will be analyzed. The results will demonstrate the strengths and weaknesses of these policies at country level, similarities and differences, and investigate the countries with the best approaches. The results of this study will enrich the policies in the member states, as well as in the whole European Union.

**Key words:** European Directives, policy framework, renewable energy, energy transition.

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## Stability studies of alcohol and bio oil blends

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**Abstract.** Alcohols ethanol, 1-butanol and methanol form an interesting triplet in renewable fuel genre as blending components. In this study, the aim was to clarify whether it is possible to mix alcohols with a little refined and relatively cheap material, bio oil, and get stable fuel samples. Several different blends of rapeseed oil with butanol and ethanol were prepared and their stability was followed visually. At room temperature, the stable samples consisted of rapeseed oil blended with butanol at 5 vol-%, 10 vol-%, 20 vol-%, 30 vol-% and one sample of rapeseed oil with 5 vol-% of ethanol. The subsequently analyzed fuel properties were kinematic viscosity (at 40 °C), density (at 15 °C) and surface tension. Cold filter plugging point was measured for rapeseed oil with 20 vol-% and 30 vol-% of butanol. According to the results, the stability of butanol or ethanol and rapeseed oil can be achieved at the studied volumes. The density of neat rapeseed oil and all the alcohol – rapeseed oil blends met the requirements set for residual marine fuels. The 30 vol-% butanol – rapeseed oil blend met the requirements for distillate marine oil for density, and almost for kinematic viscosity. The 20 vol-% and 30 vol-% butanol – rapeseed oil blends complied also with biodiesel standard for density and with biodiesel and diesel standard for cold filter plugging point for summer grade in Finland. The blends appeared most suitable for power plants and marine engines. More detailed analyses of the properties are needed before recommendations for use.

**Key words:** alternative fuels, biofuels, blend properties, renewable energy.

## The potential of sequential bioethanol and biomethane production from Nigerian Napier grass: an optimized process flow

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**Abstract.** The Nigerian large economy mostly depends on crude oil for survival despite the adverse effect the fossil fuels have on the environment. Although in 2017 the nation decided to diversify away from oil by investing in a new bioethanol plant, which uses cassava and sugarcane as feedstock, it could lead to the food-versus-fuel debate because cassava and sugarcane are major food crops in Nigeria. One way around this problem is to utilize one of the nation's abundant uncultivated and inedible plants - the Napier grass (*Penisetum purpurium*) as a feedstock for biofuel production. Combining this grass with the novel nitrogen explosive decomposition (NED) pretreatment method is a very promising solution for the production of liquid and/or gaseous biofuels.

This research aims to investigate the potential of the Nigerian Napier grass for bioethanol and biomethane production by means of solid and liquid separation of the substrates. The biomass was obtained from Effurun town of Delta State in Nigeria. It was harvested and sundried in Nigeria before exporting to the Estonian University of Life Sciences in Tartu, Estonia, for analysis. The dried samples were first milled to a particle size of 3mm or less using a cutting mill SM 100 (Retsch GmbH). After milling, the samples were pretreated using the NED at four different temperatures (150 °C, 170 °C, 190 °C, and 200 °C) respectively. The solid and liquid fractions were separated, and the liquid fractions were sent for hydrolysis during 24 hours using the cellulase complex Accelerase 1500 enzyme. Again, a separation of the fractions occurred, after which, the liquid fraction of the post hydrolysis broth was fermented for 7 days using yeast (*Saccharomyces cerevisiae*). Distillation was carried out to separate the bioethanol produced from fermentation. The untreated biomass, the solid and liquid fractions after pretreatment and hydrolysis and the distillation sidestream were all analyzed for biomethane potential assay (BMP). The anaerobic digestion was carried out in triplicates under mesophilic conditions for 42 days. The results of this investigation showed that the lowest glucose and ethanol yields were gained at 150 °C; 14.9 g/L and 8.4 g/L, respectively. The highest glucose and ethanol yields were gained at 200 °C; 31.6 g/L and 10.3 g/L, respectively. The highest biomethane yield was reported in samples from the solid fraction of the pretreatment stage that were pretreated at 150 °C (1.13 mol CH<sub>4</sub>/100 g), while the batch with the lowest biomethane yield was reported in samples from the liquid fraction after the pretreatment stage (0.14 to 0.2 mol CH<sub>4</sub>/100 g). The lower biomethane yields reported in samples from the liquid fraction of the pretreatment stage might be due to the composition of the broth. As it is composed mainly of hemicellulose and it has negligible amounts of cellulose and lignin, it means that there are less sugars available for anaerobic digestion as well as the inhibitors which form as temperature increases.

These results indicate that pretreating the Napier grass with NED results in a high potential for bioethanol and biomethane production and that samples from liquid fraction of the pretreatment should be separated and removed from the production chain since they do not add value to the process. The results also show that bioethanol and glucose yields are influenced by the pretreatment temperatures and that the solid and liquid separation of the substrates enhances the bioenergy yields and improves the efficiency of the production chain. The temperature of pretreatment is an important factor to be considered when processing the Napier grass for biofuel generation. The fuel obtained after the distillation process can replace the fossil fuels currently used in Nigeria and provide alternative energy for the transportation and domestic sectors, especially in countries rich in this raw material in Africa.

**Key words:** anaerobic digestion, bioethanol, biofuel, lignocellulose, side streams, zero-waste.

**Acknowledgement.** The authors gratefully acknowledge the financial support of the European Regional Development Fund via the Mobilitas Pluss (project MOBERA1) of the Estonian Research Council.



## Impact of pretreatment on hydrothermally carbonized spruce

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**Abstract.** Upgrading biomass waste streams can improve economics in wood industries by adding value to the process. Previous studies have considered the extraction of biomass components, such as lignin, however no study has looked at the usefulness of the residual biomass after extraction. This work considers use of a hydrothermal carbonization (HTC) process for the residual feedstock after lignin extraction. Batch experiments were performed at 200–240 °C temperatures and 3 h residence time with an 8:1 biomass to water ratio for two feedstocks: raw spruce, and spruce after lignin extraction treatment. The proximate analysis and higher heating value showed similar results for both feedstocks, indicating that the thermochemical conversion is not impacted by the lignin removal; the pretreatment processing slightly increases the higher heating value of the treated feedstock, but the HTC conversion process produces a consistent upgrading trend for both the treated and untreated feedstocks. The energy yield was 9.7 percentage points higher for the treated wood on average across the range temperatures due to the higher mass yield in the treated experiments, where some mass loss has already taken place during the lignin extraction. The energy densification ratio and the mass yield were strongly correlated with reaction temperature, while the energy yield was not. Energy densification was not affected by the prior lignin extraction, indicating that the HTC reactions proceed unaffected by the extraction, though further chemical analysis of the internal reaction mechanisms is required to confirm this finding.

**Acknowledgements.** The authors gratefully acknowledge M.Sc. (Tech.) Clara Lisseth Mendoza Martinez for her help in conducting the chemical analysis of the samples.

## The use of DNA markers for the evaluation of maize lines and hybrids based on cytoplasmic male sterility

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**Abstract.** The use of cytoplasmic male sterility (CMS) is very important for the production of maize hybrids. The new inbred lines and hybrids of maize of Ukrainian breeding were studied. In the field, four pairs of sterile analogue of line RL106S were obtained during four backcrossing (17M, 19M, 23M, 27M and 29M) and maintainer lines of RL106fS (18M, 20M, 24M, 28M and 30M) for S type cytoplasm and RL108C (195C, 201C, 205C, 207C, 209C) i RL108fC (196C, 202C, 206C, 208C, 210C) for C type respectively. For S type, the following combinations were obtained: RL23S×RL106fS, RL107S×RL106fS, RL98S×RL106fS, RL105S×RL106fS, RL113S×RL106fS and for C type: RL109C×RL108fC, RL110C×RL108fC, RL112C×RL108fC, RL114C×RL108fC, RL115C×RL108fC. The obtained hybrid combinations were planted the following year in a control nursery for field trials. According to the results of the field assessment, all the hybrids were sterile. The types of sterility of the studied lines and hybrids were determined using polymerase chain reaction (PCR) with specific primers for C and S types of cytoplasm. The presence of specific amplicons 398 and 799 bp was determined in sterile lines with C and S types of cytoplasm, respectively. Amplicons 398 and 799 bp were identified in simple-cross and simple reconstituted hybrids on a sterile basis, and can be used to determine the type of hybrid and its maternal component at the stages of selection and examination of new hybrids.

**Key words:** *Zea mays* L., DNA markers, cytoplasmic sterility.

## Second-generation bioethanol production: Strategies for sidestreams valorisation

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**Abstract.** Second generation biofuel production using cellulosic biomass as a raw material has been extensively studied to produce biofuels such as biomethane, biodiesel and bioethanol. Although liquid and gaseous biofuels are widely used, their production still has some drawbacks caused mainly by the recalcitrant structure of lignocellulosic biomass, which requires expensive pretreatment methods to break down the plant cell wall and to successfully convert cellulose into bioethanol and biogas. Also, at the end of the production chain a large quantity of sidestream is generated. These residues are highly pollutant and require appropriate treatment options before its discharge in the environment. Management of these residues can bring additional costs to the bioethanol production. Therefore, production of value-added products from bioethanol sidestreams can be used as a solution to the large quantity of residues generated after bioethanol production, and at the same time bring additional revenue to the production chain. This work investigates three different pathways for the valorisation of sidestreams from bioethanol production chain: 1) traditional bioethanol pathway; 2) the process flow using phase separation of the substrates; and 3) optimised process flow using phase separation of the substrates. Barley straw and Nigerian Napier grass were used as feedstocks in the experiments. The raw material was pretreated with nitrogen explosive decompression and synthetic flue gas explosive decompression with and without bubbling through, at pressure of 30 bar using different temperatures (150 °C, 170 °C, 190 °C, and 200 °C). After the pretreatment, the samples were further hydrolysed, fermented, and distilled. Untreated material, pretreated, hydrolysed, fermented materials, and bioethanol stillage were further utilized in a biomethane potential assay. The results of this study show that the biomethane yields of bioethanol stillage can reach up to 94% - 97% of the biomethane yields of samples from the fermentation step; phase separation increases the biomethane yields of bioethanol stillage by 45%; the optimised process flow has shown that samples from the liquid fraction of post-pretreatment samples should be removed from the process since they have low bioethanol, biomethane yields, and have an inhibitory effect on the following processes.

**Key words:** anaerobic digestion; bioethanol; biofuel; lignocellulose; sidestreams; zero-waste.

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## Response surface for biodiesel production from soybean oil by ethylic route

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**Abstract.** Petroleum has been the most consumed energy source in the world, but it tends to run out due its non-renewable character. Among biofuels, biodiesel has emerged as the main candidate to substitute petroleum diesel. The present study aimed to identify the maximum yield point of biodiesel production by generating a response surface using molar ratio, temperature and agitation time as independent variables, and yield as a dependent variable. From the response surface, it is observed that the increase in temperature and reaction time leads to reduced yield. The configuration that resulted in maximum yield of 93.30% was 12:1 molar ratio, 30°C temperature and 30-minute reaction time. From the chromatographic analysis it was possible to identify five different fatty acids in the composition of the biodiesels. Total saturated fatty acids (palmitic and stearic acids) ranged from 41.53% to 42.09% and total unsaturated fatty acids including monounsaturated and polyunsaturated fatty acids (oleic, linoleic and linolenic acids) ranged from 57.92% to 58.48%. According to the results of the physicochemical analyses, the specific mass at 68°F is in agreement with Brazilian, American and European specifications, ranging from 877.46 Kg.m<sup>-3</sup> to 879.64 Kg.m<sup>-3</sup>. The kinematic viscosity at 104°F ranged from 4.49 mm<sup>2</sup>.s<sup>-1</sup> to 4.82 mm<sup>2</sup>.s<sup>-1</sup>. The acid value obtained did not vary within the limits established by the norms, and values between 0.54 and 2.74 mg KOH.g<sup>-1</sup> were observed.

**Keywords:** biofuels, ethanol, optimization, transesterification.



## **IV ERGONOMICS**

## Qualimetry as Productivity Criteria in Metal-cutting Operations

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**Abstract.** The qualimetry method will allow an objective assessment of the performance of metal-cutting machines and the production capacity of machinery, as well as an objective assessment of their use in multi-product manufacturing, applying the qualimetry approach and qualimetry indicators, which are based on the concept of qualification of metal removing during machine operations. The aim of the study is to develop methods for measuring the performance of metal-cutting machines and open the way to create a regulatory framework based on quantitative indicators of the equipment quality. Qualimetry measured volume of metal removing allows setting the maximum possible productivity (quali-power) of metal cutting machinery, based on a small number of basic quality indicators contained in the machinery data sheets. It is essential that the quali-power of the machinery is an objective indicator of its quality, independent of the specific conditions of its operation at any given time. Hence the productivity criteria in metalworking cutting operations can be measured.

**Key words:** qualimetry, ergonomics, quantitative, manufacturing, equipment.

## Psychosocial Risks Analysis for Employees in Public Administration

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**Abstract.** Nowadays psychosocial risks at work have a serious impact not only on the health of employees, but also on the economic performance of organisations, and this is the biggest challenge in working environment. In Latvia, employees in public administration comprise 11% of the total population. Hence the aim of this study was to analyse the causes of psychosocial risks and the differences in their prevalence among inspectorate officials employed in the State Administration compared to office staff employed by the State Administration. A modified Copenhagen Psychosocial Questionnaire from the Danish National Research Centre for the Working Environment was used to assess psychosocial risks at work. One public administration organisation was selected for the study, which involved 111 staff (60 inspecting officers and 51 office staff). The analysis of the results of the psychosocial risk assessment shows that there are statistically significant differences in the assessment of four out of 11 psychosocial risks to the working environment. The most common psychosocial work environment risk factor among inspectors is the inadequate attitude of management, but the most common risk factor among office employees is the lack of impact on work. To reduce the spread of psychosocial risks more effectively, an individual approach is required for each worker.

**Key words:** public administration, inspectors, office workers, psychosocial risks, work environment.

## The Co-influence of Noise and Carbon Dioxide on Humans in the Work and Living Environment

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**Abstract.** The aim of the paper is to investigate the co-influence of noise and carbon dioxide on people in different situations (inside/outside houses/classrooms) depending on the traffic intensity, the fuel used for heating in residential buildings etc.). All the measurements and the questionnaire have been carried out during the autumn of 2019 (at the mean temperature of 5-10° C). Riga has a more intensive traffic compared to Tallinn and has greater problems of exceeding the permissible noise levels. The levels of carbon dioxide inside classrooms are also very high in Latvia (1500-2000 ppm). The concentration of carbon dioxide outside buildings is low in the forest areas (measured in the south of Estonia), being 340-350 ppm. In regional towns, it is 500 ppm (measured in autumn-winter near a busy street). The co-influence of noise and carbon dioxide on the residents has been investigated by using the Weinstein questionnaire. High carbon dioxide levels cause fatigue. Although it was not particularly pointed out by the residents questioned in a panel house with small apartments, the air was considered to be stuffy. The house is situated near a busy street, so the problems with noise are higher. ANOVA statistics has been used for the questionnaire ( $p < 0.001$ ,  $\alpha = 0.93$ ). The decrease of noise and carbon dioxide levels help people stay healthy and the environmental impact from the investigation is emphasising the necessity and providing possibilities to decrease the concentration of CO<sub>2</sub> in the ambient air.

**Key words:** environmental noise, carbon dioxide, risk assessment.

## **Reliability of camera systems to recognize facial features for access to specialized production areas**

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**Abstract:** The article deals with ergonomics and reliability of camera systems for recognition of facial features and identify person for access to specialized areas. The monitoring of areas relates not only to crime, but it is also an integral part of access to specialized production areas (pharmaceutical production, chemical production, specialized food production, etc.). It is therefore important to adequately secure these premises using the relevant system. One of them is a system based on user identification using specific facial features. For this purpose, there are CCTV systems for recognition of facial features of different price categories (conventional cameras, semi-professional and professional) on the world market. However, problematic situations may occur when identifying. For example, by having the user partially masked face. This research is focusing on the problem. The main goal of the research is establishing the scale of negative impact, in case the identified person has partially masked face, on camera systems recognizing facial features, primarily on recognition time. The results are evaluated in detail. Some camera systems are not suitable in specialized production areas due to their insufficient recognition ability. From all the tested devices, the HIKVISION iDS-2CD8426G0 / F-I camera identification system has proved to be optimal for identification purposes. In the case of designing, it is therefore necessary to choose suitable camera systems that have ergonomics and reliability at a level that will guarantee their sufficient use in the mentioned areas, while decreasing comfort and user-friendliness as little as possible. By measuring the ergonomics and reliability of these CCTV systems, it can be stated that there are statistically significant differences between conventional, semi-professional and professional systems, and it's not just a design change, but also a more efficient recognition method.

**Key words:** security, agricultural buildings, ergonomics, camera systems, face detection.

## **V LIVESTOCK ENGINEERING**

## **Lighting and noise levels in compost dairy barns with natural and forced ventilation**

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**Abstract.** The housing system, called compost barn, is attracting the interest of several farmers. It allows dairy cows to remain in free movement inside a shed without any containment partitions like those used in freestall barns. In Brazil the compost barns with open sides are very common, but recently some closed barns with climatic control systems have been implemented. The objective of this work was to evaluate and compare lighting and noise levels in an open compost barn with natural ventilation and in a closed compost barn with a climate control system. The latter one is based on tunnel ventilation: inlet of air trough evaporative cellulose panels and exit through fans placed on the opposite wall. Through analysis of the collected data it was observed that the sound pressure recorded inside both analysed buildings did not exceed the ranges of noise discomfort recommended for the rearing of animals. However, the sound pressure amplitude inside the barn with climate control system was greater than in the open barn. The light intensity was significantly lower in the closed barn when compared to the open barn (84.96 and 1,413.58 lx, respectively). The artificial lighting system distributed throughout the closed barn was not sufficient to maintain brightness within the recommended range for lactating cows. In addition, it was found that in the closed building with forced ventilation, the highest brightness values are located near the exhaust fans.

**Key words:** animal facility, dairy cows, compost-bedded pack barn, light intensity.

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## Growth performance and carcass characteristics of finishing boer goats

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**Abstract.** In developing countries, goat kids are usually reared naturally under extensive conditions, but kids that are fed high concentrate diets generally have higher daily gains, dressing percentage and carcass quality than those produced in extensive system. Feeding of goat kids is the main factor affecting growth performance and carcass characteristics of finishing Boer goats. A study was carried out within the framework of the project “Zootechnical and economic efficiency of feeding of fodder pulses to ruminant’s meat production”. Eight kids of Boer breed were individually fattened for 60 days under an intensive management system, of which 4 kids received *ad libitum* concentrated feed of melted grain mix (GG) that was produced in farm and consisted of 25% oats, 25% barley and 50% fodder beans, but 4 kids received pelleted concentrated feed (CG) produced in feed company. Fattening performance, slaughter traits and carcass characteristics were evaluated. The carcasses were analyzed by weight and proportion of tissue: muscle, bone, fat. Daily live weight gain during 60 days of the fattening period was 235g per day for CG kids, which is by 42.4% greater than for GG group kids (165 g per day ( $P < 0.05$ )). Feeding of GG kids by grain mix showed a lower growth rate of kids than feeding by pelleted concentrated feed (31.1 kg and 35.5 kg pre-slaughter, respectively), but had a higher dressing percentage (49.5% and 43.5%, respectively). Consequently, there was no significant difference in carcass weight (14.36 kg and 14.50 kg, respectively). GG carcasses had a higher fat content - 11.8% vs. 9.4%. In terms of the muscle-to-fat ratio, the carcasses of the kids of the two groups were significantly different ( $P < 0.05$ ), where in the GG group there was 5.0 kg of muscle tissue per kg of fat and in the CG group there was 6.8 kg of muscle tissue. Total feed costs per day per animal and per kg live weight gain were higher in the CG group, as the feed price from a feed company was significantly higher than for farm-based grain meal. The results suggest that diet has an impact on the goat kid growth performance and carcass quality, and in intensive fattening systems it is more profitable to use a self-produced grain mix.

**Key words:** kids; fattening performance; carcass characteristics; meat quality.

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



## Assessment of the methane emission for different typologies of fattening swine facilities in the department of Antioquia – Colombia

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**Abstract.** The explosive growth of swine production at high stocking densities in confinement farming worldwide, has raised concerns the environmental impact, health and livestock productivity and the production of associated gases in this type of large-scale farms. The aim of this paper was to study the methane gas concentration and emissions of ten different typologies of swine production installations. The facilities were in the department of Antioquia - Colombia, they were located between 800 - 2300 meters above sea level (m.a.s.l.) of heights, they mainly employed natural ventilation as refrigeration strategy and they were used for pigs in fattening stage. Methane measurements were taken at animal height. Sensors were located at intermediate points of the ventilation inlet and outlet areas. The behaviour of methane concentration and emission of the facilities were analysed along with the correlation and temporal evolution of climatic variables, comfort indices and construction typologies. The information was analysed using *descriptive statistics*, *analysis of variance (ANOVA)* and *principal component analysis (PCA)*. Were found an *average* of CH<sub>4</sub> Emission Rate (ER) per facility (kg year<sup>-1</sup>) of 607.9, Global Warming Potential (GWP) per facility (kg year<sup>-1</sup>) of 15197.42 and significant correlations between ER and cleaning frequency (CF), animal unit (AU), air flow (Q), animal density(AD) and relative humidity (RH) were evidenced. This is the first research reported in Colombia, that will be important to create some governmental policies.

**Key words:** typologies of construction, methane emissions, natural ventilation, greenhouse gases, swine production.

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## **Association between body condition and production parameters of dairy cows in the experiment with use of BCS camera**

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**Abstract.** Dairy production effectiveness in the farm depends on many technical, technological and biological factors. State of the dairy cow condition constitutes one of the most important element in the assessment of dairy herd and production indices. Including access to modern technical solution to assess body condition of dairy cows, i.e. BCS camera, some results of observation in the herd with 362 cows were collected to find any relationship between BCS index and milk yield per cow including 5 lactation groups and cows differed in age as well as four seasons. Basing on data collected in the period of 11 months it was found that cows with the BCS index lower than 2.9 showed the highest daily milk production. Increase in BCS index was associated with decrease in amount of produced milk per day. The statistical analysis showed significant effect of lactation period, age of animals and season on BCS results in the considered dairy cow production cycle.

**Key words:** BCS, camera, cow, index, milk yield.

## Estimate of manure present in compost dairy barn systems for sizing of manure storage

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**Abstract.** Milk production is increasingly modernized as a result of the growing demand for food around the world. Improvements in livestock facilities are observed, with a large increase in the use of feedlot systems such as the Compost Dairy Barn. Increasing milk production in confinement systems has also raised concerns such as the management of wastes (water, faeces and urine) from the system, which has become one of the most important issues in the intensive dairy farms. The aim of this work was to estimate the amount of manure present in compost dairy barn systems in order to size the manure storage. The study was conducted at four compost dairy barns in southern Minas Gerais, Brazil. These compost barns had different bedding materials and dimensions. In each farm, data on milk yield and quality (daily production, fat and protein content), animal weight and amount of feed ingested by the animals were collected. Total-day manure delivered by the cows in the feeding alley and milking parlour was piled up together and weighed. Based on the results, it was observed that, in the compost dairy barns, only part of the total manure produced per day was delivered in the milking parlour (1.6 and 2.0%) and in the feed alley (27.6 to 49.3%). These results are very important for designers for the proper manure management system design of the dairy farms.

