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Book of Abstracts. 13<sup>th</sup> International Conference on Biosystems Engineering 2023

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

<http://bse.emu.ee>

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ISBN 978-9916-719-24-4 (pdf)

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# I AGRICULTURAL ENGINEERING

## Testing Outcomes of IoT based Continuous Crop Weight and PAR Sensors at Industrial Greenhouse

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**Abstract:** Industrial greenhouses have automated control systems for climate, lighting, irrigation, ventilation, and heating regulation using different types of feedback sensors. Nowadays it is a trend to increase the data precision and measurement data amount, thus various additional IoT sensors are installed, and the regulation becomes more precise, due to available data, which enables new analytical features to create new control rules or strategies. The general aim is to raise the level of process automation, quality, energy efficiency, and other important parameters. Still, further, we go into data resolution and amount, and the problem of data reliability and interpretation starts to become a challenging problem. In this article, authors focus on earlier developed PAR sensor modules and continuous tomato crop weight sensor modules (TWS) testing and received data analysis from an industrial greenhouse. Both sensors were tested in detail at the tomato greenhouse of “Latgales Darzenu Logistika” in Mezvidi parish, with a total growing area of 5062.4 m<sup>2</sup> from 1.05.2022 to 30.06.2022., and data gathering and analysis is still ongoing. Received sensor data can be used as the main feedback signal to create a lighting control strategy, same time increasing energy efficiency and reducing also costs. As artificial lighting energy consumption costs make 20-40% of total greenhouse costs, it is worth having a more precise lighting control system algorithm, integrating the crop increase and accumulated light energy during the day from the sun, and then adding only the missing amount (also period) of light provided by artificial lighting.

**Key words:** Greenhouse control systems, IoT, sensors, and weight measurement.

**Acknowledgements:** Publication is created with support of the Latvian Rural Development Program Project N.18-00-A01620-000006 project “Development of greenhouse complex lighting system evaluation method”.



## Physical parameters kinetics during the drying process of quarters and halves cut tomatoes

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**Abstract:** Tomato drying is a time-consuming industrial process. Moreover, the prolonged use of high temperatures decreases the quality of tomatoes and increase the environmental footprint of the process. In most cases, drying is performed on halved tomatoes. Alternatively, the use of quarter tomatoes could guarantee a drying times reduction without compromising the final product quality. This work aimed at modelling changes in physical characteristics of half and quarter tomatoes. The drying tests were conducted at 50 and 60 °C. The kinetics of weight loss, colour change, and volume reduction were determined. Colour change was monitored through image analysis, while volume reduction using RGB-D reconstructions. Based on the results, an increase in the drying temperature and the use of quartered tomatoes allow a significant reduction in drying times. The loss of water kinetic allowed the determination of a critical moisture. Between initial and critical moisture, loss of water occurred at constant rate (zero-order kinetic), while after that the rate decreased exponentially (first order kinetic). The colour kinetics showed an initial constant rate followed by a linear increase for brown pixels. The variation of red pixels did not have a clear trend. Increasing the temperature there was no significant reduction in colour quality while quarter tomatoes showed a greater loss of redness than halved tomatoes. Furthermore, the temperature increase does not affect the volume reduction of the tomatoes. Increasing the temperature and the use of quartered tomatoes are simple solutions to reduce drying times. However, quartered tomatoes are less visually appreciable than halved tomato.

**Key words:** modelling, artificial vision, sustainability, food quality, process optimization.

## **II AGRICULTURAL ECONOMICS**

## **Change in the carbon footprint of Iranians' food consumption from 1961 to 2019: A decomposition analysis of drivers**

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**Abstract:** This study investigates the role of three drivers namely, population, per capita energy intake, and dietary change on the carbon footprint (CFP) of food consumption in Iran over the period 1961-2019. Iran was chosen for this analysis because 1- Iran has experienced a noteworthy population increase in the past century, and 2- the imposed international sanctions have changed the economic welfare of the nation. To address this, data on food consumption in Iran are extracted from FAOSTAT Food balance sheets (FBSs) and data on CFP per item are obtained from literature. Logarithmic Mean Division Index (LMDI) is utilized to decompose the impacts of the drivers. The results show that the carbon footprint of food consumption in Iran has increased by 1.6 during this period. We also found that population increase, and per capita energy intake were the main drivers of the carbon footprint of food consumption in Iran while diet change contributed negatively.