**Key words:** animal facility, compost-bedded pack barn, dairy farming, manure, organic wastes.

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

## Comparison of airflow homogeneity in Compost Dairy Barns with different ventilation systems using the CFD model

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**Abstract.** In the pursuit of high milk productivity, producers are using confinement systems in order to improve performance and animal welfare. Among the housing systems, the Compost bedded-pack barns (CBP) stand out. In these barns a bedding area is provided inside, where cows move freely. Generally this area is covered with carbon source material (such as sawdust or fine dry wood shavings) which together with manure, thanks a regular mechanically stirring, ensures the aerobic composting process. The ventilation in these facilities has the function of dehumidifying the air, improving the air quality, drying the bedding, improving the thermal comfort conditions of the confined animals. This work aimed at validating a computational model using Computational Fluid Dynamics (CFD) to determine the best homogeneity of airflows generated by different forced ventilation systems used in CBP barns. Two CBP barns were compared with different ventilation systems: high volume low speed (HVLS) and low volume high-speed (LVHS) fans. The results showed that the proposed model was satisfactory to predict the flows generated by both types of fans. It was concluded that the use of HVLS fans produced a more homogeneous airflow when compared to LVHS fans. The use of mechanical ventilation in tropical conditions is necessary for the proper functioning of the system. In this study, the systems used promoted the increase in air speed to levels close to adequate.

**Key words:** airflow, animal housing, compost-bedded pack barn, dairy cows, simulation.

**Acknowledgements.** The authors thank the following groups for financial support: Brazilian State Government Agency, FAPEMIG; National Counsel of Technological and Scientific Development (CNPq - Brazil); Federal agency, CAPES.

## **Assessment of spatial variability of environmental variables of a typical house of laying hens in Colombia: Antioquia state Case**

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**Abstract:** This paper aimed to analyze the magnitude and spatial variability of environmental variables: Temperature and Relative Humidity Index (THI), Radiant Thermal Load (RTL), Globe Temperature and Relative Humidity Index (BGTH) and Enthalpy (H), inside a house for laying hens, in the state of Antioquia (Colombia) during the month of August. A traditional Colombian poultry house with natural ventilation was used. All variables were manually measured at equally spaced 1.0 x 1.0 m points, totaling 99 data collection points inside the poultry house. Geostatistical techniques were used through semivariogram analysis, and isochore maps were generated through data interpolation by kriging. The semivariogram was fitted by the restricted maximum likelihood method. The used mathematical model was the spherical one. After adjusting the semivariograms, the data were interpolated by ordinary kriging. The semivariograms and the isochore maps allowed identifying the non-uniformity of the spatial distribution of all evaluated variables throughout the poultry house. The results show that THI, RTL, BGTH and, H presented values above the comfort limits in the most significant part of the poultry house during the observed period. It is possible to conclude that the use of natural ventilation alone was not sufficient to guarantee the homeothermy conditions for the layers. Thus, it is suggested that in addition to natural ventilation, secondary modifications should be used to improve farm productivity.

**Keywords:** Animals production, animal welfare, natural ventilation.

**Acknowledgements.** The authors would like to thank the National University of Colombia Campus Medellín and the Federal University of Lavras, Brazil for their partnership in the development of this research.

## **Improvement of the elk domestication technology at Sumarokovsky State nature reserve**

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**Abstract.** The paper discusses the technology of elk domestication and measures for its improvement at Sumarokovsky state nature reserve, the largest world center for the domestication of elks, as well as an environmental, research, cultural and educational institution. The article contains the data on ethological observations, the evolution of elk behavior in the conditions of ecological tourism, on elk keeping and on the conditions of the food base, on technological processes and suggests possible ways to correct them. It has the description of the organizational structure of the reserve, of the forestlands around and of their forage capacity; gives information about the vegetation composition, the mode of keeping and feeding elks. The reserve, due to its presence in a specially protected area, experiences significant restrictions on forest use on its territory, which leads to a deterioration and decrease in the area and quality of forage land for domesticated elks. The article shows the necessity of improving the regulatory framework as well as of the development and implementation of biotechnological measures to preserve and increase the forage capacity of forestland. It also shows that the technological chain of domestication makes it possible to get a controlled, stress-resistant, calm, friendly and safe animal, to carry out the selection period for the formation of dairy herds earlier, to obtain unique milk with both high nutritional and medicinal properties. Considering the fact that the largest number of domesticated elks in the world is concentrated in the reserve, the technology there is unique. Because of the potential danger of an elk as a source of human infection with various pathogens, the veterinary service requires intensification. It includes monitoring, development of treatment methods, drug application, prevention and control measures for diseases, provision of normative documents, etc. A change in the elk domestication technology under the increasing role of ecological tourism has led to the formation of a new economical type of a reserve, which combines elements of a stationary-exit, multidisciplinary and enclosure types.

**Key words:** domestication, elk, elk farm.

## Usability improvements of the Thermipig model for precision pig farming

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**Abstract.** Pig livestock farming systems encounter several economic and environmental challenges, connected with meat price decrease, sanitary norms, emissions etc. To deal with these issues, methods and models to assess the performance of a pig production system have been developed. For instance, Thermipig model represents the pig fattening room and simulates performances of pigs at the batch level, taking into account interactions between the individual variability of pigs, farmer's practices, room characteristics and outdoor climate conditions. The model requires some static basic inputs fulfilled in several spreadsheets (such as rooms, pigs, and dietary characteristics) but also data files for voluminous variable inputs (such as outdoor temperature or climate control box parameters) for further modelling and outcome producing. This leads to challenges in data providing by the farmers and have to be improved. This paper deals with the implementation of the separate modules of the developed data warehouse system for usability improvements of the Thermipig model. The idea is to substitute input from the data files with online data input and automated variable processing by the model using the python script for connection to the remote data warehouse. The data warehouse system is extended with 'Property Sets' section dealing with all the operations that can be performed to a set of input variables. This approach demonstrates the ability of the data warehouse to act as data supplier for the remote model. As well the outcome of the model is also transferable back to the data warehouse for evaluation. This work is done within the Era-Net SuSan PigSys project - Improving pig system performance through a whole system approach.

**Keywords:** precision agriculture, precision livestock farming, modeling, Thermipig model, system usability, system integration

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## **Influence of local extruded soybean cake and imported soybean meal on fattening pig productivity and pork quality**

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**Abstract.** The aim of this study was to determine the influence of feeding local and imported soybean protein feeds to fattening pigs and examining its impact on the quality of pork. The trial was created with 40 pigs divided into two groups (20 in each). Pigs in the control group received imported soybean meal, in the trial group local farm grown in Latvia extruded soybean cake mixed in the compound feed. The diets were designed to be nutritionally equivalent. For fattening pigs each diet was available on an ad libitum basis to pens. During the study pigs were weighed three times at 84, 140 and 190 days of age. Feed consumption, pig carcass traits and meat chemical composition were determined. The final live weight in control group was  $108.33 \pm 2.904$  kg and in trial group was  $111.88 \pm 2.793$  kg there was no significant difference ( $P > 0.05$ ). Average daily live weight gain in the all experimental period in control group was  $0.779 \pm 0.096$  kg and in trial group was  $0.822 \pm 0.103$  kg, there was no significant difference ( $P > 0.05$ ). Feed consumption per kg of live weight in control group was 2.39 kg in trial group was 2.24 kg. Pig carcass traits and meat chemical composition were similar for both groups without significant differences ( $P > 0.05$ ). Soybeans grown and processed in Latvia were equivalent to imported soybeans and give good rates of pig growth and quality of pork.

**Key words:** fattening pig, pork quality, soybean protein.

**Acknowledgements.** Publication and dissemination of research results were carried out due to the support for EIP groups cooperation project “New technologies and economically viable solutions for the production of local feed for pig production: cultivation of non-genetically modified soybeans and new barley varieties in Latvia” Nr. 18-00-A01612-000015.



## Longevity and milk production efficiency of Latvian local breeds during last decades

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**Abstract.** The aim of the study was to analyse the longevity and the amount of energy-corrected milk (ECM) per day of local dairy cattle breeds Latvian Brown (LB) and Latvian Blue (LZ). The study was based on the data of LB genetic resources (LB) 1770 and LZ 921 cows, which were born from January 1<sup>st</sup>, 2000 till December 31<sup>st</sup> year 2015. Milk productivity and longevity of the LB and LZ cows were analysed by birth year periods: 2000–2005, 2006–2010 and 2011–2015. LZ culled cows lifespan was in average  $2,762.8 \pm 55.14$  days, or 7.6 years and it was significantly higher than for LB. The average lifespan of LB culling cows was 6.7 years. There are cows which had closed 7-12 lactations. On average, cows' lifespan decreased during analysed period. In general, LZ cows are characterized by higher length of productive life and milking days. LZ cows produced more EC milk during their productive life; however, they had the lower milking day ECM productivity than LB cows.

**Key words:** local breed, longevity, milk production efficiency.

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## **Rational selection and usage of rotary type milking equipment**

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**Abstract.** The advisable time of operation of the rotary type milking equipment per day depending on the specific exploitation costs has been investigated. It has been stated that these costs can be reduced, if the rotary type milking equipment load is increased. Therefore, it is advisable to organise the work of milkers in two shifts, so that the milking equipment is operated even up to 16 h per day. For this reason the herd of cows should be accordingly large. For instance, milking twice with the equipment with 50 milking places the cow herd can reach having even 2500 cows, but at milking three times – up to 1400 cows.

**Keywords:** milking, rotary type equipment, milking time, exploitation costs.

## Evaluation of feed conversion efficiency for different dairy cows breeds by milk yield, milk content and faecal amount

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**Abstract.** The objective of this study was to evaluation of feed conversion efficiency for Latvian Brown (LB) and Holstein Black and White (HM) dairy cows breeds to define optimal crude protein (CP) content in the feed. In the research study were completed three (A, B, C) dairy cows group (8 cows in each group) with LB and HM breed's cows in the early lactation period, from 10 till 30 lactation days. Each groups cows were feeder with total mixed ration (TMR) with different CP content (approx. 18.0%; 17.5%; 17.0% accordingly). In the research period were controlled the amount of feed fed and regularly collected feed samples. After 21 days feeding was controlled milk yield, collected milk samples for content testing, and faecal amount and samples. Milk samples were analysed for fat, total protein (%) and urea content ( $\text{mgdL}^{-1}$ ). Milk samples for content parameters were analysed in an accredited milk quality laboratory. The statistical analyses were performed with the SPSS program package. The results acquired show that in all studied parameters were not significant differences between study groups. To evaluate the feed conversion efficiency during the study, we used the energy corrected milk (ECM) and the feed dry matter content during research and calculated the coefficient for each cow individually and on average in the study group. Milk yield, protein and faecal amount were significantly different among breeds. Milk urea content was average  $28.5 \text{ mg dL}^{-1}$  for all LB breed cows in all groups, for HM breeds it was  $23.6 \text{ mgdL}^{-1}$ . These results show that LB breed cows did not converse feed proteins wholesome. Total milk and faecal amount were decreased in a group with CP 17% in feed by 10% and 7% accordingly. By using this data, the farmer may make evaluations and forecast of farming efficiency; cows breed preference and environmental threats.

**Key words:** milk yield, milk urea, faecal, protein in feed.

**Acknowledgements.** Research was conducted with support from Latvia Ministry of Agriculture project No S349, agreement No 19-00-SOINV05-000024.

## Embryo transfer results in endangered cow breeds in Latvia

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**Abstract.** Since 2017 multiple ovulation (MO) and embryo transfer (ET) were used to save endangered cow breeds in Latvia. The aim of this work was to analyse results to establish factors influenced recipients' pregnancy obtained up to now. Recipients age, induced (IRC) or native reproductive cycle (NRC), level of estradiol (E2) and progesterone (P4) in recipients' blood on ET day, stage and quality of embryo, fresh or thawed embryo usage and person provided ET were taken into account. Repeated artificial insemination (AI) had been provided in 19 (22.1%) recipients before ET. Pregnancy was accepted in 23 out of 76 recipients (30.3%) until now. Higher pregnancy results were obtained using fresh embryos (19 out of 53 (35.8%)) vs thawed embryos (4 out of 23 (17.4%)), ( $P < 0.05$ ). The IRC was more productive than NRC ( $P < 0.05$ ). The development stage, quality of embryos, E2 level were significant factors to reach pregnancy ( $P < 0.05$ ) but recipients age, P4 level and person provided ET did not influence the pregnancy rate in the present study ( $P > 0.05$ ). More successful pregnancies were reached using embryos obtained from donors which had a higher glucose and cholesterol level in blood ( $P=0.05$ ). In conclusion, our newly educated MOET team should gain their experience and results could be improved using IRC in recipients, fresh embryos, and more attention could be paid to the donor-cows management in order to reach more qualitative embryos. Somatic cell count in the donors' milk could be one of the indicator to avoid unsuccessful embryo obtaining.

**Key words:** cow embryo, embryo transfer, recipients.

## Effect of concentrate feeding technology on nutrient digestibility in latvian dark-head lambs

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**Abstract.** Research has been conducted to evaluate the effect of concentrate feeding technology on nutrient digestibility in Latvian Dark-Head lambs. Twenty-four purebred Latvian Dark-Head lambs (rams) were divided into three study groups (four lambs in each group). Concentrate was offered with different feeding technologies: group 1 – *ad libitum* once per day (ADL); group 2 – five times per day (5TD); group 3 – three times per day (3TD). Lamb live weight at the start of research was 24.6 kg (ADL), 24.1 kg (5TD) and 25.6 kg (3TD), the average age – 83±1.4 days (ADL;  $p<0.05$ ), 75±1.4 days (5TD) and 75±1.6 days (3TD). Research data were collected over three periods and two repetitions during lamb fattening in July, August and September, 2019. During the data collection period lambs were transferred to cages with slatted wooden floor and a container with a grid under it. The highest concentrate intake in all data collection periods was found in ADL lambs (1.25±0.106 kg – 1.75±0.092 kg on average per lamb). Hay intake was not equal (90–350 g in average per lamb). The highest average faecal production was found in 3TD and 5TD lambs (F – 0.98 ± 0.102 kg (3TD), S – 1.13 ± 0.060 kg (5TD) and T – 0.99 ± 0.070 kg (5TD)). The least urinal production was found in 3TD lambs (0.24 ± 0.038 kg (F), 0.61 ± 0.078 kg (S) and 0.47 ± 0.033 kg (T)). Dry matter digestibility was 66.54–80.39%. Faecal consistency was soft for ADL and 5TD lambs and solid for 3TD lambs.

**Key words:** lamb fattening, digestibility, dry matter intake, faecal production, manure.

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## **Study of influence of proteolytic action fodder additive in the composition of feed on productivity and development of broilers chickens' internal organs**

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**Abstract.** In the system of comprehensive assessment of feed nutritional value, protein plays a special role. With the correct selection of proteolytic enzymes in the diet and with appropriate conditions (pH, temperature, duration and quantity of enzymes), most feed proteins can be degraded to preferred degree in the body: either partially, limited by proteolysis, or deep and complete – to individual amino acids, which is accompanied by an increase in animal productivity.

The objective was to study the efficiency of using the exogenous enzyme Sibenza DP 100 in the broiler chicken's diet. The experimental part of the work was carried out under the industrial conditions of private limited company 'LISKoBroiler' on Ross 308 broiler chickens. When the proteolytic enzyme was added to the birds' diet without decreasing the nutritional value of crude protein and digestible aminoacids, higher values of the average daily gain were observed among all experimental groups compared to the control group, while reducing feed output per 1 kg of gain. While reducing the nutritional diet value in accordance with the matrix by 2.5% for crude protein and digestible amino acids and with the addition of the Sibenza DP 100 enzyme (500 g t<sup>-1</sup>), growing broilers was characterized by a slight lag in live weight compared to the control group, but with the most effective consumption feed per 1 kg of gain. The abovementioned system for the proteolytic enzyme use had the most positive effect on the morphological structure of the pancreas of broiler chickens.

**Key words:** enzyme preparation, protease, broiler chickens, pancreas, nutrient digestibility, intestinal length.

## **Non-Invasive measurer for methane and carbone dioxide emissions in bovine cattle through TRIZ**

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**Abstract.** Greenhouse gases (GHG), mainly methane (CH<sub>4</sub>) and carbon dioxide (CO<sub>2</sub>), can be generated in agricultural activities, not only in waste but also in the process of breathing of livestock. The Theory of Inventive Problem Solving (TRIZ) is an innovative Russian methodology that allows finding the solution to a problem raised. This paper presents the use of two TRIZ tools to design a non-invasive prototype that detects CH<sub>4</sub> and CO<sub>2</sub> emitted by cattle in real time. The tools were the matrix of technical contradictions and the nine-screen analysis with which the parameter to be improved (A) was found and the best possible solution to design a prototype that allows quantifying gases for animal welfare, Final Ideal Result (IFR) a wireless module with a sensor system for each of the gases placed on the bovine head, which convert the detected gas into an electrical signal to be sent wirelessly to a range of 1.5 km in free space at a receiver for its visualization representing the parts per million (ppm) of CH<sub>4</sub> and CO<sub>2</sub> that the bovine is generating during the measurement.

**Keywords:** Cattle, CH<sub>4</sub>, CO<sub>2</sub>, TRIZ.

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## **Aerobic solid-state fermentation of the solid fraction of pig slurry**

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**Abstract.** Current expansion in the pig number in Russia and their concentration in separate locations contribute to higher environmental risks. One key risk factor is the slurry produced. To utilize it more efficiently, many pig farms introduce its solid-liquid separation. The study objective was to explore the feasibility of accelerated aerobic solid-state fermentation of the solid fraction of pig slurry in closed installations. The stable thermophilic process under the temperature above +55 °C achieves shorter processing time of 3–4 days. To date, however, there is no representative evidence of such an experience. Four options of fermented mixture composition were tested based on two types of the solid fraction of pig slurry: Type 1 fraction coming from a screw separator and Type 2 fraction coming from a decanter centrifuge. The fermenter operating modes were tested in the authors’ previous studies associated with processing of the solid fraction of cattle manure and bedding poultry manure. The intensity measure of fermentation was the temperature reached by the processed material in the fermenter. Under the investigated operation modes, the stable temperature was observed for nine days in the mesophilic process: 20 °C to 55 °C; in some cases, the transition to the thermophilic process – above 55 °C was recorded. Adding the catalytic components to the processed material accelerated the substrate self-heating and a higher temperature up to 59 °C was reached. This suggests that the considered operating modes of the fermenter were suitable for the fermentation of the specified substrate.

**Key words:** solid-state fermentation, aerobic fermentation, pig slurry, slurry handling.



## Comparative analysis of performance by cows confined in different typologies of compost barns

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**Abstract.** The compost barn system was designed to be a sustainable alternative housing system for dairy cows. In order to help producers in the region to choose the best type of facility from the point of view of the milk production of the animals, this study compared the productivity of cows confined in an open composting barn with natural ventilation and in a closed composting barn with negative pressure ventilation and evaporative cooling panels. The temperature and relative humidity of the air were monitored, as well as the milk production of the animals housed in the facilities, and THI (Temperature and Humidity Index) were calculated. During the trials, the maximum daily temperatures of the air reached values around 27°C and the THI remained within the normal range of up to 70. The average productivity remained in the general pattern described in the literature from 23 to 44 kg of milk cow<sup>-1</sup> day<sup>-1</sup>, with lower rates obtained in the closed house. As the variation of the index used to describe the internal environment was not significant, it can be inferred that climatic elements as temperature and air humidity, under the conditions analyzed were not the main factors influencing the productivity rates of dairy cattle. In conclusion, under the analysed conditions the use of a closed barn with negative pressure ventilation is hardly justified as a plant that favoured the productivity of the confined cows.

**Key words:** compost-bedded pack barn, dairy cows, cattle housing, thermal comfort.

**Acknowledgements.** This work was carried out with the support of CNPq, National Council for Scientific and Technological Development – Brazil.

## Variable Velocity System for Evaluating Effects of Air Velocity on Japanese Quail

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**Abstract.** This study documents the design and performance of a system to apply different magnitudes of air velocity to Japanese quail, to evaluate the combined effects of velocity, temperature and humidity on bird behaviour, performance and welfare. The system was developed to simulate observed field conditions occurring in regions with high winds where quail are raised in curtain-sided housing. System performance consisted of characterizing air velocity distribution in cages downstream of the air velocity which was directed at the front of the cages. The system consisted of two fans attached to a 25 cm PVC tube, one at each end, with the outlet airflow directed through a continuous slot over the cage front at the feeder. The design and performance of this experimental system was evaluated, with six such systems were built and utilized in research trials. To assess system performance, air velocity was measured at 275 points per cage uniformly arranged along the three dimensions (length, width and height) in eight cages with zero, 1, 2 or 3 m s<sup>-1</sup> nominal velocity setpoints. Spatial distribution of velocity was analysed by mapping and from descriptive statistics, with attention to the zone closest to the feeder where birds must go to eat. There was no significant difference ( $P>0.05$ ) found in mean paired difference of air speed data measured for pairs of front portion cages with similar velocities. A significant positive correlation was found ( $P<0.001$ ) between the measured air velocity at paired points in the cages subjected to the same velocity treatment. A comparison of measured mean air velocity to the nominal setpoint values used for experiments indicated that careful attention to outlet adjustment is important, especially at higher nominal velocity setpoint as 3 ( $\pm 0.10$ ) m s<sup>-1</sup> which was difficult to achieve with the system. An example of the use of the deployment of the variable velocity system in controlled environment chambers with Japanese quail is provided.

**Key words:** cold stress, effective temperature, engineering design, heat stress, wind chill.

**Acknowledgements.** Federal University of Viçosa, Iowa State University and University of Florence. This research was supported by the Foundation for Research Support of Minas Gerais (FAPEMIG); Coordination for the Improvement of Higher Education Personnel (CAPES); and National Counsel of Technological and Scientific Development (CNPq).

## Hydrogen sulfide emissions from cattle manure: experimental study

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**Abstract.** Animal waste products, manure, in particular, are the sources of gases harmful to human and animal health. Hydrogen sulfide ( $H_2S$ ), which is produced from the breakdown of organic matter in animal faeces, is one of them. Its concentration in the cow barn air should not exceed  $5 \text{ mg m}^{-3}$ . A special laboratory setup was designed and the level of hydrogen sulfide emissions from the cow manure was determined depending on the time and manure temperature and moisture content. The most intensive emission of hydrogen sulfide from manure was in the first 24 hours – the increment of  $H_2S$  concentration was  $0.168 \text{ mg m}^{-3}$  per hour average. During the next 24 hours, it was  $0.021 \text{ mg m}^{-3}$  per hour. When the manure temperature increased,  $H_2S$  concentration increased also; when the temperature manure decreased,  $H_2S$  concentration decreased also. In 48 hours, the hydrogen sulfide concentration was  $1.1 \text{ mg m}^{-3}$  at the manure temperature of  $+3.0 \text{ }^\circ\text{C}$ . At the manure temperature of  $+23.4 \text{ }^\circ\text{C}$  and  $21.3 \text{ }^\circ\text{C}$ ,  $H_2S$  concentration was  $6.53 \text{ mg m}^{-3}$  and  $4.97 \text{ mg m}^{-3}$ , respectively. The higher was the manure moisture content, the lower was the emission of hydrogen sulfide into the environment. After 24 hours under the manure moisture content of 88.5% and 92.5% and its temperature of  $21 \text{ }^\circ\text{C} \pm 0.3 \text{ }^\circ\text{C}$ , the difference in the hydrogen sulfide concentration was 1.18 times depending on the manure moisture content. The selected regression equations described the dependence of the hydrogen sulfide concentration on the considered factors. The determination coefficients and Student's criteria proved the reliability of the results obtained at the significance level  $P \leq 0.05$ .

**Key words:** hydrogen sulphide, emission, manure, cattle, farm.

## **VI PRECISION AGRICULTURE**

## **Spatial distribution of soil mechanical strength in a controlled traffic farming system as determined by cone index and geostatistical techniques**

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**Abstract.** Controlled traffic farming (CTF) is a mechanisation system in which all load-bearing wheels are confined to the least possible area of permanent traffic lanes and where crops are grown in permanent, non-trafficked, beds. In well-designed systems, the area affected by traffic represents less than 15% of the total cropped field area. The extent and distribution of soil compaction at locations laterally outboard traffic lanes may explain the performance of the crop established on the rows either side of wheel lanes. This compaction is influenced by lateral soil displacement caused by repetitive wheeling, soil conditions (strength), and soil-tyre interaction effects at the time of traffic. The impact of compaction on crop rows adjacent to traffic lanes is also dependent on the seasonal effect of weather, because of changes in soil water. This work was conducted to model the spatial distribution of soil mechanical strength under increasing number of passes of a farm vehicle to simulate the conditions that may be encountered in a CTF system at locations near-traffic lanes. The study was conducted on a *Typic Argiudoll* soil (26% clay, 72% silt, 2% sand) with four traffic intensities (0, 6, 12 and 18 passes) using a 120 HP tractor (overall load: 5.1 Mg). Traffic treatments were applied to experimental plots using a completely randomized block design with three replications. The spatial distribution of soil strength within wheeled and non-wheeled zones was determined using a cone penetrometer (depth: 0-300 mm) and geostatistical techniques. In all treatments, cone index showed a quadratic response with depth, which explained about 70% of the variation in soil strength as determined by cone index. The number of passes had no effect on the range of spatial dependence of residuals. No differences were observed in the proportion of pixels where penetration resistance was greater than 2 MPa (considered to be the limit soil strength for root growth of most arable crops) between-traffic treatments, or wheeled and non-wheeled zones, respectively. The estimated overall mean proportion of pixels ( $4.86 \pm 4.5\%$ ) suggested relatively high variability of this measure, which therefore needs to be considered to inform the design of future experimental work.

**Key words:** axle load, field traffic, soil compaction, soil mechanical properties, soil penetration resistance.

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## Use of olive pomace as an amendment to improve physico-chemical parameters of soil fertility

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**Abstract.** Given their richness in nutritive elements, the majority of agricultural waste is used as soil amendments, including olive oil waste. The purpose of this study is to determine the effects of the use of olive pomace from three extraction systems on the physico-chemical fertility of the soil, after their use as an amendment for faba bean cultivation. The experiment is carried out at the Civil Engineering and Environment Laboratory in the EST of Salé, in pots where the olive pomace has been mixed with the soil, respecting the percentages studied. Several relative physico-chemical parameters of soil fertility were determined at the end of the experiment, namely pH, electrical conductivity (EC), total kjeldhal nitrogen (NTK) content, organic carbon and exchangeable bases concentration and soil cation exchange capacity (CEC) determination. Different percentages of pomace from the three extraction systems were applied (control, 10%, 15%, 25%, 50%, 75% and 100%) for four months of bean germination test. The application of the pomace reduced soil pH, and increased soil organic matter and organic carbon content in proportion to the added percentage of pomace. The available phosphorus and exchangeable potassium content increased significantly ( $p < 0.05$ ) in pots containing different percentages of pomace compared to their concentrations in the soil (control). The total nitrogen content has not increased sufficiently but remains significantly different from the control, especially for the percentages of 25%, 50% and 75%. For its part, the cation exchange capacity (CEC) is important and will allow a good retention of nutrients for all percentages.

**Key words:** Olive pomace, Physico-chemical fertility, Soil amendment

## Impact of different fertilisers on elemental content in young hybrid aspen stem wood

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**Abstract.** The biomass production using fast-growing tree species such as hybrid aspen (*Populus tremuloides* Michx. x *Populus tremula* L.) has been recognized as an environmentally friendly and cost-effective approach. Growing these species can reduce the negative impact of earlier land mismanagement and at the same time provide additional biomass growth. The application of fertilisers may introduce not only the necessary macro elements (N, P, K) but also significant amounts of toxic heavy metals. Therefore, the knowledge about elemental flows from fertilised soil to the different parts of hybrid aspen trees is essential and especially meaningful for the evaluation of element content in specific environmental ecosystems. The impact of different fertilisers (sewage sludge, digestate and wood ash) on the concentrations of micro- and macro elements in the wood of six-year-old hybrid aspen stands grown on former agricultural land was studied. The determination of element concentrations in different tree rings of hybrid aspen trees was accomplished by inductively coupled plasma mass spectrometry (ICP-MS). Isotope ratio mass spectrometry (IRMS) was used to determine the nitrogen and carbon content and isotope ratios in different parts of hybrid aspen trees. Stem disc samples from hybrid aspen trees were obtained from agricultural land in the central part of Latvia. Samples were taken from six-year-old hybrid aspen trees that at the moment of planting were fertilised with sewage sludge, a residue of biogas production (digestate) and wood ash. The obtained results indicated that the chemical element accumulation in hybrid aspen was affected by the applied fertiliser type. In this study, the use of wood ash, as well as digestate, affected the elemental content in hybrid aspen to a greater extent than the use of sewage sludge, relative to unfertilised (control) subplot. The analysed elements varied in the analysed stem plane (across the tree rings). The most significant changes between the rings were observed for the content of K and Ca.

**Keywords:** hybrid aspen, heavy metals, macro elements, ICP-MS, IRMS.



## Effect of cattle trampling and farm machinery traffic on soil compaction of an *Entic Haplustoll* in a semiarid region of Argentina

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**Abstract.** Soil compaction has detrimental effects on the physical, mechanical and hydraulic properties of soils, and affects important soil processes and function, and crop productivity. This work was conducted to investigate soil compaction impacts in integrated arable cropping-livestock systems managed under conventional tillage (CT) and no-tillage (NT). The work examined the combined effects of cattle trampling and farm machinery traffic on: soil strength, soil deformation, and water infiltration into soil. The following treatments were applied to soil (*Entic Haplustoll*, 60% sand) managed under CT and NT: three traffic intensities (1, 5, 7 passes) performed with light (2WD, 53 kN) and heavy (4WD, 100.4 kN) tractors, and two stocking densities (400 and 700 kg ha<sup>-1</sup>), respectively. Controls were also used to represent the condition of the soil without any effect of livestock or field traffic. In both tillage systems, soil penetration resistance (strength) increased and water infiltration into soil decreased as traffic intensities or stocking rates applied increased. There was a significant traffic intensity × stocking rate interaction, which influenced the depth and extent of soil compaction at depth. Despite these results, stubble grazing during fallow should not be discouraged as this practice offers mixed farming systems several agronomic and financial benefits. If stubble was to be grazed, the system would need to be carefully managed: (1) avoid 'random' traffic using permanent or semi-permanent traffic paths to minimise the field wheeled area, (2) vacate livestock from the field, or confine it to a sacrificial area, when the soil water content exceeds a critical level above which soil damage is likely, and (3) maintain more than 60%-70% ground cover. Tillage repair treatments can be targeted to those sacrificial or 'hot-spots' areas so that localised, as supposed to widespread, compaction problems are rectified before the next crop is established.

**Key words:** axle load, cone index, ground cover, infiltration, soil deformation, traffic intensity.

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## **Atmospheric attenuation of the ku band along the space-earth path due to clouds and rain**

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**Abstract.** The weather conditions formed in troposphere causes the greatest signal attenuation in satellite communication systems especially at frequencies above 10 GHz. This paper describes possible signal attenuations on the satellite-earth path due to rain and clouds. It was measured whether it is advantageous to use the Ku band for data transmission over other bands. The measurement was carried out in the Czech Republic using a beacon signal from Eutelsat 12W satellite at 12.5 GHz. Clouds and the rainfall rate at the measured location were obtained from the CHMI portal. The measurements show that the clouds cause negligible attenuation. Significant attenuation was caused by rainfall. The measured values of slant path rain show a significant decrease in signal strength even in light rain. The measured cumulative rainfall rate was found to be close to the ITU-R model. The measurements show that the Ku band is advantageous for data transmission in rain poorer regions including Central Europe.

**Key words:** signal, attenuation, weather, satellite, rain, clouds.

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## Biological features of formation of perennial binary grass crops

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**Abstract.** The paper deals with the impact of binary mixtures of perennial grasses on the productivity and quality of forage crops that differ in their species composition. The studies have shown that mixed crops exceeded single-species crops in all indicators of forage crops productivity. In total over five years binary crops of *Poterium polygamum* exceeded single-species ones in all productivity indicators. The plants safety by the end of vegetation was also slightly lower than in single-species crops, which can be explained by greater competition for light, moisture and nutrients. So the safety of *Medicago sativa* L. was 81.8%, *Onobrychis* – 83.6%, *Galéga orientális* L – 89.7%, *Poterium polygamum* – 74.6%, which is lower than that of legumes in single-species crops. In all years of herbage use, the binary crops exceeded single-species ones. On average, for 5 years of research, the yield of *Poterium polygamum* was 25.5 t/ha, *Medicago sativa* L. – 22.5 t/ha, *Onobrychis* – 23.7 t/ha. Among legumes, the maximum yield had *Galéga orientális* L agrocenosis – 26.1 t/ha. Mixed crops of burnet with leguminous grasses were characterized for yielding the vegetative mass on average 28.5-30.9 t/ha. Maximum values of binary *Poterium polygamum* crops characterized crops with the leguminous plant component of goat's rue in all years of research. Mixed crops also showed maximum values of dry matter per unit area and amounted respectively 33.52 – 36.74 t/ha. The same pattern continued in the yield of fodder units, digestible protein and metabolic energy, their maximum was obtained at the variant *Poterium polygamum*+ *Galéga orientális* L..

**Key words:** sowing, mixed, grasses, productivity, yield.

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## Comparative environmental analysis of soil sampling methods in precision agriculture for lime application in Paraná State, Brazil

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**Abstract.** Precision agriculture (PA) provides techniques that favour the localized application of inputs allowing their rational use. This makes the PA a potential indicator of reduced operational costs, input volume, and environmental impacts. The objective of this study was to evaluate and compare the environmental effects of three different sampling methods used in PA for the lime application. The first sampling method evaluated was the grid sampling (GS). It was performed at a density of one sample per hectare in a 100 × 100 m georeferenced grid. The second method was the directed sampling, that was performed after defining the management zones by soil apparent electrical conductivity (ECa) using a soil electrical conductivity sensor. The last sampling method was the Altitude-based management zone (AMZ) sampling that was developed based on altitude maps of the field. These sampling methods were tested in three different areas in the south of Brazil. This study evaluated the spatial variability of the lime volume in the soil and compared quantitatively and spatially the recommended application volumes achieved by each sampling method. Results highlighted that the sensor-directed soil sampling method was the alternative that would generate the lowest environmental impact.

**Key words:** environmental impact, management zones, sample grids, soil apparent electrical conductivity.

## The evaluation of light conditions for strawberries grown vertically in open area and greenhouse

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**Abstract.** Light is one of the most important factors in plant life, which significantly affect the growth and development. The low intensity of natural light can be the limiting factor for production and yield of strawberries. Growing strawberries in covered areas can extend the harvest season, reduce risks and increase income. However, studies are needed to clarify growing methods and systems, their impact on yield quantity and quality as well as economic viability. The aim of this research was to evaluate the light conditions for strawberries grown vertically in open area and greenhouse, and their vegetative parameters and chemical composition in response to these conditions. The experiments were done at the Faculty of Agriculture, Latvia University of Life Sciences and Technologies (LLU). *Fragaria* plants of three strawberry cultivars - 'Honeoye', 'Sonata' and 'Rumba' were planted in double-layer plastic greenhouse and open field conditions. Plants were grown in growing bags with coarse sphagnum peat. Bags were installed in vertical growing system in three layers – 10 cm, 90 cm, and 155 cm, and drip irrigation system was used. The light intensity and spectral content were detected by using spectroradiometer Gigahertz-Optic MSC15. Content of chlorophylls, carotenoids, phenols, flavonoids was analysed in this research. The differences in plant growth, response to light and biochemical content between cultivars and growing systems were detected. In total, 56.6% of light intensity was lost in greenhouse, compared to open area, and bottom levels had just 71% of light intensity in top levels, moreover, light intensity in bottom level also varied more due to shadows. However, these differences in the light intensity did not significantly influenced average leaf and inflorescence counts per plant. Although significant differences in leaf biochemical composition were found in tested growing conditions, cultivars responded differently to them.

**Key words:** light intensity, *Fragaria × ananassa*, vertical growing, leaf chemical composition.

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## **A comparative study of the properties of industrially produced humic substances**

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**Abstract.** Humic substances (HSs) are produced industrially in large quantities from low rank coal, weathered coal, peat, also from soils, composts and other sources. Considering that the applications of industrially produced HSs also include food, pharmaceutical applications and environmental technologies, it is important to evaluate their composition and quality and to identify their sources. The aim of the present study is to compare the properties of industrially produced HS samples. HSs were characterised using spectroscopic and other methods. For the identification of origin of HSs, different methods can be used, such as elemental analysis and ratios of light stable isotopes. HSs nowadays have a wide range of agricultural applications and, therefore, are produced at an industrial scale worldwide. The results of the study indicate that many industrially produced HSs are of poor quality. In this situation, rigorous quality control should be implemented. The composition of materials suggested for agricultural applications has not been analysed much. Most of the studied materials were designated as HAs, followed by fulvic acids (FAs) and HSs. However, an analysis of the humic matter types indicates that the majority of substances offered on the market are in fact mixtures of HAs and FAs; so, it would be more appropriate to designate them as HSs or their salts. As HSs increasingly become an industrially produced material for agricultural applications, its quality is of utmost importance. This study identifies the main quality problems of industrially produced humic substances: 1) lack of strict quality indicators, 2) absence of indication of source materials/origins of HSs.

**Key words:** peat, humic substances, humic acids, characterisation, spectroscopy.

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## The biological basis for the use of protein growth stimulant made from cattle split for wheat foliar feeding and disease suppression

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**Abstract.** The new modern preparation – protein growth stimulant – was generated in accordance with technology of employees of Saint-Petersburg ITMO University and Saint-Petersburg State Agrarian University. Biological activity of the preparation was determined by measurements of 20 indicators of the wheat productivity. In addition, 16 indicators of different types of pathogenesis were determined. These can be formed at distribution of *Helminthosporium* root rot, wheat rust species, powdery mildew and wheat leaf blotch. The use of the protein growth stimulant promoted increase of potential yield in 80% of samples. In comparison with the control, 15 wheat varieties, treated with the preparation, showed an increase in the main productivity indicators: the length of the spike, the number of spikelets per spike, the weight of 1000 grains, the productive tilling capacity and the general bushiness. The intensity of *Helminthosporium* root rot development decreased 11.9% (it was found in 53.3% of samples) and the wheat leaf blotch by 15.6% (in 66.7% of samples). The wheat brown rust development intensity decreased insignificantly (3.6% compared to the control). In the same time, values of the pathogen pustule area decreased at average by 79.8%. There was an increase in total nitrogen in wheat leaves at 92% of samples. As was revealed, the effectiveness of the protein growth stimulant largely depends on the wheat variety. To conclude, the prospect of using the new effective protein growth stimulant to increase productivity of wheat and protection from diseases was shown.

**Keywords:** diseases of wheat, growth stimulants, soft wheat, the elements of productivity

**Acknowledgements.** The authors express their deep gratitude to the head of the Department of genetic resources of wheat, VIR- E.V. Zuev, to our colleagues V.V. Bogomolov and S. I. Snarsky from the Leningradskaya inter-regional veterinary laboratory for many years of productive cooperation and assistance in research.

## Model for the bee apiary location evaluation

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**Abstract.** Honeybees are predominant and ecologically as well as economically important group of pollinators in most geographical regions. As a result of analysing current situation in studies and practices, a conclusion was drawn that beekeeping sector is in decline. The identified reasons for this are land-use intensification, monocropping, pesticide poisoning, colony diseases, parasites and adverse climate. One of the solutions is to find a proper bee colony harvesting location and use luring methods to attract bees to this location. Usually beekeepers choose the apiary location based on their own previous experience and sometimes the position is not optimal for the bees. This can be explained by different flowering periods, variation of resources at the known fields, as well as other factors. This research presents a model for evaluation of possible apiary locations, taking into account resource availability estimation in different surrounding agricultural fields. Authors propose a model for real agricultural field location digitization and evaluation of possible apiary location by fusing information about available field resources. To achieve this, several steps have to be completed, such as selection of fields of interest, converting selection to polygons for further calculations, defining the potential values and coefficients for amount of resources depending on type of crops and season and calculation of harvesting locations. As the outcome of the model, heat map of possible apiary locations are presented to the end-user (beekeeper) in the visual way. Based on the outcome, beekeepers can plan the optimal placement of the apiary and change it in the case of need. The Python language was used for the model development. Model can be extended to use additional factors and values to increase the precision for field resource evaluation. In addition, input from users (farmers, agricultural specialists, etc.) about external factors, that can affect the apiary location can be taken into account. This work is conducted within the Horizon 2020 FET project HIVEOPOLIS (Nr.824069 – Futuristic beehives for a smart metropolis).

**Keywords:** Precision Beekeeping, Smart apiary location, harvesting location evaluation, HIVEOPOLIS.

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## Improving Options of Nitrogen Use Efficiency in Latvia's Crop Production

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**Abstract.** Nitrogen loss from fertilizer has become a persistent environmental problem in the world, including European Union. Nitrogen fertilizer use in agriculture is associated with: i) most common and widespread pollutant in groundwater water pollution via nitrate leaching; and ii) occurrence of greenhouse gas emissions, particularly nitrous oxide. Nitrous oxide has a strong warming effect on climate change, because it is about 300 times more effective at heating the atmosphere than carbon dioxide. While water pollution by nitrates cause water eutrophication, which is serious environmental issue in inland waters as well as in the Baltic Sea.

The aim of this study is two-fold: 1) to estimate trends of nitrogen balance as well as nitrogen, especially inorganic, use efficiency in Latvia's crop production via comparing them among the Baltic Sea Region countries, including the Baltic States; 2) to evaluate optimal nitrogen management and farming practices for reducing inorganic nitrogen fertilizers usage, and efficient options or measures for improvement the nitrogen usage efficiency in crop production.

The principal materials used in the studies are as follows: various sources of literature, e.g., scholars' articles, the reports of institutions (esp. EU), etc. The data were obtained from Eurostat database and database of Central Statistical Bureau – CSB. The mixed methods, combining suitable qualitative research methods (i.e., monographic, analysis and synthesis, content analysis, etc.) and quantitative research methods (i.e., correlation-regression analysis) have been used.

The soil carbon balance and loss of soil organic matter, which is an important criterion or indicator of soil degradation. Decrease of soil organic matter leads to the increasing of nutrients, including nitrogen, leaching. The findings in Latvia show some negative impact on soil quality, caused by certain agricultural practices that are environmentally unsustainable. For example, intensification of crop production, particularly cultivation of monocultures (e.g., winter wheat and rape), increased usage of inorganic fertilizers, notably nitrogen, and agricultural chemicals (i.e., pesticides).

Notwithstanding in all Baltic States the significant increase of nitrogen fertilizer's consumption is detected, a more obvious trend is observed in Latvia. Similar results are observed related to the nitrogen use efficiency.

Analysing recommended improving measures of efficient nitrogen management, it is concluded that main part of them are noted as mandatory or voluntary requirements under the Rural Development Programme (RDP) of Common Agriculture Policy (CAP).

**Key words:** nitrogen, fertilizer, balance, crops, efficiency.



## Climate Change Adaptation and Mitigation: Opportunities in Cropping Systems

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**Abstract.** Environmental impacts of agriculture, especially cropping, under a changing climate are considered more and more important. The challenge of cropping within the climate change context is two-fold, both to reduce emissions and to adapt to a changing and more variable climate. The primary aim of the mitigation options is to reduce emissions of nitrous oxide or to increase soil carbon storage. All mitigation options affect the carbon and/or nitrogen cycle of the agroecosystem. This also affects the soil properties and nutrient cycling. Adaptation to increased variability of temperature and rainfall involves increasing the resilience of the crop production systems. This could be done by improving soil water holding capacities through adding crop residues and manure to arable soils or by adding diversity to the crop rotations. Most of adaptation options for climate change have positive impacts on mitigation.

Most categories of adaptation options for climate change affecting the mitigation options and include: These options include: (i) measures that reduce soil erosion and reduce soil degradation; (ii) measures that reduce leaching of nitrogen and phosphorus; (iii) measures for conserving soil moisture, (iv) increasing the diversity of crop rotations, and choices of crop species or varieties; (v) modification of microclimate to reduce temperature extremes, (vi) land use change involving abandonment or extensification of existing agricultural land, or avoidance of the cultivation of new land. These adaptation measures can reduce greenhouse gas emissions – nitrate oxide, as well as nitrate leaching, by improving nitrogen use efficiency and improving soil carbon storage.

The principal materials are as follows: different sources of literature, e.g. scholars' articles, research papers and the reports of international (i.e., IPCC, UNEP), EU institutions, as well as Latvia's institutions. For comparison and evaluation of the state and trends among countries in the Baltic Sea Region, the EU Member States (Denmark, Estonia, Finland, Germany, Latvia, Lithuania, Poland and Sweden) were chosen. The suitable qualitative and quantitative research methods (e.g., monographic; analysis and synthesis; logical and abstractive constructional, etc.) according to the tasks were used.

There are various widely accepted and evidence based effective climate change adaptation options proposed by scholars and experts for cropping systems. Most important of them, for example, are the following: agricultural input efficiency; improving (i.e., less energy-intensive) farming; reducing nitrogen surplus and nitrogen use efficiency via fertilizer usage; crop and soil management strategies' change, such as tillage practices, permanent crops; crop rotations and use of cover crops or catch crops, organic farming, green manuring; as well as reducing and/or completely removing agrochemicals; carbon sequestration and improve soil physical, chemical and biological properties. Furthermore, implementation of agro-ecological and conservation agriculture principles that affect biodiversity conservation (agrobiodiversity; i.e., crop genetic diversity) and supports many ecosystem services. Adaptation measures include technological advancements, adaptive farming practices, etc. The paper presents results of current situation's evaluation, analysing above-mentioned measures implementation status, as well as provides proposals for implementation of most promising adaptation measures in Latvia's agriculture. Moreover, necessary policy decisions and public financial support (i.e., RDP 2014-2020, RDP post 2020) are indicated.

**Key words:** crop rotation, diversification, soil carbon, non-tillage, catch crops.

## Developing of Modern Cultivation Technology of Organic Potatoes

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**Abstract.** Medium term field experiment demonstrates the effectiveness of biological ways to increase potatoes yield on the sod-podzolic, light loamy soil. The effects of the following two groups of factors were studied:

1. The level of mineral nutrition provided by compost;
2. Microbiological plant protection product (bio preparations): Flavobacterin which has N fixer attribute and Vitaplan and Kartoffen, which have bio fungicide features.

Potatoes varieties “Nevsky” and “Udacha” were cultivated. The compost was applied in the dose range from 0 to 160 kg N ha<sup>-1</sup>. Treatment with bio-preparations was carried out by potato tubers during planting and leaves during the growing season. Weeds were removed mechanically. Weather conditions had a significant impact on the formation of the crop. The average yield of standard potato tubers for 2017-2018 ranged from 14.1 to 29.3 t ha<sup>-1</sup>. The use of both microbiological preparations and compost gave approximately the same effect and increased yields by 35-37% compared to the control. The use of compost together with bio-preparations provided an output of 27.6-29.3 t ha<sup>-1</sup> of potatoes. In 2019, the joint use of compost and bio-preparations allowed to reach a yield of 40 tons ha<sup>-1</sup> of marketable potatoes. On the basis of the obtained data, the mathematical dependences of the yield of potatoes on the dose of compost, the type of biological preparation and the complex indicator of the year conditions were determined.