**Key words:** carbon footprint, food consumption, diet change and Iran.

## **III BIOENERGY**

## **Influence of flue gas on the cultivation of microalgae *Chlorella vulgaris***

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**Abstract:** Climate change and associated environmental impacts are posing an existential threat to the world. Understanding the critical situation, the EU developed the European green deal as a strategy towards making Europe a climate-neutral continent and thus creating a sustainable economy, offering better life quality and protecting biodiversity and ecosystems. One of the major targets of achieving a climate-resilient society focuses on reducing various greenhouse gas emissions by 2030 by at least up to 55% compared to 1990 levels. Compared to the high-energy consumption of existing carbon capture technologies, microalgae offer a sustainable solution in carbon absorption to reduce atmospheric carbon levels. Advancements in microalgal cultivation offer wider applications in CO<sub>2</sub> fixation combined with side streams of other industries creating value-added byproducts. In this investigation, *Chlorella vulgaris* was cultivated in photobioreactors in the presence of flue gas with optimized conditions. Flue gas is a waste byproduct created during the combustion process. In addition to oxides of carbon, sulphur and nitrogen, flue gas also contains particulate matter, heavy metals and water vapour. Flue gas composition varies depending on the fuel composition and combustion parameters. Herein, the evaluation of the carbon tolerance and the growth kinetics of *Chlorella* in the presence of flue gas was estimated. Furthermore, to evaluate the changes in various biomolecules, a comparative analysis of the different biomolecules such as carbohydrates, proteins, pigments and lipids will be done. The harvested *Chlorella* will be used for the preparation of aquafeed. The toxicity evaluation and the safety analysis will be conducted on fish models at later stages, ensuring the complete valorization of the microalgal biomass.

**Keywords:** microalgae, flue gas, CO<sub>2</sub> sequestration, climate neutrality, biomass.

## **Fungal ligninolytic enzymes and their application in biomass lignin pre-treatment**

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**Abstract:** Lignocellulosic biomass is a significant source for sustainable fuel and high-value chemical production. However, due to the complex cross-linked three-dimensional network structure, lignin is highly rigid to degradation. In natural environments the degradation is performed by fungi, however, the process is slow and, thus, use of lignin degradation by fungi has not been regarded as feasible technology in the industrial lignocellulose degradation. At the same time, the fungi produce a wide variety of enzymes that can be directly introduced in the industrial processing of lignocellulose. Laccase production is typical for the wood-rotting fungi causing white rot and a related group of litter-decomposing fungi, i.e. the fungal species causing lignin degradation. Nevertheless, introduction of these enzymes in industrial processes are still linked with high costs and dependence from commercial manufacturers. Furthermore, fungi can produce different forms of laccases that are expressed differently depending on the substrate that these fungi encounter. Within this study qualitative screening of laccase production using ABTS and Azure B was performed for 13 fungal strains with potentially high lignocellulose degrading enzyme production abilities. In addition to standard screening methods, laccase production was assessed in medium containing lignin and hay biomass as carbon source. As a result, it was possible to select most potent strains of fungi, such as *Irpex lacteus*, *Pleurotus dryinus*, *Bjerkandera adusta* and *Trametes versicolor*, to produce lignocellulose degrading enzymes and to demonstrate its potential application in biological lignocellulose pre-treatment.

**Key words:** biomass pre-treatment, lignocellulosic biomass, ligninolytic enzymes and white rot fungi.

## **Rhamnolipid and sophorolipid production from torrefied lignocellulosic waste**

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**Abstract:** Biosurfactants are amphiphilic molecules with surface activity. At present, the microbial biosurfactant industry is not as cost-competitive as its chemical-based counterparts. This is in part because of the high cost of substrates. In theory, substrate costs can be minimized by using alternatives such as agro-industrial and forestry wastes. However, such wastes often have a high lignocellulosic content, which is difficult for microorganisms to degrade. This can be overcome by a thermochemical pre-treatment method, torrefaction, wherein waste biomass is heated at 200°C–300°C in an inert atmosphere, yielding monomeric sugars, which can be easily converted by microorganisms to biosurfactants. Herein, we propose the use of torrefied biomass as a substrate for the production of glycolipid biosurfactants, viz. rhamnolipids and sophorolipids, with improved process efficiency and economy.