**Key words:** crop rotation, potatoes, organic fertilizers, microbiological drugs, field experiment.

## Experimental efficiency evaluation of 445 nm semiconductor laser for robotized weed control applications

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**Abstract.** Robotized weed control is one of perspective approaches for decreasing ecological impact of farming. Although current level of technology development allows robotized weed control to be economically reasonable only in specific applications, it is only a matter of time to introduce them in full-scale industrial farming. In general terms weed control using agricultural robots consist of two parts: recognition and spatial localization of weeds (distinguishing them from crops) and precision application of some kind of growth limiting activity. Recognition and localization is usually carried out using computer vision solutions (image filtering and transformations, artificial neural networks etc.). Growth limiting in its turn is performed by mechanical, precise chemical, thermal, cryogenic or other means. This article covers application of laser radiation for thermal destruction of unwanted plant canopies. In most cases CO<sub>2</sub> type lasers with 10.6 μm wavelength is used as they are affordable and they are applicable to use with plant biomass due to their spectral characteristics. Drawbacks of CO<sub>2</sub> lasers are low efficiency, size, weight and complex maintenance. In recent years relatively powerful short-wavelength semiconductor lasers have become broadly available on market. Light absorption of healthy green leaves is much better in blue-UV spectrum than in green, far infrared and near infrared, which is almost completely reflected by leaves. Thus an experimental study of using 12 W output 445 nm blue semiconductor laser for weed canopy cutting was carried out. The experiments were performed with direct laser radiation, the laser module was positioned using robotic manipulator with different speeds and cutting patterns.

**Key words:** weed, laser, efficiency, robot.

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## **What happens to peat during bog fires? Thermal transformation processes of peat organic matter**

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**Abstract.** Bog fires are a serious natural phenomena. Major increase in the number of fires has happened during the last decades due to bog transformation into agricultural lands, accidents and human activities.. During bog fires the peat is exposed to high temperatures due to which chemical transformation and even mineralisation of peat can occur. The aim of the study was to analyse the impacts of the bog fires on the bog as an ecosystem, advance the understanding and knowledge of fire impact on peat and humic matter properties and application possibilities. As the material for the study peat samples from burnt sites and thermally treated peat were used. To reveal peat transformation during bog fires, thermogravimetric analysis of peat samples were done, where amounts of bitumens, humic acids and mineral matter were estimated. During bog fires thermal modification of peat properties takes place, resulting in full mineralisation of peat and release of mineral substances. Bog fires lead to development of peat char, bitumens and significant changes in structure and properties of peat humic acids. However, from perspective of application of peat as a substrate and from perspective of impacts on the bog ecosystems, the effects are negligible.

**Key words:** bog fires, humic substances, peat, recultivation, torrefication.

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## **Modeling the impact of weather and climatic conditions and nutrition variants on the yield of spring barley varieties (*Hordeum Vulgare L.*)**

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**Abstract:** Crop yield is a result of the interaction between plant genetic traits, soil properties, agrotechnology and climatic regimes. Low yield tend to be formed in regions where it is limited to the extent of water availability, heat stress and the short duration of the grain filling period. High temperature and drought stress are projected to reduce crop yields and threaten food security. The article presents the results of studies on the effectiveness of treatment of spring barley crops with modern growth-regulating drugs on the background of mineral fertilizers, carried out in different weather and climatic conditions in 2013 — 2017 yrs on the Southern chernozem in the conditions of Steppe of Ukraine. It was studied the influence of weather and climatic conditions, varietal characteristics of spring barley and nutrition variants on the formation of grain yield. It was determined that the cultivation of spring barley, the introduction of pre-sowing cultivation of mineral fertilizer at a dose of N<sub>30</sub>P<sub>30</sub> (background) and the use of crop foliar fertilizing at the beginning of the phase of stooling and earing by the complex organo-mineral fertilizer Escort bio created favorable conditions for the growth and development of plants of the studied varieties, which in turn had a positive effect on grain yield. Thus, according to this variant of nutrition, on average, during the years of research, it was formed the yield of 3.25 - 3.61 t ha<sup>-1</sup> grains depending on the studied variety.

Results of researches showed that weather conditions during the years of research significantly influenced on the productivity of spring barley varieties. In 2016 the amount of precipitation was the highest (174.0 mm), the temperature during vegetation of spring barley was +14.9 °C. In 2013 the amount of precipitation was the lowest (67.4 mm), the temperature was +18.5 °C. The lowest crop yield was formed in 2013, and the highest yield was formed in 2016. Studies showed that the influence of weather factors in various interfacial periods of growth and development of spring barley was significant enough for the manifestation of signs of yield and its elements and is more dependent on rainfall.

**Key words:** spring barley, variety, plant nutrition, weather and climatic conditions, grain yield, modeling of regularities.

## Isolation of streptomycetes causing common scab from 3-years old potato samples from South America

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**Abstract.** In this paper, we aimed at assessing the best conditions for the isolation of actinobacteria from old potato samples. A set of media and pretreatments were tested. The optimal were chosen for the isolation of actinobacteria from potatoes from Peru, Chile and Argentina. Isolates were tested on the presence of thaxtomin phytotoxin by amplification of the respective gene. Phylogenetic position of strains was compared with their geographical origin, pathogenic potential and existence of common scab (CS) symptoms on potato sample. We demonstrated that RNAlater can be successfully used for the long-term preservation of potato peel for subsequent isolation of actinobacteria on R2A medium. Many streptomycetes were thaxtomin-positive, though they are distantly-related to described pathogens causing CS. Genus *Nocardia* was first reported to be thaxtomin-positive. Potentially pathogenic strains were isolated not only from infected potato but also from those lacking CS symptoms. Some strains from scabby potatoes were thaxtomin-negative.

**Key words:** common scab, streptomycetes, thaxtomin, potato disease.

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## Coffee crop coefficient prediction as a function of biophysical variables identified from RGB UAS images

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**Abstract.** Because of different Brazilian climatic conditions and the different plant conditions, such as the stage of development and even the variety, wide variation may exist in the crop coefficients (Kc) values, both spatially and temporally. Thus, the objective of this study was to develop a methodology to determine the short-term Kc using biophysical parameters of coffee plants detected images obtained by an Unmanned Aircraft System (UAS). The study was conducted in Travessia variety coffee plantation. A UAS equipped with a digital camera was used. The images were collected in the field and were processed in Agisoft PhotoScan software. The data extracted from the images were used to calculate the biophysical parameters: leaf area index (LAI), leaf area (LA) and Kc. GeoDA software was used for mapping and spatial analysis. The pseudo-significance test was applied with  $p < 0.05$  to validate the statistic. Moran's index (I) for June was 0.228 and for May was 0.286. Estimates of Kc values in June varied between 0.963 and 1.005. In May, the Kc values were 1.05 for 32 blocks. With this study, a methodology was developed that enables the estimation of Kc using remotely generated biophysical crop data.

**Key words:** *Coffea arabica* L., Drone, Irrigation, Leaf Area, UAV (Unmanned Aerial Vehicle).

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## **The use of biogas digestate and wood ash as bio-fertiliser and liming material: a review**

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**Abstract.** An uneven soil use and different cultivation and fertilisation practices affect the soil's structure, agrochemical properties and fertility. The percentage of soils with insufficient organic matter and low acidity is increasing every year in Latvia, which negatively affects the influence of fertilisation as well as the crop yield. The content of organic substances in soil is an important indicator of soil quality. It impacts the attraction of chemicals, formation of the soil structure as well as the regime of humidity and air in the soil. A digestate as a by-product of biogas production is one of the sources of organic matter that is currently used in Latvia. Usually it is a semi-solid mass that consists of a semi-degraded plant material, a biomass of microorganisms and a slurry (if it was used in a biogas production process). It is mainly used as a liquid fertiliser, which is incorporated into the soil. The dry matter content of digestate makes approximately 5-10%. Transport costs are relatively high because of the digestate's large water content. For that reason, the separation and drying of digestate is used. The resulting product contains relatively few nutrients. The adding of wood ash to digestate's dehydration process gives the opportunity for soil liming as well as for soil enrichment with nutrients. The article reviews the possibilities and effect of the use of digestate and ash for increasing the yield of different crops, for the optimisation of nutrients as well as to influence the soil pH and some environmental risks arising the application of digestate in agricultural practice.

**Key words:** digestate, wood ash, bio-fertilisers.

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## Comparison of growth of maiden trees of cultivars and genotypes of Cornelian cherry (*Cornus mas* L.) in a nursery

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**Abstract.** Cornelian cherry (*Cornus mas* L.) is still not a very popular fruit plant in Poland. Fruit growers have been recently increasingly interested in the cultivation of plants with fruits that can be widely used in processing. Fruits of Cornelian cherry can be eaten raw, and processed in various ways: for tinctures, juices, jams, silage, candied, etc. Both the fruits and preserves are characterised by high pro-health properties due to the content of vitamins, anthocyanins, and loganic acid. *Cornus mas* adapts well to the climate and soil conditions in Poland. The only limitation of its broader cultivation is lack of good planting material. The experiment investigated the efficiency of budding on two-year-old seedlings (*Cornus mas* L.) of several cultivars and genotypes of Cornelian cherry. Moreover, the height of plants, stem diameter, average number of shoots, number of leaves on selected shoots, and quality of roots were determined. The cornelian cherry maidens obtained by budding with dormant bud in August on two-year-old seedlings of Cornelian cherry (*Cornus mas* L.) constitutes high quality material suitable for establishing commercial plantations. Maiden trees of particular cultivars and genotypes of cornelian cherry significantly differ in height, diameter, number of branches and leaves, as well as the size of the root system. The diameter of the trunk is a good indicator of the quality of Cornelian cherry maiden, because it is closely positively correlated with the height of plants and the number of shoots.

**Keywords:** growth correlations, stem diameter, T -budding, quality of cornelian cherry maiden trees.

## Restricting the eligible maintenance practices of permanent grassland – a realistic way towards more active farming?

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**Abstract.** As a result of agricultural, land and ownership reforms coupled with liberal agricultural policy during the transition, agricultural land use in Estonia became more fragmented. A significant portion of agricultural land users are now considered passive farmers who maintain their agricultural land (often permanent grasslands) in good agricultural and environmental conditions and are therefore eligible for single area and greening payment. The maintenance of permanent grassland is one of the objectives of the EU Common Agricultural Policy (CAP), which contributes to the overall climate and biodiversity objectives of the EU. Until 2014, in Estonia, the minimum eligible activity for the maintenance of permanent grassland was to cut the grass and leave it on the ground. In 2015 and 2016, the area on which the cut grass could be left on the ground was restricted in order to increase incentives for more active agricultural land use. This paper analyses the likely effects of such restriction on the use and maintenance of permanent grasslands. The results of the study show that in the case of restrictions on the eligible practices of permanent grassland maintenance, passive land users as well as crop and mixed **crop-livestock** farms are likely to reduce the area of permanent grasslands (*shrinking farms*). At the same time, grazing livestock farms (*expanding farms*) would be willing to expand their permanent grassland area. More than 70% of the permanent grasslands of *shrinking farms* are located within 1 km and more than 90% within 2 km of *expanding farms*. However, in some regions it is likely that the maintenance of permanent grasslands is stopped as a result of the restrictions. It is argued that if permanent grasslands are to be maintained, it is necessary to introduce supports for grazing livestock farms, targeted supports for passive land users for their maintenance or more comprehensive land use policy that takes the climate change mitigation requirements into account.

**Key words:** permanent grasslands, passive farming, greening, Common Agricultural Policy, direct payments.

**Acknowledgements.** The authors wish to thank the Estonian Ministry of Rural Affairs for financing the collection of data that was used for this paper (project No. 8T160094MSDS, *Application of minimum requirements for maintaining agricultural land in good agricultural and environmental conditions in the framework of direct payments from 2013–2016*), Estonian Agricultural Registers of Information Board for providing data on the beneficiaries of the SAP and greening payment, and all the respondents to the questionnaire.

**Effects of the interaction between slurry, soil conditioners, and mineral npk fertilizers on selected nutritional parameters of *Festulolium Braunii* (K. Richt.) A. Camus**

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**Abstract.** The research was aimed at assessing the biomass yield of *Festulolium braunii* and its content of raw protein and crude ash after application of slurry, both on its own and together with soil conditioners (UGmax and Humus Active), and mineral fertilizers. The studies were conducted on the basis of a two-year field experiment. The interaction between slurry and soil conditioners and between slurry and mineral fertilizers was studied on the Sulino variety of *Festulolium braunii*, a hybrid between *Lolium multiflorum* and *Festuca pratensis*. Compared with plants treated with liquid manure on its own, slurry applied with soil conditioners and mineral fertilizer did not significantly increase the biomass yield of the grass. However, there was higher protein content in *Festulolium braunii*, even if statistically insignificant, as a response to slurry supplemented with mineral fertilizer than in plants treated with slurry only. Various forms of treatment did not differentiate crude ash content in plant dry matter in a statistically significant way.

**Key words:** forage grass, fertilization, nutritional value.

## **Application of feature selection for predicting leaf chlorophyll content in oats (*Avena sativa* L.) from hyperspectral imagery**

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**Abstract.** Feature selection can improve predictions generated by partial least squares models. In the context of hyperspectral imaging, it can also enable the development of affordable devices with specialized applications. The feasibility of feature selection for oat leaf chlorophyll estimation from hyperspectral imagery was assessed using a public domain dataset. A wrapper approach resulted in a simplistic model with poor predictive performance. A filter approach based on the minimum redundancy, maximum relevance criterion reduced the number of model inputs from 94 to 3 bands. The filtering led to improved prediction accuracy, with the root mean square error decreasing from 0.17 to 0.16 g m<sup>-2</sup> and R<sup>2</sup> increasing from 0.57 to 0.62. The obtained model estimated leaf chlorophyll concentration from near infra-red reflectance, canopy darkness, and its blueness. The prediction robustness needs to be investigated, which can be done by employing an ensemble methodology and testing the model on a new dataset with improved ground-truth measurements.

**Key words:** remote sensing, imaging spectroscopy, unmanned aerial vehicles, partial least squares, reproducibility.

**Acknowledgements.** The work was conducted with the financial support from the Ministry of Agriculture of the Czech Republic, institutional support MZE-RO0418; and from the European Union Erasmus+ Programme. Lammert Kooistra and Jan Clevers read the paper draft and provided valuable remarks.

## **Application of geographically weighted principal components analysis based on soybean yield spatial variation for agro-ecological zoning of the territory**

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**Abstract.** In this study, the geographically weighted principal components analysis as an alternative method for agro-ecological characterization of the region was provided. The spatial and temporal distribution pattern of soybean yield was analyzed by using spatial statistics technology, which provided a good reference for agricultural development planning. The soybean yield was selected for the present study because it is a comprehensive indicator reflecting the production potential of the regional agroecosystems. The organized data set, which included the average per year yields of soybean in 10 regions (206 administrative districts) of Ukraine, was used for analysis. The regular temporal trend, specific for each district, was previously extracted from the time series data. The principal components analysis of the detrended data allowed to identify four principal components, which altogether can explain 58% of the soybean yield variation. The geographically weighted principal components analysis allowed to reveal that four spatially determined processes were influencing the yield of soybeans and had the oscillatory dynamics of different periodicity. It was hypothesized that the oscillating phenomena were of ecological nature. Geographically weighted principal component analysis revealed spatial units with similar oscillatory component of soybean yield variation. Our study confirmed the hypothesis that within the studied territory there are zones with the specific patterns of the temporal dynamics of soybean yield, which are uniform within each area but qualitatively different between zones. The territorial clusters within which the temporal dynamics of soybean yield is identical can be considered as agro-ecological zones for soybean cultivation.

**Keywords:** cluster analysis, geographically weighted principal components analysis (GWPCA), soybean, spatial variability, productivity, yield.

## **VII PRODUCTION ENGINEERING**

## Development of hemp hurd particleboards from formaldehyde-free resins

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**Abstract.** Low density of hemp hurd (*Cannabis Sativa L*), better end of life impact, performance comparable to wood chips and low energy requirement for cultivation make it a suitable alternative raw material for particleboards (Pb). However, due to concerns about sustainability and formaldehyde emissions, it is essential to develop the new bio-based resins from renewable resources. In this research, the mechanical and physical properties of Pb produced from hemp hurds (HH) and a variety of resins: Urea-formaldehyde (UF), formaldehyde-free acrylic resin (Acrodur®) and bio-based soy resin (Soyad™) were compared to those of wood particles (WP) bonded with UF. The results indicate that boards from HH are generally lighter than WP with a 5.6% variation between HH+UF and WP+UF. Hemp boards based on soy-resin showed higher tensile performance, with an average of 0.43 MPa compared to the 0.28 MPa and 0.24 MPa of (HH+UF) and (WP+UF) respectively. Nevertheless, thickness swelling (TS) of HH+UF (27%) was the least, while there was no significant difference in the water absorption (WA) compared to HH+Soyad4740, both were still lower than that of WP+UF. The overall outcome shows that bio-based soy resin can be a suitable alternative to UF as a binder in Pb production.

**Keywords:** Bio-resin, hemp hurd, mechanical properties, particleboard, urea-formaldehyde.

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## A method for obtaining plastid pigments from the biomass of *Chlorella* microalgae

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**Abstract.** Microalgae are distinguished from land plants by the high content of plastid pigments and the biodiversity of carotenoids. The aim of this study is to develop a technology for extracting a pigment complex from the biomass of the microalgae of the genus *Chlorella* and to determine the extracted pigments' composition. To obtain biomass, a crude cell suspension of microalgae was used, which was obtained under laboratory conditions for pre-culture cultivation of *C. sorokiniana* (strain 211-8k). Ultrasonic extraction of plastid pigments from air-dry biomass after disintegration of cell membrane was performed in the 40 kHz mode. It was found that the highest pigment content in ethanol extracts was observed after 30 min ( $870.0 \pm 27.1 \text{ mg l}^{-1}$ ) at 45–50 °C. The pigments' composition in the resulting total extracts was determined by spectrophotometry and the Reverse Phase HPLC method. The established content of chlorophyll *a* in the obtained extracts was  $537.5 \pm 10.0 \text{ mg l}^{-1}$ , the content of chlorophyll *b* was  $182.5 \pm 27.5 \text{ mg l}^{-1}$ ; the maximum output of the amount of carotenoids in extracts was  $150.0 \pm 10.0 \text{ mg l}^{-1}$ . Thus, the main identified forms of carotenoids in extracts from the biomass of microalgae *C. sorokiniana* were xanthophylls: lutein and fucoxanthin (18.6 and 4.7% of the amount of pigment in extract, respectively) and  $\beta$ -carotene (1.8% of the amount of pigment). It is planned to further fractionate the obtained total extracts of the pigment complex to obtain various forms of chlorophylls and carotenoids to study the spectrum of physiological activity of plastid pigments.

**Key words:** *Chlorella* microalgae, pre-culture cultivation, disintegration, ultrasonic extraction, chlorophyll, carotenoids.

**Acknowledgements.** The analysis of the composition of the pigments of the microalga *C. sorokiniana* using using the Reverse Phase HPLC method was carried out on the basis of MIP «Analytics. Materials Technologies» Peter the Great St. Petersburg Polytechnic University. We would like to express our gratitude to Igor Vadimovich Kruchin-Bogdanov, Director of the small innovative enterprise «Analytics. Materials. Technologies» Peter the Great St. Petersburg Polytechnic University.



## Comparison between the thermal properties of cement composites using infrared thermal images

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**Abstract.** The use of agribusiness residual lignocellulosic fibres can be a good alternative in the development of lignocellulosic composites. The current work aimed to investigate the thermal performance of cement-based composites with lignocellulosic materials: Eucalyptus, sugarcane bagasse, coconut fibre in comparison with commercial gypsum board to be used as internal partitions of the building using infrared thermal images. Three repetitions for each kind of lignocellulosic material were made, and three commercial gypsum boards were used. In the production of the panels, the following parameters were applied: material and cement ratio, 1:2.75; water and cement ratio, 1:2.5; hydration water rate of 0.25; additive, 4% (based on cement mass). The calculations were performed for a nominal panel density of 1200 kg m<sup>-3</sup>. The thermal analysis was performed in a chamber composed of MDP (Medium-Density Particleboard) and with an internal layer of rock wool and the heat source (thermal resistance). For the superficial temperature measurement, a FLIR E75 camera was used to capture the infrared images. When the internal temperature of the chamber stabilized at 50 °C, an infrared thermal image was collected from each side of the composite. Thermal properties were analysed: thermal conductivity, resistivity, resistance, and transmittance. Based on the results, sugar cane cement composites were characterized by higher values of thermal conductivity. Related to thermal resistivity, thermal resistance, and thermal transmittance, only the coconut panel presented similar behaviour to the commercial gypsum board. Thus, cement composite using coconut can be a potential alternative that might solve energy and environmental concerns simultaneously.

**Keywords:** conductivity; thermal cameras; thermal transmittance, thermal analyses, alternative building material.

**Acknowledgements.** The authors would like to thank the Minas Gerais State Agency for Research and Development (FAPEMIG Grant n. CAG-APQ-01100-15).

## Thermal analysis of cement panels with lignocellulosic materials for building

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**Abstract.** The use of lignocellulosic material residue in cement composites can be considered as a good option because they allow good thermal behaviour. This paper aimed to compare three kinds of cement panels reinforced with different lignocellulosic materials (Coffee husk, Coconut shell, and Banana pseudostem) based on their thermal properties. To produce each panel, the methodology suggested by Souza (1994) was used. Six replicates of each lignocellulosic panel with dimensions of 7.0 x 7.5 were evaluated. The thermal analysis was performed in a chamber composed of MDP (medium density particleboard). The chamber contained the heat source (incandescent lamp) connected to a thermostat that maintained the temperature at 48.0 °C. The porosity and thickness of the panels and the thermal behaviour of each sample panel (thermal conductivity, resistivity, resistance, and transmittance) and the difference in temperature of both sides of the panel were evaluated. The temperature difference to stabilization was obtained after a sampling time of 200 minutes, with 1000 readings of 12 s each. Although all the panels were submitted under the same temperature, the inner and external superficial temperatures of the coffee husk panels reached smaller values. Besides, coconut and banana pseudostem panels presented the best results of thermal transmittance and thermal resistance. Thus, coconut shell panels present the best thermal performance, which means that this panel might be an attractive alternative building material, in terms of heat insulation for indoor applications.

**Keywords:** Conductivity, thermal cameras, thermal transmittance, alternative building material, coffee husk, coconut shell, and banana pseudostem.

**Acknowledgements:** The authors would like to thank the Minas Gerais State Agency for Research and Development (FAPEMIG Grant n. CAG-APQ-01100-15).

## Chemical analyses of lignocellulosic materials residue for cement panels reinforcement

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**Abstract.** The use of lignocellulosic material residue in cement composites is on the rise as sustainable building materials in most developing countries. Besides, this alternative is seen as a good option for new cement panels formulations for indoor applications. Thus, the current paper aims to evaluate the chemical properties of five potential lignocellulosic materials residues to be used for cement panels reinforcement: Eucalyptus, sugarcane bagasse, coconut fibre, coffee rusk, and banana pseudostem. The following physical properties of the lignocellulosic materials were evaluated: lignin, extractives, ash, and holocellulose. To evaluate the similarity of the chemical composition of the lignocellulosic materials, Hierarchical Cluster Analysis (HCA) was used identified by using Ward's method of cluster analysis. These compositions were grouped by dendrograms in which the similarity of these data was qualified. It was observed that there were statistical differences among all types of lignocellulosic materials related to the chemical composition. Coconut showed the smallest amount of extractives, and sugar cane the most significant amount. Eucalyptus and coffee husk presented the most similar chemical composition. All of the evaluated materials could be used in fibre cement production for indoor applications.

**Keywords:** Cementitious composites, chemical properties, dendrograms, hierarchical cluster analysis.

**Acknowledgements:** The authors would like to thank the Minas Gerais State Agency for Research and Development (FAPEMIG Grant n. CAG-APQ-01100-15).

## Utilization of fused deposition method 3D printing for evaluation of discrete element method simulations

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**Abstract:** FDM 3D printing is used for designing prototype assessment in engineering production. It is usually used to verify the functionality of kinematics mechanisms. It can also be used for innovation in agricultural production, eg. the development of new mechanisms for agriculture tools. Such a mechanism as well as the entire components is printed using FDM and they are made of plastics. This whole can be experimentally verified in a laboratory trough. The article deals with the verification of the possibilities of using FDM technology for the design of agricultural tools. The material properties, namely stress-strain, of the plastics after printing are entered into the Ansys mechanical library, and the DEM results are also imported into Ansys mechanical. Material properties of plastics for FDM technology such as PLA, PETG show that its mechanical properties limited their using for validation.

**Key words:** FEM, DEM, design of tools, mechanical, manufacturing, industry 4.0.

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## **Physico-mechanical properties of modified antifriction coatings based on babbitt B83**

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**Abstract.** The introduction presents the primary reasons for the decrease in the working efficiency of plain bearing assemblies and suggests key areas for the formation of a stable working capacity of these assemblies.

In addition, the introduction discusses preexisting methods for improving the working efficiency of plain bearings. These methods are based on the use of antifriction coatings and have the drawbacks which are considered in the text. The authors proposed a technology for producing an antifriction coating based on a metal composition. This antifriction coating is produced by high-speed laser processing of powder materials. The technology allows to create antifriction coatings, which have significant wear resistance and the effect of self-lubrication while also provide a minimum run-in time of the bearing assembly.

The methodology validates the choice of materials for the formation of an antifriction coating. An alloy with significant tribotechnical properties based on babbitt B83 was chosen as the basis (matrix). To improve the bearing capacity of the coating, the babbitt base was transformed with MoS<sub>2</sub> molybdenum disulfide. The laser radiation usage in the formation of an antifriction coating based on babbitt B83 synthesizes finely dispersed intermetallide phases and forms a porous coating structure due to incomplete melting of the powder material. Molybdenum disulfide is released mainly through the porous structure, which leads to self-lubrication of the bearing assembly during oil starvation.

The results of microstructural and X-ray diffraction analysis are presented to display the structure of the obtained coatings based on antifriction materials. Research value is characterized by the presence of the following intermetallide phases in the structure of the formed coating: Fe<sub>2</sub>Sn, SnSb, Cu<sub>3</sub>Sn. The dispersivity of the formed phases is much greater than that of standard babbitt coatings, which is determined by higher crystallization rates under conditions of laser radiation processing. The analysis of diffractograms makes it possible to conclude that the distribution of intermetallide phases along the coating depth is uneven. The underlying layers close to the basis (matrix) are more soft and supple due to the presence of  $\alpha$  - solid solution. The surface layers are solid and saturated with the finely crystalline Cu<sub>3</sub>Sn phase. The research undertaken on formed coating under conditions of dry friction allows to conclude that the antifriction coating can work without supplying lubricant to the bearing assembly.

**Keywords:** laser radiation; babbitt B83; antifriction coating; plain bearing; working efficiency; wear; intermetallide phases; molybdenum disulfide.

## Characterization of materials used in the manufacture of ceramic tile with incorporation of ornamental rock waste

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**Abstract.** The production of ceramic tiles, such as tiles, has a great environmental impact, either in the extraction of natural raw materials or gas emissions in the burning stages. The use of industrial solid waste in ceramic materials can contribute to the reduction of these impacts, according to the characteristics of solid waste and its interaction with ceramic materials in the processing steps. Thus, this study aimed to characterize the materials needed to make a ceramic tile with incorporation of ornamental rock waste (ORW), thus evaluating its main characteristics regarding the feasibility of this incorporation. The physical characterization of the clays used in the production of ceramic artifacts was performed, and for the waste the mineralogical analyzes were performed, through x-ray diffraction (XRD), microstructure analysis from confocal optical microscopy, after sintering the prototypes and chemical analysis by X-ray spectroscopy (EDX). Soon after the raw materials went through the step of conformation and preparation of the prismatic specimens by the process of extrusion of the ceramic mass, with an incorporation of the ORW in 0% and 15% of the ceramic mass, for its subsequent The prototypes were sintered at three different temperatures (850 °C, 950 °C and 1050 °C). The specimens were submitted to technological tests of mechanical resistance, water absorption, firing shrinkage and porosity to evaluate the incorporation viability. The results indicated the presence of quartz particles in all raw materials, and also that the clays of the study region are predominantly kaolinitic. The presence of these materials in the ceramic masses directly influences the micrographs, because they result in the formation of liquid phase, inert particles that can turn the site into a stress concentration point and when incorporated in the ORW the specimens met the technical specifications of the Brazilian standard for application on ceramic tiles. The results found in the technological tests carried out, that the incorporation of 15% of ornamental rock waste in both clays did not affect the tile properties, indicating the feasibility of incorporating this waste in civil construction, minimizing the impacts generated.

**Key words:** waste, reuse, rural constructions, sustainability.

## **New approach for recycling spare parts, components and assemblies**

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**Abstract.** Recycling and disposal are one of the most complicated topics in the lifecycle of a mechanism, especially in case of previous generations of machines that were designed without taking any care of post exploitation period. In the current work, the “feasibility points” of recycling units, methods of recycling as well as pricing formation for recycling materials, reviewed and proposed by several world universities and scientific bureaus and applied by major world brands have been analysed. The general principles that should be rated as a basis when designing and creating new mechanisms, as well as the actions which we consider as a necessary supplement to the existing rules of the lifecycle of assemblies and which should be applied in practice, were introduced by authors in the “Management of parts and components for units and assemblies in mechanical engineering industry and its impact on the environment”. It was discovered that even modern assemblies, not to mention previous generations, are being designed without taking into consideration any possibilities of easy recycling the used materials. The number of components of mechanisms, which are being repaired as assemblies, is continuously increasing, while maintainability and repairability of separate parts is decreasing. Taking into account the state of the art in the field, the new approach for promoting the reusing natural resources and decreasing the harmful effects of obsolete components of mechanisms on the environment is proposed.

Thus, using the fast-moving parts, that in post operational period can be easily detailed by type of a material, will ensure more efficient consumption of natural resources. Our research and developments significantly reduce the costs of recycling and these materials become competitive comparing to the new ones.

Taking into account the state of the art in the field, the new approach for promoting the reusing natural resources and decreasing the harmful effects of obsolete components of mechanisms on the environment is proposed.

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



## **Towards a Business and Production Engineering Concept for Individual Beer Brewing applying Digitalization Methodologies**

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**Abstract.** Individualization is a common trend in many fields of production across the industries. Also in the food sector, significant changes can be observed. For many products, individual offerings towards the customer are meanwhile either mandatory or at least help to increase the sales and revenue. Somehow, individual product design and production contradicts scaling effects, which are especially important for food production. On the other hand, as digitalization is implemented in a fairly limited way in the food sector, currently great chances can be observed to build a unique selling proposition and consequently gain market share by implementing appropriate measures to enable a digital food factory. This is where the proposed idea comes into the game. The starting point is the idea to produce individually developed beer and ship it to the individual customer. The beer can be designed on a web page based on typical parameters, like beer type, bitterness, colour, or alcohol concentration. In an expert mode, individual beer creations may be thoughtful, allowing the creation of completely individual recipes (for sure, not guaranteeing the customer a perfect drinking experience). In any way, the data from the web page is directly fed to the brewing equipment in the brewing facility. There, using newly to be developed specialized machines, the individually ordered beer will be produced automatically. In this paper we discuss the individual challenges at each point in the production cycles and propose solutions to those.

**Key words:** digital factory, individual food production, smart manufacturing, gamification, industry 4.0



## **VIII RENEWABLE ENERGY**

## **Design and data comparison of the photovoltaic power plants in the southern and northern hemispheres**

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**Abstract.** We have recently developed a unique monitoring system for photovoltaic power plants and have gradually improved it in recent years. The system is installed at about 80 power plants in several European countries and at one power plant in Chile. We collect and evaluate all data in our laboratory. In this paper we describe the unique design of a photovoltaic power plant in the southern hemisphere in Chile with photovoltaic panels installed on tracking stands. We present the evaluated data and we discuss their comparison with photovoltaic power plants installed in Europe. We also discuss different solar conditions of these locations.

**Key words:** Photovoltaics, PV power plant, data monitoring.

**Acknowledgement.** The work was supported by the internal research project of the Faculty of Engineering IGA 2020:31120/1312/3106.

## The combined impact of energy efficiency and embodied energy of external wall over 30 years of life cycle

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**Abstract.** Decreasing the energy consumption in production and building activity is the main aim nowadays as well as in the future. Taking into account that almost 50% of European Union's final energy consumption is used for heating and cooling, of which 80% is used in buildings it is essential to minimize this amount beforehand. Looking at the energy losses we see that the main heat losses are caused due to the transmission through the envelope and ventilation system.

EU energy efficiency target for buildings to 2030 is at least 32.5%. According to this, national energy efficiency action plans were done, which mean that existing building stock need renovation and new buildings will be constructed according to the energy efficiency requirements. One important factor to improve energy efficiency is to modify thermal transmittance of the envelope. In 2017 minimum energy efficiency requirements were validated in Estonia and determined that the thermal conductance of outer wall must be less than  $0.22 \text{ W m}^{-2} \text{ K}^{-1}$  (recommended range of  $U = 0.12\text{--}0.22 \text{ W m}^{-2} \text{ K}^{-1}$ ). According to this the energy loss through the envelope was calculated over the year taking degree-days as bases. In our area this number is 4,933 degree days per year, what gives us the calculated heat loss through the envelope  $10.22 \text{ kWh m}^{-2}$  if the thermal conductance of the wall is  $0.092 \text{ W m}^{-2} \text{ K}^{-1}$ . This required value of thermal conductance we can achieve using good insulation materials. Still there are possibilities to choose between insulations.

Done tests and calculations allow to conclude that energy consumption during building life cycle together with embodied energy of building materials gives us more realistic overview of the energy efficiency of the building. Our results confirm that the use of local natural insulation materials is 1.67 times more sustainable and energy saving than using industrial materials.

**Key words:** embodied energy, thermal conductance, energy efficiency.

**Acknowledgement.** This article was supported by the Estonian Centre of Excellence in Zero Energy and Resource Efficient Smart Buildings and Districts, ZEBE, (2014–2022) funded by the European Regional Development Fund.

## Optimization of a photovoltaic lifepo<sub>4</sub> battery charger

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**Abstract.** The paper describes the analysis and construction of an autonomous photovoltaic system for charging a LiFePO<sub>4</sub> battery. The system is optimized for available components and their pricing to achieve a minimum battery charging time. The efficiency of the power transmission from the photovoltaic generator to the terminals of the charging battery, when they are directly inter-connected, is compared to the efficiency of conventional chargers with a DC/DC converter controlled by the “Maximum Power Point Tracking” algorithm. The system analysis was performed on the basis of experimentally determined typical waveforms of Current-Voltage photovoltaic module characteristics and the waveforms of LiFePO<sub>4</sub> battery charging characteristics. The simulation showed that the efficiency in the range of 94-99% can be achieved by matching the battery to the photovoltaic generator. The experimental photovoltaic system was tested at the end of summer 2019. During the sunny days, the intensity of the solar flux reached a maximum value of only 880 Wm<sup>-2</sup> at a module temperature 52°C. An average efficiency achieved by an experimental system, when the battery was charged throughout the day, was in the range of 95–97%, which corresponds to the values set by the simulation with a deviation less than 2%.

**Key words:** LiFePO<sub>4</sub> battery, PV power accumulator charging, MPP tracking effectivity.

**Acknowledgements.** Thanks for the cooperation between the Laboratory of Photovoltaic Systems Diagnostics and the Laboratory of Precise Time and Frequency, Faculty of Electrical Engineering, Czech Technical University in Prague and the Department of Electrical Engineering and Automation, Faculty of Engineering, Czech University of Life Sciences in Prague.

## **A control method for increasing the heat usage efficiency of nearly-zero-energy buildings with heat pumps**

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**Abstract.** In the retrofitting of older buildings with central heating into nearly zero-energy buildings more and more air to water heat pumps are used. These heat pumps are normally connected to heating systems, producing heat only on demand. The greatest demand for heat occurs when the outside temperature and therefore the COP of the pump is lowest. Outside temperature varies during the day, meaning it is possible to save energy by producing and storing heat in a situation where the COP is higher. To determine the periods with higher COP values weather forecast data and COP curves are used. The data enables to rank and select time periods for heat production. This in conjunction with the heat demand curve of the building enables to create an operation schedule for the heat pump. The aim of the study is to develop heat pump control methods for renovated buildings to comply with nearly zero energy building codes. Dependant on the heat pump and weather conditions, up to 10 % of the electricity demand for heating can be decreased.

**Key words:** heat demand modelling, heat production scheduling, heating season, optimization, temperature fluctuations.

**Acknowledgements.** The authors express their gratitude for the research funding by the Estonian Ministry of Education and Research through the Estonian Centre of Excellence in Zero Energy and Resource Efficient Smart Buildings and Districts, ZEBE, grant TK146 funded by the European Regional Development Fund.

## Conversion of cellulose to activated carbons for high-performance supercapacitors

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**Abstract.** Biomass-derived activated carbons are promising materials that can be used in various applications. Current work investigates the possibilities of the cellulose-derived activated carbons in substituting the commercial alternatives for the supercapacitors' electrodes with high efficiency, stable performance and relatively low cost. Hydrothermal carbonization (HTC) followed by chemical activation with KOH is used to convert cellulose into highly porous activated carbons. The effect of HTC parameters on the material porosity development and electrochemical properties of the electrodes is evaluated with several variations of the residence time and the weight ratio between cellulose and water during the pretreatment. The analysis shows that intensification of the HTC process (longer residence time and higher water/cellulose ratio) results in increase of the surface area of both hydrochar samples and subsequent activated carbons: with the highest surface area for the sample produced after 2 h HTC treatment with water/cellulose ratio of 6/1 – 2645 m<sup>2</sup> g<sup>-1</sup>. As for the electrochemical analysis, the highest values of the specific capacitance are found for the samples produced from 2 h HTC treatment: 110.3 F g<sup>-1</sup> (water/cellulose ratio of 3/1) and 102.5 F g<sup>-1</sup> (water/cellulose ratio of 6/1). Additionally, it is noted that electrodes produced from the samples treated during 4 h have higher impedance at low operation frequency. The present study proves the possibility to substitute commercial activated carbons with cellulose-derived materials, the porosity of which can be tuned accordingly already during the pretreatment step.

**Key words:** cellulose, hydrothermal carbonization, activated carbon, electrodes, supercapacitors

**Acknowledgements.** The authors would like to thank Toni Väkiparta and Liisa Puro from Chemical Technology Unit of LUT University for valuable help and assistance during the analysis of the samples.

## Investigation of dual varying area flapping actuator of a robotic fish with energy recovery

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**Abstract.** Autonomous under-water vehicles (AUV) performing a commanded task require to utilize on-board energy sources. At the time when on-board power source runs low during operation, the vehicle (AUV) is forced to abort the mission and to return to a charging station. The present work proposes the technique of an energy recovery from surrounding medium. This effect is studied for dual action actuator movement that obtains energy from fluid. It is realized that a flapping or vibrating actuator can be used for energy extraction phenomenon apart from the non-traditional propulsive technique. In the present work a simple dual flapping actuator that can switch between simple flat plate and perforated plate at extreme end positions (angles) by using an efficient mechatronic mechanism that would help in overcoming viscous forces of the operating medium is extensively studied. The main objective of the present article is to develop a new approach for energy gain and recharge power pack of on-board sources from the surrounding medium and to create a robotic fish that would work autonomously by using unconventional drive along with the possibility of energy restoration by using dual varying area type vibrating actuator. At the time of recharge, the robotic fish would project its tail (actuator) out of water and use surrounding medium (air) to scavenge the energy. All the equations describing the process are formed according to classical laws of mechanics. The mechatronic system is explained and the results obtained are discussed in detail for air as the operating fluid to scavenge energy.

**Key words:** Energy extraction, flapping tail, robotic fish.

**Acknowledgements.** This research is funded by the Latvian Council of Science, project “Creation of design of experiments and metamodeling methods for optimization of dynamics of multibody 3D systems interaction with bulk solids and fluids”, project No. lzp-2018/2-0281.

## **IX VEHICLES & FUELS**



## The effect of expansion chamber design on exhaust pressure oscillations in gasoline internal combustion engines

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**Abstract.** This paper investigates the effect of exhaust expansion chamber design on pressure oscillations in spark-ignited internal combustion (IC) gasoline engines. It is known that exhaust expansion chambers are becoming increasingly more popular among both – original equipment (OE) and aftermarket equipment (AE) exhaust system manufacturers for performance oriented motorcycles equipped with mainly single cylinder engines but the companies are reluctant to reveal any detailed principles of operation of the said expansion chambers. The aim of this study is to evaluate the changes in amplitude and frequency of the pressure oscillations inside the exhaust header pipe produced by combustion events using different expansion chamber parameters. Time-dependent computational fluid dynamics (CFD) analysis was carried out in Solidworks Flow Simulation environment on a simplified exhaust header pipe model imitating engine operation at full load and steady speed. Honda CRF450R motorcycle engine was used as the example and fully defined using a 1D engine performance calculator software to determine the combustion chamber pressure and exhaust valve lift at any given crankshaft position. Volume flow rate of exhaust gasses at the header pipe inlet was calculated based on engine parameters and operating speed. The average pressure values with respect to physical time were measured and graphed across the header pipe inlet cross-section. Eight different header pipe and exhaust expansion chamber combinations were modelled, tested, and results compared at low, medium and high engine speeds. It was found that the presence of exhaust expansion chamber tends to dampen the amplitude and decrease the frequency of pressure oscillations generated at the opening of the exhaust valve(s). Observations show that the addition of an expansion chamber as per design of performance oriented motorcycles helps to decrease the negative effect of engine tuning while also dampening the positive effect.

**Key words:** computational fluid dynamics, flow simulation, exhaust system, expansion chamber.

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## **Effect of diesel fuel–coconut oil–butanol blends on operational parameters of diesel engine**

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**Abstract:** Global concentration of greenhouse gasses in the atmosphere is increasing as well as the emissions of harmful pollutants. Utilization of liquid biofuels in combustion engines helps to reduce these negative effects. For diesel engines the most used alternative fuels are based on vegetable oils. Blending neat vegetable oils with diesel and/or alcohol fuels is a simple way to make it suitable for diesel engines. In the study a coconut oil was used in the ternary fuel blends with diesel and butanol. The coconut oil is potentially usable source of renewable energy, especially in Pacific, where it is a local product. Diesel fuel–coconut oil–butanol fuel blends were used in concentrations of 70%–20%–10% and 60%–20%–20%, 100% diesel fuel was used as a reference. The effect of the fuel blends on, production of harmful emissions, engine smoke, performance parameters, fuel consumption and solid particles production was monitored during the measurement. The engine was kept at constant speed during the measurement and the load was selected at 50%, 75% and 100%. From the results it can be stated that in comparison with diesel fuel, the specific fuel consumption increased with a positive effect on reduction of engine smoke.

**Keywords:** Engine, diesel fuel, coconut oil, butanol, emissions, performance, fuel consumption.

**Acknowledgement.** This research was funded by Internal Grant Agency of Czech University of Life Sciences Prague, Faculty of Engineering – IGA CULS – 2018:31190/1312/3117 and IGA CULS – 2019:31190/1312/3101.

## Research on energy efficiency of pneumatic cylinder for pneumatic vehicle motor

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**Abstract.** Compressed gas is a relatively expensive source of energy. When compressed gas is used for propelling of pneumatically driven vehicle, efficient gas utilization is favoured. The design and control strategy of pneumatic cylinder, with the emphasis on effective energy conversion is being discussed in this paper. Mathematical model, results of computer simulation and experimental work are provided and discussed. Experimental research is performed on the competition vehicle, equipped with pneumatically driven piston motor and instrumented. Relative significance of various geometric and control parameters of pneumatic cylinder on efficiency of energy conversion is presented.

**Key words:** gas consumption, compressed air vehicle, pneumobile, gas expansion, efficacy.

**Acknowledgements.** The authors thank Emerson Electric Co and National Instruments for the inspiration and provided hardware.

## **Combustion and emission studies of a common-rail direct injection diesel engine with various injector nozzles**

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**Abstract.** Fuel injection has a critical role in an internal combustion engine and a significant effect on the quality of the fuel spray. Fuel spray affects directly on combustion and further on the efficiency, power and emissions of an engine. In this study, three different injector nozzles were compared in a high-speed non-road diesel engine at three different engine loads (100%, 75%, 50%) and two engine speeds of 2200 rpm and 1500 rpm. The nozzles had 6, 8 and 10 holes and a rather high mass flow rate (HF). Detailed and comparative injection and combustion characteristics, as well as gaseous emissions were investigated with diesel fuel oil (DFO). The combustion parameters seemed to be very similar with all studied injector nozzles. Based on the emission measurements, hydrocarbons (HC) and partly carbon monoxides (CO) and nitrogen oxides (NO<sub>x</sub>) decreased when using the 6- and 10-hole nozzles instead of the reference 8-hole nozzles. However, smoke number increased when alternative nozzles were used.

**Key words:** Diesel engine, fuel injection, injector nozzle, combustion performance, emissions.

**Acknowledgements.** This project was one part of the national Future Combustion Engine Power Plant research program. The authors wish to thank Business Finland for the financial support of the program. The authors offer their appreciation to Dr. Katriina Sirviö, Mr. Olav Nilsson, Mr. Markus Uuppo and Mr. Teemu Ovaska for the assistance in the measurements. The authors also express their gratitude to Mr. Henri Huusko and Mr. Marko Vallinmäki at AGCO Power Inc. for their kind assistance in providing test nozzles and their specifications for the study.

## Study on performance of compression engine operated by biodiesel fuel

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**Abstract.** The analysis of the performance of biofuel is aimed at evaluating the energy efficiency of operating the engine with the use of biodiesel fuel as function of the fuel's composition and other physical-and-chemical parameters. The mathematical models and analysis techniques known to the authors do not take into account the effect that the use of different bio-diesel fuels has on the operation of the engine and, therefore, need refinement in terms of the mathematical expressions and empirical formulae that describe the physical processes taking place in the engine's cylinders. The aim of the study is to improve the mathematical relations taking into consideration the physical-and-chemical parameters of different types of fuel. The research methods proposed in the article are based on step-by-step consideration of the mathematical models of processes that follow each other, with due account for their possible overlapping, which jointly have an effect on the engine's output indices. The boundary conditions and parameter increments are pre-set in electronic work sheets. Thus, it becomes possible, using the refined mathematical model, to calculate the main performance indices of the diesel engine with due account for the changes in the physical-and-chemical parameters of the fuel. The novelty of the described approach is in the possibility, through the use of the refined model and taking into account the data on the composition of the fuel and the design and operation parameters of the engine, to calculate the indices that allow evaluating the efficiency of use of specific fuels in the internal combustion engine under consideration. In results, formulas for the calculation of the effective power of the engine, fresh air charge density, excess air factor, effective specific fuel consumption and combustion pressure have been developed. Combustion pressure modelling and experimental data is presented.