**Keywords:** biosurfactant, torrefaction, pre-treatment, lignocellulose and process improvement.

**Acknowledgement:** This work was financially supported by the Estonian Research Council under the RESTA5 program grant agreement.

## Increased Biogas Production from Lignocellulosic Biomass by Soaking in Water

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**Abstract:** Due to its large production worldwide, lignocellulosic biomass represents a substrate with great potential to produce biogas. However, this type of biomass is characterized by a complex and solid structure, which is difficult to decompose by anaerobic microorganisms. Applying the correct pre-treatment method can increase its biodegradability. Lignocellulosic substrate was pre-treated by soaking in water for one day at room temperature to increase biogas production and monitoring of long-term operation of laboratory models of anaerobic reactors for anaerobic digestion of such pre-treated maize waste was employed. Monitoring results in two reactors, R1 with biogas produced from a substrate soaked in water for one day and R0 with the production of biogas from a substrate mixed with water just before dosing into the reactor, were compared showing positive effect of the pre-treatment method. This was expressed by higher values of biogas production and higher methane content in biogas from the substrate soaked in water for one day. The achieved specific biogas productions during four different phases of reactor operation in reactor R1 were in the range of 190-335 mL g<sup>-1</sup> of VS (volatile solids) and 101-221 mL g<sup>-1</sup> of VS in reactor R0. Methane content of biogas during reactor operation was 49.3-55.2% in reactor R1 and 42.5-45.5% in reactor R0. During long-term operation of another reactor, pre-treated maize waste was used as a co-substrate for maize silage, in the ratio of 1:1 based on VS of the substrates proving as a suitable co-substrate for maize silage, as the achieved average value of specific biogas production during reactor operation at OLR (organic loading rate)=1.75 kg VS m<sup>-3</sup> d<sup>-1</sup> was 510 mL g<sup>-1</sup> of VS and during first 67 days at OLR=2 kg VS m<sup>-3</sup> d<sup>-1</sup> it was 454 mL g<sup>-1</sup> of VS.

**Key words:** anaerobic digestion, bioenergy, maize waste, methane and pre-treatment.

**Acknowledgements:** This article was written with the generous support by the Operational Program Integrated Infrastructure for the project: " Support of research activities of Excellence laboratories STU in Bratislava ", Project no. 313021BXZ1, co-financed by the European Regional Development Fund.



## Enzymatic depolymerization of lignins: Toward practical applications

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**Abstract:** Lignin is the second most abundant renewable resource capable of replacing different raw materials in the chemical industry. It can be obtained from various lignocellulosic biomass (LCB) via different pre-treatment methods. One such possibility is Ionic Liquid pre-treatment in combination with enzymatic hydrolysis of cellulose and thus producing Ionosolv lignin (IL). In this study IL from the Ionic liquid pre-processing technology and Kraft lignin (KL) from traditional pulp industry was utilized for enzymatic conversion. The completely soluble IL was obtained via ethanol solubilization followed by the anti-solvent precipitation to obtain lower molecular weight lignin fractions. IL and KL was tested with three different bacterial laccases to identify the best optimal conditions for its conversion. Among the tested laccases, engineered laccases was found to display highest rate of IL and KL conversion i.e., 40g/l in 0.25M NaOH solution. The size and structure of IL and KL was characterized before and after the enzymatic oxidation by size exclusion chromatography (SEC) and two-dimensional heteronuclear single quantum correlation nuclear magnetic resonance (2D HSQC NMR) methods. Also, the potential applications for both types of lignins were elucidated before and after oxidation for complete valorization of the LCB.

**Keywords:** biorefinery, lignocellulosic biomass, lignin depolymerization, Ionosolv lignin and laccases.

**Funding:** This research was supported by ERDF and the Baltic Research Programme Project No. EEARESEARCH-173 “Novel biorefinery concepts for valorization of lignocellulosic residues (NoviCo)” under the EEA Grant of Iceland, Liechtenstein and Norway (Agreement No. EEZ/BPP/VIAA/2021/7).