**Key words:** Biofuel, Efficiency, Composition, Physical-and-chemical parameters of the fuel, Internal combustion engine.

## Recognition of retroreflective traffic signs by a vehicle camera system

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**Abstract.** The systems of traffic sign recognition are based on the evaluation of three components of every sign: shape, colour and pictogram. There are different factors that can have an influence on the efficiency of detection and recognition of these components. One of the most important factors is the quality of the retroreflective sign surface. Retroreflective sheeting improves the readability of colour and pictogram of traffic sign by increasing brightness of its background and/or legend elements. The aim of the paper is to provide a comprehensive survey of the efficiency of sign's recognition by a modern vehicle camera system. The traffic sign sheeting was measured by the handled retroreflectometer. Then this measurement was repeated by the modern camera system used for recognition of traffic signs in the vehicle. The results of this paper present the analysis of the recognition efficiency of traffic signs and the overview of other factors that can have a significant impact on sign detection and recognition distance. The results can be used for creation a traffic sign database for learning-based recognition techniques to vehicle camera systems.

**Key words:** ADTF, recognition distance, attributes of the sign, TSDR .

**Acknowledgements.** The author gratefully acknowledges that the present research was supported by the Internal Grant of Faculty of Engineering, CULS Prague (grant number IGA 2019:31170/1312/3113).

## **Impact of diethyl ether / rapeseed oil blends on performance and emissions of a light-duty diesel vehicle**

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**Abstract.** The paper presents results of experimental research of diesel (DD), rapeseed oil (RO), and three different blends of rapeseed oil and diethyl ether (10DEE, 20DEE and 30DEE) tested on VW Golf vehicle on chassis dynamometer MD-1750. Fuel consumption and emission tests were realized at idling, IM-240 cycle, 50 and 90 km/h. The analysis of obtained results have showed slight reduction of engine power and increase of fuel consumption for all blends based on DEE addition compared to RO, demonstrating better perspectives for low level blends. Emission tests have showed decrease of HC and NO<sub>x</sub> emissions for all blends with DEE content in almost all testing conditions, and also slight increase of CO and CO<sub>2</sub> compared to rapeseed oil. Largest decrease of NO<sub>x</sub> was observed during 90 km/h and cycle IM-240 reaching almost 24% reduction for 20DEE and 30DEE in comparison to neat RO.

**Key words:** rapeseed oil, diethyl ether, power, fuel consumption, emissions, engine.

## Investigation in fuel consumption of a hybrid and conventional vehicle

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**Abstract.** During the last decade the introduction of more environmentally friendly technologies were raised more rapidly by the decline in the global fossil energy resources and the increased negative environmental impact of conventional vehicles. One of such technology is the hybrid, which is currently making the transition from conventional vehicle with internal combustion engine to an electric vehicle. At this time there exist a lot of offers of such vehicles from different manufacturers, but there do not exist many researches connected with real hybrid performance in different road cycles and conditions allowing evaluate its real economical performance.

This research was realized with the aim to evaluate performance and fuel consumption of hybrid electric vehicle and its conventional internal combustion engine analogue in laboratory conditions. Tests were realized with two new Toyota Yaris vehicles in Alternative Fuels and Research Laboratory on chassis dynamometer MD-1750 using AVL KMA Mobile system. The results showed better adaptation of Toyota Yaris Hybrid to urban operation, demonstrating 21.3% lower fuel consumption than Toyota Yaris conventional gasoline vehicle, accordingly 7.29 and 8.84 l (100 km)<sup>-1</sup>.

**Key words:** hybrid, testing, driving cycle, operating time.



# **X NANOCOMPOSITES AND NANOMATERIALS & WASTE RECOVERY**

## The advanced application of the wood-originated wastewater sludge

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**Abstract.** The wood hydrothermal treatment is one of the plywood production's stages, which resulting in the production of wastewater containing such components as hemicelluloses, lignin and wood extractive substances (HLES). It is necessary to improve the wastewater treatment technology with the aim to enhance the yield of sludge from plywood wastewater for its effective and rational recycling. In the present study, the optimal coagulation conditions for the HLES removal have been found using the developed aluminium salt-based coagulant. The developed composite coagulant is characterized by lower doses, a wide range of the work pH values, the insensitivity against temperature changes and a higher coagulation efficacy compared with traditional aluminium salts. The proposed treatment technology generates many tons of wood-originated sludge – a biomass coagulate. It was found that the formed coagulate produced in the process of wastewater treatment can increase the sorption ability of clay. The optimal content of the dry coagulate in a clay sorbent does not exceed 0.11%. The sorption capacity of the developed sorbent for water, rapeseed and silicone oil increases by 35%, 31% and 21%, respectively, relative to the unmodified clay sorbent. The sorption efficiency of heavy metals from water solutions is also increased by 10–12 %. The thermal treatment of the modified clay sorbent at the high temperature leads to an increase in its sorption capacity for oil products.

**Key words:** coagulation, composite coagulant, woodworking wastewater, sludge, clay sorbent.

## Investigation of the anticorrosion lignin coatings after crosslinking with triethyl phosphate and their adhesion to a polyurethane topcoat

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**Abstract.** This study investigates the anticorrosion properties of sustainable organic coatings, which were prepared by dissolution of two different types of technical lignins - organosolv lignin (OL) and kraft lignin (KL) - in an organic solvent and applied onto iron-phosphated steel by air-assisted spray coating. Influence of triethyl phosphate (TEP) as a crosslinking agent for lignin and its effect on the anticorrosion properties of coatings during 24 h of immersion in 3.5% NaCl were investigated. Results obtained from electrochemical impedance spectroscopy (EIS) of coated steels suggest that the initial protection performance (1 h immersion) of non-crosslinked OL is higher than that of KL. Nevertheless, KL coatings that contained TEP and were heat-treated at elevated temperature (180 °C) demonstrated the best overall anticorrosion performance. In contrast, a similar trend was not observed for OL coatings, which indicates that the structural properties of lignin may be a crucial factor in applicability of TEP as a crosslinking agent. In addition, a layer of polyurethane was applied on all the different types of lignin coatings prepared and their adhesion characteristics were studied by crosscut adhesion measurements (ISO 2409). These adhesion results revealed that neither KL-TEP nor OL-TEP coatings demonstrate proper adhesive characteristics with a polyurethane (PU) topcoat and consequently these coatings are not suitable for utilization as a primer coating for the PU topcoat studied.

**Keywords:** corrosion protection, kraft lignin, organosolv lignin, triethyl phosphate crosslinker, sustainable coatings.

**Acknowledgements.** The funding of this research was provided by Technology Industries of Finland/Jane and Aatos Erkko Foundations “*Future Makers: Biorefinery Side Stream Materials for Advanced Biopolymer Materials (BioPolyMet)*” and Academy of Finland (NoWASTE, No. 297962). The necessary facilities for conducting this research was provided by the RawMatTERS Finland Infrastructure (RAMI) at Aalto University, supported by the Academy of Finland. Additionally, we express our gratitude to Antti Karkola and Mikael Rähkä (Teknos Ltd.) for sharing expertise, services and for providing metallic panels. Furthermore, Dr. Moritz Leschinsky (Fraunhofer Center for Chemical-Biotechnological Processes (CBP)) is acknowledged for providing the organosolv lignin.

## **Comparison of phosphorus removal efficiency of conventional activated sludge system and sequencing batch reactors in a wastewater treatment plant**

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**Abstract.** The aim of this study was to evaluate the effectiveness application of sequencing batch reactors (SBRs) for phosphorus removal compared to the conventional activated sludge (CAS) treatment system. The results showed that the removal efficiency of phosphorus reached about 99% at wastewater treatment plant with CAS system. At the same time, the maximum phosphorus removal efficiency can be achieved to 88% if the SBRs system operating parameters are optimized. Finally, this study demonstrated that even if granules are not fully developed, the SBR system is working with a good efficiency.

**Key words:** phosphorus removal, activated sludge process, SBR, aerobic granules, wastewater treatment plant.

**Acknowledgements.** This work has been supported by the Central Baltic INTERREG Programme within the project CB50 “Pilot watersheds as a practical tool to reduce the harmful inflows into the Baltic Sea – WATERCHAIN”. We thank Kaspars Neilands for technical assistance and Ltd. Adazu water for support during this research.

## Thermal Decontamination of Sewage Sludge

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**Abstract.** Every year a huge amount of sewage sludge is formed at municipal wastewater treatment plants. Sewage sludge contains a sufficient amount of biogenic elements and organic components, which characterizes them as possible raw materials for the production of organic fertilizers. However, direct incorporation of these sediments into the soil is impossible due to the fact that, in addition to useful organic and mineral components, they contain pathogens, viruses and helminth eggs. The aim of the study was to optimise thermal disinfection conditions for preparing of safety sewage sludge fertilizer. Laboratory studies were carried out using sediments from wastewater treatment plants of some cities. During laboratory experiments, the conditions for thermal disinfection of sediments — the thickness of the sediment layer, the air temperature in the disinfection furnace, and the treatment time of the sediment — were determined. When conducting industrial tests of a conveyor-type sediment decontamination furnace, the operating conditions of the furnace were determined, i.e., the temperature regimes of the sludge heating zone, the decontamination zone and the cooling zone, and the optimum parameters of the sludge layer thickness on the conveyor and the conveyor speed were determined.

**Key words:** layer thickness, movement speed, organic fertilizers, sewage sludge, thermal disinfection, residence time.

**Acknowledgements.** This research is being conducted based on agreement signed between SIA “Earth Revival” and SIA “ETKC” (Centre of Competence for Energy and Transportation) within the framework of project Nr. 1.2.1.1/18/A/001 co-funded by the European Regional Development Fund.

## **Recycling of secondary raw materials for the production of new composite products: a devulcanised crumb rubber case study**

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**Abstract.** Novel composite materials become more and more finely tailored for specific applications, containing many different matrices and fillers. Thus, recycling methods should take into account the possibility of reusing components with obtaining new materials during the recycling process. Current investigation encompass a short overview of modern methods of materials recycling, including critical raw materials, composites, and elastomers. Different processing methods such as grinding and homogenisation are combined in a single technique - desintegration. A special attention is given to mixed materials, including 'crumb rubber (devulcanised crumb rubber) – metal powders' mixes and electronic scrap (e-scrap) processing for further recycling of valuable components. For instance, e-scrap (PCB) processing by desintegration technique facilitates formation of homogenous powder suitable for further treatment by hydrometallurgical processes for metals extraction.

Key words: critical raw materials, devulcanised rubber, milling, disintegrator, mixing, mechanochemistry, fine powder, pcb recycling.

## **Tensile properties of wood plastic composites based on plant-filled polyvinyl chloride/poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) matrices**

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**Abstract.** The article considers the obtaining and studying of microcomposites based on polyvinyl chloride (PVC)/poly(3-hydroxybutyrate-co-3-hydroxyhexanoate) (PHBHHx) polymer matrix, filled with a various fraction of different natural plant fillers. In work, such plant fillers as wood flour without lignin, spruce flour and rice husk were used. Microcomposites were obtained by melt rolling processing method with subsequent analysis of their morphology and mechanical tensile properties. It is shown that the filler particles were strongly oriented in the direction of the melt rolling process and have a different aspect ratio depending on the filler type. The tensile strength of materials strongly depends on the particle's aspect ratio. When the aspect ratio of the particles is 4.25, the material has a strength value comparable to a pure PVC/PHBHHx matrix.

**Key words:** polyvinyl chloride, polyhydroxyalkanoate, wood-polymer composites, composites morphology, mechanical properties.

**Acknowledgements.** This work was carried out on the basis of the International Scientific and Research Institute of Bioengineering of ITMO University with financial support from ITMO University.

## Features of the influence of copper nanoparticles and copper oxide on the formation of barley crop

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**Abstract.** In addition to modern methods of agricultural technology, currently the achievements of selection and genetics are widely used, as well as modern nanotechnology and nanomaterials, to improve food production. One of the forms of biologically active nanomaterials is metal nanopowders and their derivatives. The application is carried out in minimal doses that can significantly reduce costs in agricultural production. Improving the yield and quality of crops by optimizing nutrition and plant protection using nanotechnology and nanomaterials will solve not only the problems of increasing the yield and quality of farmed products, but also environmental problems. The purpose of this research was to determine the effect of copper and copper oxide nanoparticles on the formation of a barley crop. Under the conditions of a lysimetric experiment, the effect of presowing treatment of spring barley seeds by nanoparticles of copper and copper oxide on the growth and development of plants, yield, and their nutritional value was studied. The used nanoparticles have the following characteristics: Cu - 40-60 nm, phase composition: Cu<sup>0</sup> - 100%; CuO - 40-60 nm, phase composition: CuO - 100%. A suspension of nanoparticles was obtained by dispersion by ultrasound in an aqueous solution. Nanopowders of copper and copper oxide in the solution contained 0.01 g per hectare seed rate. Barley seeds were soaked 30 minutes before sowing in double distilled water (control variant), as well as in a suspension of nanoparticles. Presowing treatment of barley seeds by Cu nanoparticles contributed to the intensification of growth processes, as well as an increase in green mass. The use of copper nanoparticles contributed to an increase in grain yield by 17.3% compared with the control, while there was no decrease in nutritional value: metabolic energy, feed units, digested protein. Based on the research results, it is preferable to use copper nanoparticles in comparison with copper oxide nanoparticles to obtain a higher barley yield.

**Key words:** copper nanoparticles, copper oxide nanoparticles, linear growth, spring barley yield, nutritional value.



## Morpho-physiological effects of Stymjod foliar application on *Dactylis glomerata* L.

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**Abstract.** The aim of the experiment was to study the effects of foliar application of a growth regulator containing iodine nanoparticles, with the trade name of Stymjod, on morphometrics, photosynthetic activity and chlorophyll content of *Dactylis glomerata* L. The following parameters were determined: the weight of fresh and dry matter of plants, leaves and roots, the number of shoots and leaves, potential (FV/Fm) and effective ( $\Delta F/F_m$ ) quantum efficiency of photosystem, photochemical (qP) and non-photochemical (qN) quenching, as well as chlorophyll a and chlorophyll b content in leaf blades. The pot experiment was carried out in a breeding room. Stymjod was applied at 1.5%, 3% and 4.5% concentrations in the spray solution. It is a nanotechnology-based growth regulator, with easily assimilable forms of mineral and organic ingredients, favorably affecting plant ontogenesis. Plants were treated twice with a single dose of 50 ml of spray per pot. They were sprayed till they were completely covered with the liquid. Distilled water was used to spray control plants. The results were statistically processed using analysis of variance, while the significance of the differences between means was determined with Tukey's test with  $P = 0.05$ . In the experiment it was found that different concentrations of Stymjod in the spray resulted in different response of plants. The best morphological effects were obtained using the concentration of the product exceeding 3%. In the test conditions Stymjod applied to *D. glomerata* increased the efficiency of the photosynthetic apparatus and the content of chlorophyll pigments.

**Key words:** iodine, plant morphology, photosynthetic activity, chlorophyll content.

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## Growth and yield of spinach depending on absorbents' action

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**Abstract.** The use of absorbents from Maximarin for growing spinach contributed to its faster germination, increased plant growth and development, and resulted in an increase in yields of commodity products by 2.0–6.1 t/ha and an increase in chemical composition. The use of absorbents in open ground for spinach made it possible to obtain the highest amount of contingent net profit for making the drug Maximarin in the form of a gel and the company Eco – with small granules, and in the Krasen Polissia variety – 2160 and 2102 USD ha<sup>-1</sup>, in the Malakhit variety for introduction the drug Maximarin in the form of a gel 1949 USD ha<sup>-1</sup> and the company Eco absorbent with potassium – 1575 USD ha<sup>-1</sup>. Profitability for the Matador variety has reached 75%, Malakhit grade – 69–75%, Keb – 3.0–3.2. It was established that in the closed ground application of the drug Maximarin in the form of gel and granules for spinach made it possible to obtain the highest amount of contingent net profit, which was Matador 3079 and 3025 USD ha<sup>-1</sup>, in the Malakhit variety for the introduction of gel 4304 USD ha<sup>-1</sup> and granules – 4245 USD ha<sup>-1</sup>. Profitability for the use of drugs for the Krasen' Polissia variety reached 84–77%, Malakhit – 118–116 %, the bioenergy efficiency ratio – 3.0–3.3.

**Key words:** spinach, varietal, absorbent, commodity products, yield.

## Woodworking wastewater biomass effective separation and its recovery

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**Abstract:** One of the most important birch wood processing with a high added value in Latvia is plywood production. Currently, Latvia is one of the largest plywood producers in Eastern Europe, and its production and consumption, both in Latvia and in Europe, is only increasing every year. In 2016, the quantity of the produced plywood increased by 20% compared to 2015, reaching around 360 thousand m<sup>3</sup> per year. With increasing plywood production, the wastewater amount from birch wood hydrothermal treatment basins also increases. This wastewater contains significant quantities of wood biomass – hemicelluloses, lignin compounds and wood extractives. The removal of wood biomass from wastewater can be carried out with coagulation or flocculation method. In this work, the comparative effectiveness of a treatment of the model wastewater simulating an industrial woodworking wastewater with the known cationic coagulants such as poly(diallyldimethylammonium) chloride, chitosan, polyethyleneimine, aluminium salts and the developed hybrid inorganic-organic composite coagulant based on polyethylenimine was evaluated.

The correlation between the biomass removal efficiency and the coagulation/flocculation process parameters for every coagulant was investigated and established. The optimum parameters of the biomass removal with the developed hybrid coagulant, compared with the known cationic polymers and the metal salt coagulant widely used in coagulation, were found. At the optimum pH and a dosage, using the hybrid coagulant, it was possible to achieve 97% of the wood biomass yield from the wastewater. In the hybrid coagulant, the concentration of PEI was by about 30-43% lower than if only PEI was used in the coagulation/flocculation process, while the aluminium salt dosage in the hybrid coagulant was by 40-55% less than that for the coagulant based on the polyaluminium chloride that allowed to reduce 2-2.5-fold the concentration of the aluminium ions in the treated wastewater.

The new hybrid composite coagulant essentially enhanced the efficiency of the removal of the wood biomass, especially low molecular weight lignin fragments, from the wastewater and substantially reduced the coagulant consumption in comparison with the traditional coagulants.

The performed experiments showed that the separated wood biomass could be applied with successes for light soil structuring and dust suppressing on gravel roads.

**Key words:** wastewater biomass, recovery, soil structuring.

## **XI FOOD SCIENCE & TECHNOLOGY**

## **Effect of simultaneous inoculation of commercial yeast starter cultures on kombucha fermentation**

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**Abstract.** Kombucha – a spontaneously fermented tea beverage, produced by SCOBY (a symbiont of bacteria and yeasts), has become popular in recent years. Its functional properties and features for industrial production and treatment remain largely unknown, however. Our aim of using additional yeast cultures during the primary fermentation was to modify and ultimately improve the sensory properties of the kombucha beverage. During five fermentation experiments the total viable count (TVC) of microbes was determined both in Kombucha and SCOBY samples. The first four fermentation experiments were conducted to stabilize the growth of SCOBYs that were initially of different origin. The last (5<sup>th</sup>) fermentation contained the simultaneous inoculation of three different active *S. cerevisiae* cultures into the sweetened black tea together with the SCOBY and was followed by a sensory analysis. Two samples remained as control samples without additional yeast starter culture. The yeast starter cultures affected the microbial counts of Kombucha, but the effect on the microbial count of SCOBY was not statistically significant ( $p > 0.05$ ). The Kombucha containing wine yeast culture had the lowest sensory quality, while Kombucha containing brewer's yeast had the most pleasant flavour and aroma. In conclusion, the simultaneous fermentation with commercial yeast cultures had a minor effect on the microbial counts in SCOBY when compared to the fermentation time, but all added cultures clearly modified the taste and aroma properties of the Kombucha drinks.

**Key words:** Kombucha, SCOBY, tea, simultaneous fermentation, *Saccharomyces cerevisiae*.

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## Utilization of Moringa plant in Yoghurt production: A review

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**Abstract.** Yoghurt is a fermented dairy product with potential health benefits, these intrinsic properties make this product of great research interest. Owing to the acceptability and consumption of yoghurt among different cultures, ages, and socioeconomic classes, a plethora of studies have been instigated on the fortification of this product with different ingredients (fortificant). *Moringa oleifera* is such an example of this fortificant with substantial nutritional benefits on account of its nutritional and phytochemical composition. This review evaluates literature data on the fortification of yoghurt with moringa extracts highlighting on parameters such as nutritional, physicochemical, and health benefits of the functional product. Emphasis was also placed on the effect of different extraction techniques on the biological activity of moringa extracts and the effect of these extracts on the sensory parameters of yoghurt.

**Key words:** fortification, moringa, phytochemistry, yoghurt.

## **Biochemical composition and quality of herring preserves with addition of bio-protective cultures**

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**Abstract.** Herrings rich in vitamins B12, A, D, minerals, including calcium, potassium, magnesium, iodine, possess high levels of lysine, tyrosine, phenylalanine and tryptophan, as well as omega-3 unsaturated fatty acids, namely eicosapentanoic, docosahexenoic and docosapentenoic. To suppress the microbiological spoilage of fish preserves, it is promising to use bio-protective cultures that have minimal impact on the production process and product properties. Bacterial strains are able to exert a static effect on the microflora, which causes biodeterioration of food products. Microorganisms as part of bio-protective cultures are included in the fermentation process, so they can be attributed to ordinary food ingredients, so there is no need to put separate information on the packaging. The chemical composition of the frozen Atlantic and Pacific herring fillet, the amino acid composition of proteins, and the fatty acid composition of lipids were studied. The difference between Atlantic and Pacific herrings was detected, which consists in a significantly higher content of docosahexaenoic acid. The difference in the fractional composition of triacylglycerols for the Atlantic and Pacific herring was established. The microflora of SafePro B-2 biological product (Chr. Hansen GmbH), containing multiple strains of *Lactobacillus sakei*, and the viability of the culture in preserves fillings were studied. The experimental development of canned food with SafePro B-2 additives was carried out. Microbiological, organoleptic and biochemical indicators of the preserves quality during cold storage were studied. The influence of introduced culture on the dynamics of preserves curing period and their shelf life was established.

**Key words:** frozen fillet of Atlantic and Pacific herrings, fatty acid composition, triglycerides, bio-protective cultures, preserves, fillings, buffering, curing period.

## Shelf life extension of minimally processed vegetables using combinations of bacterial bioprotection and modified atmosphere packaging

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**Abstract.** The purpose of this work is to comprehensively investigate bio-products and modified atmosphere packaging aiming at their combined use for prolonging the shelf life of refrigerated minimally processed vegetables. Sweet pepper, zucchini, eggplant, celery stalks were used for preparation of minimally processed vegetables. SafePro® bio-products from Chr. Hansen (Denmark) containing strains of *Lactobacillus sakei*, *Pediococcus acidilactici*, *Lactobacillus curvatus*, *Leuconostoc carnosum* were used as bioconservatives. For packaging minimally processed vegetables, the bags made of flat multilayer PA/adhesive/PE films and composite PET/A1/PE film material were used. The bags were filled with Biogon NC40 (60% nitrogen, 40% carbon dioxide) and Biogon NC20 (80% nitrogen, 20% carbon dioxide) gas mixtures. Storage of packaged minimally processed vegetables was carried out in a refrigerator at a temperature of  $(4 \pm 2)^\circ\text{C}$  for 16 days. The viability of cultures *Lactobacillus sakei*, *Pediococcus acidilactici*, *Lactobacillus curvatus*, *Leuconostoc carnosum* in MAP packaging was studied. It was revealed that the mixture of Biogon NC40 and the culture of *Lactobacillus sakei* contribute to the preservation of the quality of fresh-cut sweet pepper, eggplant and zucchini, and *Leuconostoc carnosum* is the more effective for celery storing. In the process of refrigerated storage for 14 days, the solids content in the experimental samples increased 1.3-2.1 times, the loss of organic substances was 26-50 %, depending on the type of vegetables. The developed technology for the refrigeration preservation of minimally processed vegetables using bio-products treatment and in MAP packaging made it possible to increase the shelf life of fresh-cut vegetables by 2 times.