**Author Contributions:** S.K. D.R ; methodology, S.K. and S.S; data curation, S.S., and S.K., D.R ; writing—original draft preparation, S.K and S.S.; writing—review and editing, T.K., C.K., S.K; visualization, S.S.; supervision, T.K., S.S.; project administration, T.K., C.K; funding acquisition, T.K., C.K.

## Effect of torrefaction condensate on growth of different microalgal strains

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**Abstract:** Pre-treatment of biomass by thermochemical methods generates a variety of by-products. In this study, gases formed during the torrefaction of wood biomass were condensed and used for the cultivation of different microalgae for the production of value-added products, especially exopolysaccharides (EPS). Microalgae are well-known for their bioremediation potential and high-value products. Therefore, growing microalgae in torrefaction condensate (TC) suggests a new microalgal bio-refinery solution by the utilization of toxic TC for the production of value-added products, such as EPS. To implement a successful biorefinery system, a detailed study of the process is required.

In the first step, 250 g of pine wood chips were torrefied at different temperatures — 225°C, 250°C, 275°C, and 300°C — for 60 minutes in an inert atmosphere using a batch reactor. TC was collected and analysed using gas chromatography–mass spectrometry. Different concentrations of the TC were tested for the cultivation of six species of microalgae (*Chlamydomonas reinhardtii*, *Porphyridium marinum*, *Chlorella vulgaris*, *Scenedesmus obliquus*, *Chlorococcales*, and *Arthrospira platensis*). The effect of TC on growth, biochemical composition of microalgal cells, and exopolysaccharide production were analysed. Among the six species, four species (*Chlamydomonas reinhardtii*, *Porphyridium marinum*, *Chlorella vulgaris*, and *Scenedesmus obliquus*) were able to grow on TC and produce EPS. EPS yield from *Chlamydomonas reinhardtii* and *Porphyridium marinum* were 0.43g/L and 2.14g/L, respectively.

**Key words:** Exopolysaccharides (EPS), microalgae, *Chlamydomonas reinhardtii* and *Porphyridium marinum*.

**Acknowledgement:** This research was supported by RESTA5 “Development and optimization of thermochemical valorization and biorefining technologies for second and third generation biochemical production from lignocellulosic biomass”.

## Sustainable valorization of lignin into value-added products by green technologies

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**Abstract:** Lignin-based chemicals and biomaterials will be feasible alternatives to their fossil-fuel based counterparts once their breakdown into constituents is economically viable. The existing commercial market for lignin remains limited due to its complex heterogenous structure and lack of extraction/depolymerization techniques. Hence, in the present study, a novel low-cost ammoniumbased protic ionic liquid (PIL), 2-hydroxyethyl ammonium lactate [N11H(2OH)][LAC], is used for the selective fractionation and improved extraction of lignin from Scots pine (*Pinus sylvestris*) softwood biomass (PWB). The optimization of three process parameters, viz., the incubation time, temperature, and biomass:PIL (BM:PIL) ratio, was performed to determine the best pretreatment conditions for lignin extraction. Under the optimal pretreatment conditions (180°C, 3 h, and 1:3 BM:PIL ratio), [N11H(2OH)][LAC] yielded 61% delignification with a lignin recovery of 56%; the cellulose content of the recovered pulp was approximately 45%. Further, the biochemical composition of the recovered lignin and pulp was determined and the recovered lignin was characterized using  $^1\text{H}$ - $^{13}\text{C}$  heteronuclear single quantum coherence (HSQC) nuclear magnetic resonance (NMR) spectroscopy, quantitative  $^{31}\text{P}$  NMR, gel permeation chromatography (GPC), attenuated total reflectance (ATR)-Fourier transform infrared spectroscopy (ATR-FTIR), and thermal gravimetric analysis (TGA) analysis. Our results reveal that [N11H(2OH)][LAC] is significantly involved in the cleavage of predominant  $\beta$ -O-4' linkages for the generation of aromatic monomers followed by the in situ depolymerization of PWB lignin. The simultaneous extraction and depolymerization of PWB lignin favors the utilization of recalcitrant pine biomass as feedstock for biorefinery schemes.