**Key words:** minimally processed vegetables, bio-products, *Lactobacillus sakei*, MAP packaging, Biogon ®NC40, refrigerated storage, vegetable microflora.



## **Analysis of safety indicators for poultry products produced in subsidiary farms in penitentiary facilities**

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**Abstract.** The production of poultry, eggs and their processed products is growing rapidly worldwide. Poultry products are in great demand; however, they are a source of a number of risks: physical, chemical, as well as microbiological. Ensuring food safety is currently the main aspect for the global food industry, including for the production of poultry products. The article discusses the safety and quality of poultry products produced in subsidiary farms of correctional facilities of the penal system. Attention is drawn to the risks and threats of sanitary and epidemiological well-being that arise in connection with the intensification of the impact of negative environmental factors. In the subsidiary farms of correctional facilities, the cage-type bird keeping system and the frequency of feeding are regulated depending on the age of the bird. The results of the analysis have shown that poultry and chicken eggs comply with established sanitary standards. Thus, the average heavy metal content in poultry meat was: Hg - 0.0061 mg / kg, Cd - 0.0233 mg / kg, As - 0.0501 mg / kg, Pb - 0.1765 mg / kg; in the egg: Hg - 0.0072 mg / kg, Cd - 0.0198 mg / kg, As - 0.0485 mg / kg, Pb - 0.1812 mg / kg. Antibiotics, radionuclides and dioxins were not found in poultry meat. The pesticide content in poultry meat was below the permissible level: by 2.2 times of DTM and its metabolites, and hexachlorocyclohexane (a, b, g - isomers) - by 5 times. Coliforms, Staphylococcus aureus, Proteus, as well as pathogenic salmonella, listeria were not found in poultry meat and eggs. NMAFAnM in meat amounted to  $0.5 \cdot 10^4$ , in the egg -  $1 \cdot 10^3$  CFU / g incl. In general, poultry products produced in correctional facilities are of high enough quality and can be used to prepare various dishes not only for adults but also for baby food. These estimates allow us to conclude about a fairly high level of quality and safety of this product.

**Key words:** safety, poultry products, quality, ecotoxicants, penal system.

## **Rowan powder based acidifying additive acidifying additive – an alternative to sourdough in the rye-wheat bread production**

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**Abstract.** Rye is an important part of the cereal food culture in the Russia and Nordic, Baltic and Eastern European countries. Rye bread is often made of whole-grain flour using long-time sourdough. In Russia, rye bread began to be produced less and less often due to the complexity and duration of its technology. Therefore, the development of fast, natural and safe technologies is relevant. The aim of the research was to develop a nutritional acidifying additive based on plant materials (rowan powder, botanical species *Sorbus aucuparia*) for accelerated rye-wheat bread technology. With an increase in the new plant additive dosage above 3.5%, the dough lifting capacity deteriorated. The bread specific volume and the crumb compressibility deteriorated when additive dosage was higher than 3.5%. It all may be due to the acidity suppression of yeast activity in the dough. Taste and smell was also better in bread with new additive due to the rowan powder chemical composition. The optimum dosage of new additive rowan powder in rye-wheat bread formulation was 3.5% by weight of the flour. Usage of new additive with 0.1% of sodium diacetate allowed slowing down moulding. New acidifying with rowan powder allowed to create accelerated rye-wheat bread technology and to get bread with high consumer properties.

**Keywords:** bread making, plant acidifying additive, sodium diacetate, accelerated bakery technologies.

## Antioxidant content of dark colored berries

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**Abstract.** Blackberries (*Rubus caesius*), elderberries (*Sambucus nigra L*), highbush blueberries (*Vaccinium corymbosum L*) and black currants (*Ribes nigrum*) were selected for research on their content of phenolic compounds, including anthocyanins and comparing their content in these berries. Samples were also assayed for ascorbic acid and soluble solid content. The unifying mark of these fruits is purple-black color, which indicates high content of anthocyanins. Analyses of these fruits showed that they contain high biological activity components that justify the uses of these fruits.

The research was done at the Department of Chemistry, Latvia University of Life Sciences and Technologies, year 2019. Berry samples were bought at the supermarket (highbush blueberries) or collected from garden in Jelgava, Latvia (blackberries, elderberries and black currants). All berries were at full maturity. The content of ascorbic acid, total phenols, anthocyanins, flavonoids as well as soluble solids was determined.

Descending order of ascorbic acid content in berries is: black currants > blackberries > elderberries > highbush blueberries. Elderberries had the highest content of anthocyanins, total phenols and flavonoids on average 161.5, 537.9 and 112.6 mg 100 g<sup>-1</sup> FW, respectively. The content of soluble solids changes from 5.83 Brix (elderberries) to 13.67 Brix (black currants).

**Key words:** berries, bioactive compounds, phenolic compounds.

## Applying beetroot as food ingredient in ice-cream production

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**Abstract.** The development of new food products with functional ingredients of plant origin is highly promising and relevant direction in food industry. Assortment of products, including ice cream is constantly expanding due to the introduction of various plant ingredients into its composition, enriching the product with health beneficial nutrients. In this study, beetroot (*Beta vulgaris*) was selected as a plant component for ice cream production. The roots of common beets contain many useful inorganic and organic substances, such as carbohydrates, proteins, organic acids, mineral salts, betalaines, vitamins, folic acid and betaine. The influence of different thermal treatment techniques of beetroots on the content of dry substances and organoleptic properties of beetroot puree have been compared and analyzed. The heat exposure technique recommended for beetroots is microwave processing for 9 minutes at a power of 800 watts. This method of heat treatment ensures the culinary readiness of vegetable raw materials while preserving dry substances in it, including betanine. The effect of the beetroot puree dose on the formation of the ice cream quality was studied. The recommended dose of the beetroot puree was established as 20%.

**Keywords:** ice cream, beetroot puree, betanines.

## The effect of yeast growth stages on the absorption of polyphenols

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**Abstract.** Colloidal stability of beer is one of the most critical challenges facing the brewing industry. In brewing, stabilization agents are widely used to remove colloids such as proteins and polyphenols. However, the removal efficiency of polyphenols depends on the yeast, which adsorbs these compounds on its surface. The adsorption of polyphenols on the yeast surface is associated with the zeta potential of the cell wall, which correlates with the mannan content in them. The purpose of the study was to investigate the role of yeast strains in adsorption of polyphenols (increasing colloidal stability of beer) and the correlation of this property with the mannan content in the cell wall during the fermentation. Two *S. cerevisiae* strains were used in this study, and the specific growth rate of yeast, the specific rate of change in the polyphenol content and the mannan content were determined. The results of this study showed that the highest mannan content in yeast was after 9 hours (the end of exponential growth phase). Its content was 10.97% by weight of dry matter in the yeast *S. cerevisiae Californian Lager* (M54), and 13.69% in the yeast *S. cerevisiae Belgian Wit* (M21). The desorption of polyphenols was observed during the period from 9 to 24 hours of fermentation, where an increase in the content of polyphenols in the medium was observed. Based on these results, it is necessary to remove the yeast at the end of the exponential growth phase to increase the colloidal stability of the beer.

**Keywords:** colloidal stability, mannan, polyphenols, *S. cerevisiae* yeast.

## **Biochemical responses of 5 buckwheat (*Fagopirum esculentum* Moench.) cultivars to seed treatment by *Azospirillum brasilense***

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**Abstract.** Cultivation condition have a large effect on efficiency of buckwheat. Drought, high temperatures and their fluctuations, salinity, oxygen deficit in the soil, ultraviolet radiation, and abnormal nutrient content in the soil are the most common reasons of decreasing productivity of plants. Suboptimal parameters of the cultivation technology can also cause abiotic stress. Plant can decrease its efficiency from 30% to 50% depend on stress conditions. Using bacterial cultures is one of the preventive approaches to overcoming the negative impact of stressors. Microorganisms produce biologically active substances that stimulate plant growth, increase their resistance to abiotic factors. They are growth regulators and long-acting anti-stressants as well. Malondialdehyde (MDA) is formed as a result of the oxidative degradation of polyunsaturated fatty acids. Fructans are polysaccharides that are derived from D-fructose residues found in higher plants, green algae and bacteria. Fructans are involved in the adaptation of plants to the action of abiotic stressors and are valuable nutrients. The effect of *Azospirillum brasilense* pre-sowing treatment of buckwheat seeds on physiological and biochemical processes of MDA and fructan content was researched. Seed treatment with *Azospirillum brasilense* reduced the content of MDA in Ukrayinka and Syn 3/02. Sofia and Olga had a low level of MDA, but seed treatment increase it. Seed treatment increased the efficiency of photosynthesis ( $F_v / F_m$ ) in Syn 3/02 from 0.58 to 0.72; in other varieties this effect was negligible. All cultivars have a strong relation between MDA and fructan content, that shows their participation in responses on cultivation conditions. Efficiency of photosynthesis in flowering–seed formation stage (BBCH 65–75) was close to maximum in field condition ( $0.70 \pm 0.05$ ) and seed treatment can increase it.

**Key words:** buckwheat, malondialdehyde (MDA), fructans, fluorescence.

## Enrichment of the low-fat yoghurt with oat $\beta$ -glucan and EPS-producing *Bifidobacterium bifidum* improves its quality

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**Abstract.** The addition of  $\beta$ -glucan or EPS-producing bacteria is mainly used to improve the quality and the acceptability of low-fat yoghurt. The purpose of this study was to investigate the effect of adding  $\beta$ -glucan, EPS-producing *Bifidobacterium bifidum*, or both on physical properties, fermentation time, and organoleptic criteria of low-fat yoghurt, additionally to the viability of *L. bulgaricus* and *B. bifidum*. Two types of low-fat yoghurt (1.5% fat) were prepared, with the addition of standard oat  $\beta$ -glucan by 0.15% or without its addition. Each type of yoghurt mixture was inoculated with two kinds of starters: traditional and probiotic (*B. bifidum*) culture. The physicochemical properties, the count of viable bacterial starter culture, and the organoleptic evaluation for all yoghurt types were evaluated after storage 24 h at 4°C. Moreover, the fermentation time was monitored. The incorporation of both  $\beta$ -glucan and EPS in yoghurt resulted in the highest viscosity (13.7 mPa.s) and WHC (55.94%), besides to the lowest syneresis (28.47%). The acidity and pH of the yoghurt samples were significantly affected ( $p > 0.05$ ) by the  $\beta$ -glucan addition. The yoghurt type *Bifidobacterium* glucan had the shortest fermentation time (215 min), and the maximum viability of both *B. bifidum* (7.63 Log CFU g<sup>-1</sup>) and *L. bulgaricus* (7.50 Log CFU g<sup>-1</sup>). The  $\beta$ -glucan had a pronounced effect on the overall acceptability of yoghurt more than the EPS. In conclusion, enriching the low-fat yoghurt with oat  $\beta$ -glucan and EPS-producing *B. bifidum* is the highest effective method for improving the yoghurt's quality and the viability of probiotics.

**Keywords:** Acceptability, *B. bifidum*, Low-fat, Oat  $\beta$ -glucan, Quality, Viability, Yoghurt.

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## **Water, mineral water, beer and sports drinks to compensate for fluid loss during physical exertion**

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**Abstract:** The human body consists predominantly (over 50%) of water. A clear indication of how important a balanced fluid management is for us. It is noticeable, that many people still do not consume enough liquid, perhaps unaware of the daily ration required, and some simply do not think about regular drinking. With the foreseeable increasing exposure to warmer temperatures (keyword global warming) or simply during physical exertion, especially sporting exertion, a sufficient supply of suitable fluids is necessary, to compensate for the loss of water and trace elements. Serious health risks can occur if appropriate countermeasures are not initiated fast enough. The body loses water and minerals - mainly sodium - through perspiration, which must therefore be compensated by the intake of fluids. Sweat losses can reach up to 2- 3 L<sup>\*h</sup>-1 at a sodium content of 50.8±16.5 (mmol/l) [mean ± SD]. The consequences of the fluid imbalance are the reduction of the plasma volume, the reduction of the blood circulation, the promotion of hyperthermia. Any loss of fluid affects the physical and cognitive function of the body. A well adjusted fluid balance leads to an increase in performance, protects the body from overheating (thermal stress), minimizes the risk of injury and helps delay the onset of fatigue.

The authors have examined water, "mineral water", sports drinks and (alcohol-free) beer to determine its suitability for compensating loss of fluid and electrolytes. The mineral water rarely shows an increased content of mineral salts and only a low osmolality: The electrolyte content is often similar to drinking water in the water extraction region. Alcohol-free beer is currently strongly recommended in advertising as a liquid substitute for physical performance and is actually predominantly isotonic. A problem of all these drinks is the low sodium content because especially sodium that is lost with the sweat in large quantities should be replaced when drinking, as it is necessary for the whole cell physiology and signal transduction processes. Only sport drinks supply (Carbohydrate-Electrolyte Solutions) sufficient amount of sodium, although due to the high sugar content they are unpopular with athletes and unsuitable for everyday use. In addition to the analysis and comparison of the various beverages, the authors have enriched non-alcoholic beer with various sodium salts. This shows that it is possible to functionalize alcohol-free beer with sodium salts and thus produce a fully-fledged isotonic sports drink.

**Key words:** health, minerals, water, beer, sport drinks, osmolality, sodium.



## Sauerkraut juice powder chemical and physical properties

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**Abstract.** Production of sauerkraut generates approximately 30% of sauerkraut juice that is recognized as by-product, but this residue can be used as a valuable source of various bioactive compounds. In current experiment sauerkraut juice was spray dried and sauerkraut juice powder was obtained. The aim of this study was to evaluate physico-chemical and microbiological properties of the sauerkraut juice powder using maltodextrin as carrier at various concentrations. Sauerkraut juice powder was produced without carrier materials and using maltodextrin (5 and 10%) as carrier. Additionally effect of  $\text{CaCO}_3$  was tested. For all the samples moisture, solubility in water, titratable acidity,  $a_w$ , salt content, total phenols, antiradical activity, organic acids and microbial parameters (total plate and lactic acid bacteria count) were tested. Organic acid profile by HPLC identified four major components – oxalic, lactic, acetic and quinic acid. Salt content ranged from 14.31% in the sample with no maltodextrin to 8.7% in the sample with 10% of maltodextrin. NaCl content was significantly influenced by maltodextrin concentration. Total plate count correlated with lactic acid bacteria count. Our study showed lower amount of survived lactic acid bacteria in the samples with 10% maltodextrin. Total phenols and antiradical activity were determined by two methods based on water and acidified ethanol extractions. Further studies are necessary to find the best solution for carrier concentration and better survival of lactic acid bacteria.

**Key words:** Sauerkraut, juice powder, spray drying, maltodextrin concentrations.

**Acknowledgements.** This study was supported by European Innovation Partnership for Agricultural Productivity and Sustainability Working Group Cooperation project 18-00-A01612-000020.

## Effect of different sugar sources on *P. Rhodozyma* y1654 growth and astaxanthin production

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**Abstract.** *Phaffia rhodozyma* (also known as *Xanthophyllomyces dendrorhous*) is one of the most promising natural sources of commercial astaxanthin. It has high growth rates, easy cultivation conditions and able to utilize different carbon substrates. This provides an opportunity to further lower production cost by using industrial waste such as molasses. This research therefore evaluates the growth dynamic and astaxanthin production of *P. rhodozyma* Y1654 growing on soy and sugar beet molasses-based media. Liquid growth media based on soy molasses (SM), sugar beet molasses (SBM) and glucose (control) as main sugar source with peptone and yeast extract supplementation were inoculated with 48 h old seed culture (grown in standard glucose media: 2.0% glucose, 1.0% peptone, 0.2% yeast extract) and incubated at 20 °C with stirring speed of 180 rpm for 7 days. Samples were taken daily throughout the study period to assess; cell count, dry cell weight (DCW) and amount of astaxanthin. Soy molasses-based media resulted in the highest biomass yield (7.7 g L<sup>-1</sup>) followed by SBM (5.8 g L<sup>-1</sup>). Generally, more than 90% of initial fermentable sugar was consumed at the end of the study. However, about 40% of total sugar in SM was unassimilable by *P. rhodozyma* Y1654. The highest astaxanthin yield was observed in the control media (77 µg g<sup>-1</sup> of DCW). Cultivation of *P. rhodozyma* Y1654 in SBM resulted in as much as twice (32.8 µg g<sup>-1</sup> of DCW) the astaxanthin yield of SM (12.4 µg g<sup>-1</sup> DCW). Molasses-based media are good for growth of *P. rhodozyma* Y1654 but for astaxanthin production, they need further optimization.

**Keywords:** Astaxanthin, Carotenoids, Molasses, *Xanthophyllomyces dendrorhous*, Agric-Food Wastes, Byproducts, Microbial Pigment

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## Changes in $\alpha$ -amylase activity in honey during the freeze-drying process

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**Abstract.** Honey is a natural product, which is appreciated for its sweetness, high nutritional value and health benefits all over the world. Despite all benefits, the usage of honey in food industry is limited due to its high viscosity. The use of dried honey could be an alternative to liquid honey, and would allow to use it as an additive in a range of many different food products such as sauces, beverages, yogurts etc. There are many parameters, which are used to determinate the quality of honey.  $\alpha$ -amylase (diastase) activity is one of the most important criteria to determine the quality and freshness of honey. The aim of the present study was to investigate and compare  $\alpha$ -amylase activity in liquid honey samples and freeze-dried honey samples. Overall, 18 honey samples were dehydrated using a freeze-drying method. Freeze-drying of the samples was carried out at  $-50.6\text{ }^{\circ}\text{C}$  and the pressure was 0.036 mbar for 72 hours.  $\alpha$ -amylase activity in the honey samples was tested using Amylazyme test tablets. The obtained results showed variability in  $\alpha$ -amylase activity after the freeze-drying process. As hydroxymethylfurfural (HMF) is another important quality parameter of honey, the content of HMF was determined in the samples by high performance liquid chromatography. In some samples the concentration of HMF after freeze-drying increased and was higher than it is allowed according to the International Honey Commission (for example,  $55.75\text{ mg kg}^{-1}$ ).

**Key words:**  $\alpha$ -amylase activity, freeze-drying, honey, HMF.

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## **Modelling of hot-air and vacuum drying of persimmon fruit (*Diospyros kaki*) using computational intelligence methods**

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**Abstract.** The study evaluated the feasibility of applying computational intelligence methods as a non-destructive technique in describing the drying behaviour of persimmon fruit using vacuum drying (VD) and hot-air-drying (HAD) methods and to compare the results with thin layer mathematical models. Drying temperatures were 50, 60 and 70 °C. Kinetic models were developed using semi-theoretical thin layer models and computational intelligence methods: multi-layer feed-forward artificial neural network (ANN) and support vector regression (SVR). The statistical indicators of coefficient of determination ( $R^2$ ) and root mean square error (RMSE) were used to assess the suitability of the models. The thin-layer mathematical models namely page and logarithmic accurately described the drying kinetics of persimmon slices with the highest  $R^2$  of 0.9999 and lowest RMSE of 0.0031. ANN showed  $R^2$  and RMSE values of 1.0000 and 0.0003, while SVR showed  $R^2$  of 0.9999 and RMSE of 0.0004. The validation results indicated good agreement between the predicted values obtained from the computational intelligence methods and the experimental moisture ratio data. Based on the study results, computational intelligence methods can reliably be used to describe the drying process of persimmon fruit.

**Key words:** Persimmon fruit, drying methods, computational intelligence methods, artificial neural network model, support vector regression model.

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## **Development of formulation and technology of non-dairy soy-coconut yogurt**

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**Abstract.** Yogurt provides an organism with probiotics, which can help digestion. However, many people do not consume dairy for a lot of reasons such as lactose intolerance, milk protein allergy, environmental and ethical concerns. The aim of the research was to develop formulation and technology of plant-based yogurt made of coconut and soy milk. The possibility of using the composition of coconut and soy milk was investigated. The effect of using different ratios of coconut and soy milk on rheological and sensory acceptability was studied. Soy milk containing 20, 30, 40 and 50% coconut milk were used in the production of soy yoghurt using commercially available yoghurt starter. The physico-chemical composition, water activity, rheological and organoleptic properties, fatty acid composition and microorganism viability were investigated. Presented production procedure enables the manufacture of a product with satisfactory functional properties and organoleptic properties.

**Keywords:** soy milk, coconut milk, kudzu, lecithin, soy yoghurt, coconut yoghurt.

## Chemical and bio-transformation of food wastes and plant raw materials to valuable products

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**Abstract:** Food industry generates large amounts of by-products, which become wastes if not properly utilized, e.g. tofu whey, soya molasses, brewer's spent grains, spent coffee grounds, fruits and vegetables pulps. All of them can be transformed into the food stuffs with enhanced functionalities, health benefits and/or sensory attributes using enzymes and microorganisms. On the other side, there are some raw plant and food materials, which can be applicable for isolation of food ingredients and biologically active substances through their (initial raw materials) chemical and bio-transformation. This research is aimed to isolate or produce some valuable biologically active substances (isoflavones, chlorella growth factor, glucosamine) and food ingredients (aminoacids, digestible sugars) from soya molasses, soya flour, chlorella algae, chitosan and brewer's spent grains using methods of chemical extraction and bio-modification.

**Methods:** The *Cellolux® A* enzymatic composition (LLC Sibbiopharm, Russia) containing cellulose, xylanase and beta-glucanase, was used both for brewer's spent grains softening in order to apply it as a base for confectionery such as grainy sweets and biscuits and for extraction of chlorella growth factor before treating Chlorella algae powder with hot water at  $T=95^{\circ}\text{C}$  at different time from 20 up to 60 minutes. Extraction of isoflavones with natural deep eutectic solvents (NADES) was performed at  $60^{\circ}\text{C}$  for 1hr. The *Distizim Protacid Extra®* enzymatic preparation (Novozyme Inc.) was used for soya flour hydrolysis to produce specific amino acids in the highest quantities. *Amylosubtilin*, *GlucoLux-F*, *Protosubtilin*, *CelloLux-A*, *CelloLux-F* (Sibbiopharm Ltd, Russia) were immobilized on alumina functionalized with different silanes for the purpose of identifying optimal heterogeneous catalytic system for producing glucosamine from chitosan.

**Results:** The grains-to-water ratio 1:10; enzyme dose 23 units of cellulase activity per 1 g brewer's spent grains; hydrolysis time 2h; temperature  $50^{\circ}\text{C}$ ; pH 5 were found to be optimal conditions for producing the maximum amount of reduced sugars released by DNS method from 10 % of brewer's spent grains natural fibers breakdown. The hydrolysis of soy flour with *Distizim Protacid Extra®* at optimal conditions (soy flour-to-water ratio 1:6, hydrolysis time 2h; temperature  $25^{\circ}\text{C}$ ) yielded the maximum amount of arginine, valine and lysine. The highest isoflavones yield and antioxidant activity of soya molasses extract were obtained at sample to NADES volume of 1:20 as compared to other ratios. The yield of chlorella growth factor extraction was found to increase by more than 100% by using enzymatic treatment before extraction. The biocatalytic system based on *Amylosubtilin* immobilized on  $\gamma\text{-Al}_2\text{O}_3$  modified with APTES, was observed to have the highest catalytic activity in chitosan breakdown the as compared to that for free one.

**Conclusion:** During studies the optimal conditions of chemical and enzymatic treatment of soya molasses, chlorella algae, chitosan, soya flour and brewer's spent grains to isoflavones, chlorella growth factor, glucosamine, aminoacids, digestible sugars, respectively, have been found.

**Key words:** chemical and bio-transformation, food wastes, plant raw materials, enzymatic compositions, natural deep eutectic solvents (nades) biologically active substances, food ingredients.

**Acknowledgements.** This work was partly supported by the Russian Science Foundation RSF (Grant 20-66-47017).

## The usage of a binder system for frozen berries in the manufacture of confectionery

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**Abstract.** The aim of the research was to create binding systems for confectionery using gelling agents. The possibility of using partially hydrolyzed liquid egg white (egg hydrolyzate) in the binding system of gelling agents (egg hydrolyzate - agar (EG-A), egg hydrolyzate - starch (EG-S)) was determined to obtain the required mechanical characteristics when creating coatings, ornaments or fillers in confectionery with whole berries or pieces of fruit. In this regard, a technology has been developed for the hydrolysis of liquid egg white in the presence of an acidic reagent. The best rheological characteristics of the gelling agent from egg white were obtained under the following hydrolysis conditions: egg white : 1% HCl ratio = 1:2, process temperature - 66°C, duration - 40 minutes, the pH of the egg hydrolyzate was 6.53, the amount of dry solids was 11.78%. The newly created systems with agar (E406, Germany), chemically modified food starch (E1442, Germany) and hydrolyzed egg white (egg hydrolyzate) allow to adjust the properties of the coating for quick-frozen berries used in semi-finished confectionaries or cakes. It is established that the coating for quick-frozen berries, which includes a system consisting of 1% E406 and 0.5% egg hydrolyzate, should be carried out in 2 stages. In the first stage, a 10-minute exposure of the coating, which has a tensile strength of 580 g·cm<sup>-2</sup>, allows to create a strong capsule around the berry, which prevents the processes of destruction from proceeding. The second stage is necessary to obtain a uniform surface coating of the semi-finished mix from the berries. In this case, the tensile strength of the coating should be 480 g·cm<sup>-2</sup>. The system created from the E1442 and egg hydrolyzate gelling agents was also used in 2 stages when making cakes, which were subsequently baked at 180°C. The content of the binding system in the coating applied to the test substrate was 6.9 – 7.7%, the effective viscosity of the coating was 120 – 180 Pa·s. The content of the binding system in the coating of the surface of the berries in the second stage was 5.2 – 6.3% with effective viscosity values of 50 – 90 Pa·s. Semi-finished berry products and ready-made baked cakes, produced with developed binding systems, can be stored at -8°C for 10 to 12 days. After refrigerated storage, the separated moisture was not observed in the test samples. The absence of the phenomenon of syneresis with the indicated proportions of the introduction of gelling agents in coating systems has been established.

**Keywords:** hydrolysis, egg hydrolyzate, binding systems, jellies, confectionery, refrigerated storage.



## Winter rye (*Secale cereale* L.) antioxidant capacity, total phenolic content and quality indices

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**Abstract.** Rye (*Secale cereale* L.) grain is an excellent raw material for healthy and tasty foods. Rye products are characterized by their unique composition and properties such as antioxidant capacity and total phenolic. The aim of the study was to assess radical scavenging capacity, total phenolic content, protein, starch content and falling number in rye varieties wholemeal. The trial included population winter rye varieties ‘Kaupo’, ‘Amilo’, ‘Dankowskie Amber’, ‘Dankowskie Rubin’, ‘Inspector’ and hybrid rye varieties ‘SU Drive’, ‘SU Mephisto’, ‘SU Bendix’, ‘Brasetto’, ‘Palazzo’ grown in Latvia. The antioxidant activity was determined using the DPPH (2,2-diphenyl-1-picrylhydrazyl radical) assay and total phenolic content was determined spectrophotometrically according to the Folin-Ciocalteu method. The rye grain antioxidant capacity was estimated as Trolox equivalent, while the total phenolic content was expressed as gallic equivalents (GAE). ‘Su Drive’ rye variety contained the largest amount of total phenolic (average 208 mg GAE 100 g<sup>-1</sup> DW), but the lowest – ‘Inspector’ rye variety 176mg GAE 100 g<sup>-1</sup> DW. In general, all rye samples tested in this study demonstrated similar level of antioxidant capacity (from 38.5 to 46.2 mmol Trolox eq. 100 g<sup>-1</sup>). Statistically higher (P<0.05) total phenols content and falling number had hybrid rye grains, compared to the population rye grains. In the present trial, the differences between hybrid varieties grains protein and *starch content* comparing to population varieties were not observed.

**Key words:** antioxidant capacity, phenolic, protein, falling number, rye, starch.



## **Current research trends in fruit and vegetables wastes and by-products management-Scope and opportunities in the Estonian context**

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**Abstract:** Globally on an annual scale, considerable amounts of fruit and vegetables wastes (FVW) are generated in the agri-food industrial sector. Costs insured for safe disposal of FVW remains uneconomical and they can pose a serious environmental hazard if left untreated. However, FVW have high potential for reuse, recycle and recovery, which is an indication that there are productive, sustainable and affordable ways of reducing and tackling them at the industrial levels. Recent years have seen progressive innovative research on FVW management strategies, which has been developed with an idea of reducing wastes and fully exploiting its potential. Further, FVW represents a potential source of valuable compounds and bioactive ingredients. Today, there are many proposed innovative approaches for handling the FVW. These include reintroducing sub-standard fruit and vegetables (small sized or misshaped fruit and vegetable) in the market, reusing FVW for soil amendments, composting, or as an animal feed, and much more. In addition, the extracted bioactive compounds from FVW and by-products can find wide applications as a natural additive in food, cosmetics and/or in pharmaceutical applications. Currently, novel cost effective strategies have been developed for effective valorisation of agri-food wastes and by-products. The field of FVW management is still limited, thus leaving a wide gap for new ideas, novelty and applications of more efficient green techniques for complete utilization of agri-food wastes and by-products. Some of the interesting aspects on wastes and by-products management are discussed in relevance to Europe and in Estonia.

**Keywords:** Food wastes and loss; Circular economy; Waste management; Bioactive compounds; Livestock feed.

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## The Influence of Milk Quality and Composition on Goat Milk Suitability for Cheese Production

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**Abstract.** The goat milk production sector is becoming more extensive in Latvia, therefore detailed studies are required to examine goat milk suitability for cheese production. There is still a lack of knowledge about the chemical composition and quality of goat milk, and their connection with milk renneting properties. The objective of this study was to analyse the influence of milk composition and quality on goat milk renneting properties. Fat, protein, lactose, urea content, somatic cell count and freezing point were measured by infrared spectroscopy. The curd firmness was analysed by Texture Analyser TA.HD.plus (Stable Micro Systems, UK). In total, 34 samples, including bulk milk samples ( $n = 3$ ), were analysed. The goats were from the second to the fourth lactation, and the analysed breeds include the Latvian Native ( $n = 9$ ), Saanen ( $n = 14$ ) and milking crosses (closer to Anglo Nubian) ( $n = 8$ ). The samples were arranged according to the lactation, somatic cell count and breeds. The fat content varied from 1.72 to 4.67%, and the protein content – from 2.93 to 4.57% in individual goat milk samples. The highest fat to protein ratio was established in the Saanen breed goat milk (0.96), but the lowest – in milking crosses' milk (0.80). The highest somatic cell count was determined in the second lactation goat milk (1,421 thous.  $\text{ml}^{-1}$ ) and in milking crosses' goat milk (1,027 thous.  $\text{ml}^{-1}$ ). The somatic cell count influences curd firmness in cheese, and the highest fat to protein ratio was established in the first group samples with lower somatic cell count.

**Key words:** goat milk, somatic cell count, renneting properties.

**Acknowledgements.** The research was supported by the project Strengthening Research Capacity in the Latvia University of Life Sciences and Technologies, contract No. 3.2.-10/2019/LLU/139.

## **Composition, sun protective and antimicrobial activity of lipophilic bilberry (*Vaccinium myrtillus* L.) and lingonberry (*Vaccinium vitis-idaea* L.) extract fractions**

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**Abstract:** Berries of the genus *Vaccinium* found in bogs and forest of Northern Europe are a valuable source of biologically active substances containing sterols, unsaturated fatty acids, flavanoids, anthocyanins. The presence of these compounds provides various health benefits of berry use – treatment of urinary tract inflammation, controls levels of sugar in the blood, improves cardiovascular health and reduces negative effects of oxidative stress caused by free radicals. The studied bilberry (*Vaccinium myrtillus* L.) and lingonberry (*Vaccinium vitis-idaea* L.) lipids were fractionated using normal-phase chromatography and they were found to contain fatty acids (oleic, linoleic acid), sterols ( $\beta$ -sitosterol), isoprenoids (ursolic and oleanolic acid) and different long-chain aliphatic compounds. The prepared extract fractions were tested for their sun protective factor and antimicrobial activity. Fractions containing high concentrations of phenolic acids (cinnamic acid, benzoic acid) were shown to have potential UV-B blocking activity, whereas the fractions with high sterol content effectively inhibited the growth of tested bacteria. These findings are empirical for the creation of natural nutraceutical and cosmeceutical functional ingredients.

**Keywords:** *Vaccinium* berries, chemical composition, lipids, wax, cuticular, antimicrobial activity, UV-B protection.

## **Low-fat high-protein fermented milk product with oat extract as a nature stabilizer**

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**Abstract.** Nowadays, the use of plant components in terms of their pronounced functional properties is of high relevance. Oat extract contains gums,  $\beta$ -glucans, vitamins (A, B1, B5, B9, PP, H), minerals (Fe, I, K, Si, Mn, Cu, Mo, etc.) and essential amino acids. It has been proven that a long-term use of  $\beta$ -glucans showed the reduction of the risk of cardiovascular disease and diabetes and the regulation of cholesterol and blood sugar.  $\beta$  glucans also have immunoprotective, anti-inflammatory, antimicrobial, prebiotic effects and improve intestinal motility. The aim of study was to develop the technology of low-fat high-protein fermented milk product with functional characteristics. Oat extract was used as a natural stabilizer and a source of  $\beta$ -glucans. Maceration technique was used for the extraction. The recommended extraction parameters were established and physicochemical characteristics of the extract were studied. The recommended doses of oat extract when introduced into milk and the optimal heat treatment conditions of the milk-oat mixture were determined. The influence of temperature on the gel-forming properties of oat extract was investigated. The effect of oat extract on rheological behavior, water-holding ability and shelf life of the finished product was studied. Regular consumption of lactic acid microorganisms has a positive effect on the digestive system and metabolism. Based on the organoleptic characteristics and physicochemical changes during the fermentation process in comparison with the control sample (without oat extract), the recommended starter culture combinations (*Lactobacillus acidophilus*, *Lactococcus lactis* subsp, *Lactobacillus bulgaricus*) were proposed.

**Key words:**  $\beta$ -glucans, oat extract, fermented milk product.

## Protein quality of fly larvae *Lucilia caesar* and its digestibility

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**Abstract:** The general insect protein quality as well as the principles of in vitro digestibility assays are discussed. Insects are considered as a sustainable protein source for animal, fish feeds and also for food products in some countries. Nutritionally, average protein content varies from 13% to 76% of dry matter depending on the type and developmental stage of the insects as well as raw insect treatment for protein extract (oven drying, freeze drying, chemical and enzymatic etc.). The nutritional value of insect protein is evaluated not only in amino acid composition, but also in protein digestibility. The variability of in vitro protein digestibility results could be the raw material type, protein powder purity and method of insect protein extracted. In this research an in vitro protein digestibility is performed to simulate the digestion of insect protein through the stomach and the small intestine of a single-stomached animal. The in vitro assay method developed to maximize the hydrolysis of the animal protein peptide bonds with minimal enzyme usage. The in vitro protein digestibility via two steps is a simple and cheap methods that can be rapidly used. Commonly pepsin in the first step and in the second step pancreatic enzymes are used. Insect protein digestibility, reported 76 to 96%. That is comparable to values for egg protein (95%) or beef (98%) and even higher than in the case of many plant proteins. Moreover, high quality of fly larvae protein is approved by contents of essential amino acids *Lucilia caesar*.

**Key words:** insect, fly larvae, *Lucilia Caesar*, protein quality, digestibility, in vitro, essential amino acids.

## **The possibility of using microwaves to obtain extracts from berry press residues and jelly products with bioactive characteristics**

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**Abstract.** The paper explores the possibility of development a microwave technology for obtaining water extracts from berry press residues (wild bilberries and cranberries as the objects) and jelly products based on them, which will allow using the waste of freshly squeezed juices in business, such as restaurants and catering services. The antioxidant activity (DPPH and FRAP methods), content of phenolic compounds, flavonoids, anthocyanins, ascorbic acid were determined in berries and in berry press residues. The antioxidant activity of bilberry press residues was due to anthocyanins, and the activity of cranberry press residues was due to flavonoids. Using the microwave oven (magnetron power 800 W, frequency 2450 MHz), water extracts were obtained in the ratio: for cranberries 1.5:10, for bilberries 1:10. The antioxidant activity of extracts depended on the type of berries and was greater in extracts from bilberry press residues. Extracts of bilberries and cranberries and their compositions (sugar-free and sugar-added) with gelatin as a gelling agent were used to produce the jelly products. Combining bilberry and cranberry extracts (70:30) with gelatin makes it possible to obtain jelly products without sugar. Heating of the ready recipe mixture after preliminary swelling of gelatin and without swelling of gelatin was carried out in the microwave oven. The antioxidant activity of jelly products was higher when using bilberry extracts than cranberries. An increase in the antioxidant activity of the extracts led to a slowdown in structure formation, but increased the plasticity of the products.

**Key words:** bilberries, cranberries, berry press residues, extracts, microwaves, jelly products, antioxidant activity, deformation.

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## Radiation use efficiency by tomato transplants grown under extended photoperiod

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**Abstract.** The study focused on the effect of an extended photoperiod on the radiation use efficiency (*RUE*) by the tomato transplants (*Solanum lycopersicum L.*) in the pre-reproductive period. In two consecutive series of experiments, the photoperiod was 16 and 22 hours. The photon irradiance at the plant tops was maintained at low, medium and high levels: 100, 170 and 240  $\mu\text{mol}\cdot\text{m}^{-2}\cdot\text{s}^{-1}$ , respectively. The plants were grown under two lighting systems with different light quality. The difference was 7% higher blue flux share in Spectrum II. The use of an extended photoperiod, especially in combination with high irradiance level, resulted in the plant leaf chlorosis. When varying the radiation dose components, the deviation from the reciprocity law was recorded. By the analysis results, the chlorophyll degradation was a response to the extended photoperiod rather than the radiation dose. Without additional blue flux, under a regular photoperiod, *RUE* reduced by 8% at the high irradiance level. Under extended photoperiod, the shift from the low to high irradiance level reduced *RUE* by 20–37%, with bigger reduction values being observed at higher irradiance levels. Seven percent addition of blue flux made it possible to increase *RUE* by 5–8% at the same and lower irradiance levels and under the regular photoperiod. With the extended photoperiod under these conditions, *RUE* decreased by 8–21%. The study results verify a great influence of an extended photoperiod on *RUE*, while the degree of influence depends on other parameters of light environment – light quality and irradiance level.

**Key words:** photoperiod, irradiance, light quality, doze, biometry, radiation use efficiency, chlorophyll, chlorosis.

**Acknowledgements.** The study was supported by the 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 of metabolic engineering approaches to regulate the content of total phenolics, antiradical activity and organic acids in callus cultures of the highbush blueberry (*Vaccinium Corymbosum* L.)**

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**Abstract.** Blueberry (*Vaccinium corymbosum* L.) is increasingly cultivated to produce high quality berries for consumption and potential applications in medicine, nutrition and as industrial precursors. Seasonal availability sets limitations on chemical compound isolation from cultivated plants. Biotechnological solutions, such as tissue cultures and metabolic engineering, can provide sufficient amounts of plant material with reasonably high metabolite levels, which may be adjusted by different strategies. Here, we describe our approach to modifying total phenolic content (TPC), antiradical activity (ARA) and amounts of selected organic acids in *in vitro* cultures of two varieties of *V. corymbosum* by varying the growth media. TPC, ARA and acid levels were determined in mature leaves of field-grown plants and in stable callus cultures derived from leaves of varieties ‘Bluecrop’ and ‘Duke’ grown on Murashige-Skoog (MS) and Woody plant (WP) media supplemented with varying concentrations and combinations of different plant growth hormones. TPC varied from 83 mg g<sup>-1</sup> dry weight (DW) to 142 mg g<sup>-1</sup> DW in leaves of ‘Bluecrop’ and ‘Duke’, respectively, and correlated with their ARA with “Duke” at the lead. For callus cultures the highest ARA, as well as the highest TPC of 94 mg g<sup>-1</sup> DW was observed in ‘Bluecrop’ grown on WP medium with 2,4-dichlorophenoxyacetic acid (2,4-D). High level of quinic acid was found in the mature leaves of all tested varieties, while callus cultures exhibited relative increase in amounts of malic, succinic and citric acids instead. Oxalic acid was found only in callus cultures.

**Key words:** Blueberry, *Vaccinium corymbosum*, total phenolic content, antiradical activity, organic acids, callus cultures.

**Acknowledgements.** This research is funded by the Latvian Council of Science project LZP2018/14 (lzp-2018/1-0101).



## **The influence of the flour amylolytic enzymes activity, dosage of ingredients and bread making method on the sugar content and the bread quality**

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**Abstract.** The aim of this study was to study the effect of the sugar dosage, improver dosage, type of bread making methods and the amylolytic activity of five different types of wheat flours on the sugar content and the bread quality. The sugar content in the bread crumb was determined using the Bertrand's method and was counted for sucrose. When the dough was prepared using accelerated technology, the improver affected the sugar content in the bread due to the starch enzymatic hydrolysis. The effect of improver dosages and sugar dosages on the sugar content in the bread was established. When using the improver, the sugar content exceeded the permitted amount in 1.25 times. No correlation was found between sugar dosage in recipe and bread quality when accelerated bread making way was used because of short fermentation time. The influence of wheat flour amylolytic activity (falling number) on the sugar content in bread was established, including when sugar was absent in the formulation. When sugar presented at bread formulation, the flour amylolytic activity did not significantly affect the bread quality, except the acidity. The bread making way had a greater influence on bread quality than falling number of flour. When sugar absent at bread recipe, the higher was the flour amylolytic activity, the higher was the sugar content in bread made by traditional way due to the starch deterioration. Obtained data have shown that when a baking method is selected, the flour amylolytic activity must be taken into account.

**Keywords:** bread, sugar content, sucrose, bread making technology.

## Comparison of phenolic compounds in various parts of *Viburnum opulus* L. (European cranberry)

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**Abstract** Phenolic compounds especially flavonoids are of great interest in food industry as well as in medicine. This is a large class of plant secondary metabolites of various structures. Polyphenols such as flavonoids and tannins are noted for their importance in food industry. Flavonoids are responsible for plant fruit colour and tannins for taste - astringency. Their medicinal properties are of great importance. *Viburnum opulus* (VO) is shrub native to Europe and Northern Asia. Fruits of VO are source of phenolic compounds, especially, flavonoids, and are well known for their antioxidant activities. Other plant parts are studied less giving a new perspective source of antioxidants. Some studies show potential of flower and bark. The aim of this study was to determine and compare amounts of phenolic compounds in 4 different parts of plant - fruit, leaf with flower, bark, and root. Herbs were harvested in Latvian commercial farm. Ethanol extracts of herbs were analysed with photospectrometric method using Folin-Chicolto reagent. All parts of the plant contained high amounts of polyphenols. Bark and root exceeded fruit, flower and leaf combination in total phenolic contents. Therefore bark and roots of VO have high food antioxidant potentials. Further studies are needed to determine exact types of polyphenols in plant parts of *Viburnum opulus*.

**Key words:** phenolic compounds, tannins, flavonoids, European cranberry, *Viburnum opulus*.

## Quality and safety problems of sports nutrition products

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**Abstract.** The purpose of this work was to study the quality and safety of some sports nutrition products. The objects of study were sports nutrition products: protein bars of ‘ProteinBar’ (Russia) and ‘Bombbar’ (Russia); capsule forms of dietary supplements  $\omega$ -3-6-9 firms ‘Sportline’ (Russia), ‘Multipower’ (Germany) and ‘Maxler’ (USA). According to the research results, the normalized safety indicators of the fat component of the studied products for sports nutrition (acid number and peroxide) are within acceptable values. The standardized safety indicators of the fat component do not fully reflect the safety requirements for the fat component of sports nutrition products, since there are no standards for the most important indicators of fat safety – the content of secondary oxidation products – copolymers insoluble in petroleum ether and epoxides. The results obtained in the course of the work showed that in almost all of the studied samples the overabundance of epoxides (more than 17–24 mmol kg<sup>-1</sup>) and secondary oxidation products — 1% or more.

**Keywords:** carcinogenic effect, epoxides, fat component, oxidation products, safety, sports nutrition, quality.

## Acceptance of low-sugar yoghurt among Latvian teenagers

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**Abstract.** Over a thousand year history, yoghurt has become one of a widely consumed product in the world. Its reputation as a healthy food has been undermined recently by concerns over the high sugar content. The majority of consumers expects and prefers yoghurts to be sweet. However, governments across Europe are calling for significant cuts in the amount of added sugar used in yoghurt production. The aim of the study was to evaluate the acceptance of low-sugar yoghurt produced by different commercial  $\beta$ -galactosidases by teenagers. Standardised milk with fat content 2.0% (SC Tukuma piens) was pasteurized at  $95 \pm 1$  °C 5 min, cooled down till  $43 \pm 1$  °C and fermented with  $\beta$ -galactosidase and starter YC-X11 (Chr. Hansen, Denmark) and fermented till pH  $4.50 \pm 0.20$ . Different commercial  $\beta$ -galactosidases: Nola™ Fit 5500, Ha-Lactase 5200 (Chr. Hansen, Denmark), GODO-YNL2 (Danisco, Denmark) and BrennZyme (Brenntag PolskaSp, Poland) were used. Fermented samples were gently mixed and cooled down till  $6 \pm 1$  °C and 5% (w/w) of sugar was added to each sample. Sensory evaluation of the yoghurt's samples was performed by teenagers (14–18 years,  $n = 50$ ) at Aizputes Secondary School (Latvia). Lactose and monosaccharides concentration prior to sugar addition was detected by HPLC (Shimadzu LC 20 Prominence, Japan).

The lactose hydrolysis into glucose and galactose by the use of  $\beta$ -galactosidase helps to increase sweetness through an occurrence of natural sugars in milk. During sensory evaluation, teenagers admitted the yoghurt with reduced sugar as sweet, significantly sweeter ( $P < 0.05$ ) was yoghurt sample with Nola™ Fit 5500. The results demonstrated that it is possible to reduce sugar in yoghurt production and to gain consumer acceptance through the occurrence of glucose and galactose, but it is problematic to offer lactose-free or reduced lactose products to consumers without lactose intolerance.

**Key words:** acceptance, sweetness, yoghurt,  $\beta$ -galactosidase.

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