**Keywords:** Renewable biomass, Lignin, Protic ionic liquid (PIL), Sustainable biomass processing, Lignin extraction, and Depolymerization.

**Acknowledgement:** This study was supported by ERDF and the Baltic Research Programme project No. EEARESEARCH-173 "Novel biorefinery concepts for valorization of lignocellulosic residues (NoviCo)" under the EEA Grant of Iceland, Liechtenstein and Norway (Agreement No. EEZ/BPP/VIAA/2021/7).

## **Comparison of different chemical-free pretreatment methods for the production of sugars, ethanol and methane from lignocellulosic biomass**

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**Abstract:** Most pretreatment methods for lignocellulosic biomass use strong chemicals, such as sulphuric acid and ammonia, to open up the cellular structure of plant biomass. However, those chemicals are not environmentally friendly and their use leads to safety risks. As a result, different chemical-free pretreatment methods have been developed, which focus on the usage of pressure, high or low temperatures and mild chemicals. Freezing pretreatment and explosive decompression pretreatments, using different operating gases, such as nitrogen and steam, are compared in the context of glucose, ethanol and methane yield in this review. For the methane production, the stillage from bioethanol production is used. The usage of this waste improves the overall valorisation of lignocellulosic biomass. The review also investigates, whether the nitrogen explosive decompression pretreatment is suitable for the treatment of softwoods, hardwoods and herbaceous materials. In the comparison of different chemical-free pretreatment methods, it is concluded that heat and water are the most influential parameters for opening up the lignocellulosic biomass structure. The operating gas and pressure in the pretreatment reactor are less relevant. Steam explosion, nitrogen explosive decompression pretreatment and autohydrolysis pretreatment are the most suitable chemical-free pretreatment methods for lignocellulosic biomass.

**Keywords:** anaerobic digestion, biofuels, fermentation, lignocellulosic inhibitors and steam explosion.

**Acknowledgements:** We gratefully acknowledge the financial support from the base-funded project P200195 by the Estonian University of Life Sciences.

## **IV ERGONOMICS**

## **Factors for success and failure in the implementation of PPE using the example of passive exoskeletons**

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**Abstract:** The presence of numerous passive exoskeletons on the market on the one hand and the high prevalence of muscular-skeletal disorders on the other suggest their use in agriculture. Several laboratory studies prove lower muscle activity and lower discomfort in the low back region and manual handling activities in agriculture seem to be a promising area for exoskeletons to improve working conditions. This paper is a synthesis of the analysis of exoskeleton implementation trials, examples from the literature about PPE implementation strategies and an expert workshop discussing implementation success and failure factors. The aim is to develop a strategy to implement long-term studies on exoskeletons in agriculture. Among the perceived benefits of the exoskeleton trials in agriculture were early worker participation in the intervention process, while the fear of losing time, discomfort or heat stress were perceived costs of the intervention. Participatory methods should include education, selection of exoskeleton model and the free choice of participation. General barriers to exoskeleton adoption in the agricultural context such as discomfort, heat stress or reduced mobility need to be addressed together with the exoskeleton developers.

**Key words:** long-term intervention trials, MSD and prevention.

**Acknowledgements:** We would like to thank Marianne Norup from Denmark (SEGES), Arne Urskov from Denmark ([exoskeletter.dk](http://exoskeletter.dk)) and John McNamara from Ireland (TEAGASC) for their valuable contribution in the expert workshop.

## **Ergonomic load indicators and LEAN approach in work environment risk reduction and implementation of preventive measures: case study of PX company in Latvia**

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**Abstract:** Ergonomic and LEAN aims to get rid of the waste in various operations. Waste during the process of work affects safety, health, productivity, and efficiency. Organizations, to improve productivity, competitiveness, working environment and conditions, should see ergonomic and LEAN as complementary approaches. In Latvia there are not many studies about the opportunities to reduce risks at workplace and the organization of preventative events, combining ergonomic load indicators with LEAN approach.

Hence combination of Human Factor approach with LEAN methodology can significantly decrease work environment risk influence and improve worker's wellbeing, productivity and efficiency at the organizational level. The aim of the research is to study the indicators of ergonomic load in connection with the Lean approach in reducing the risks of the working environment in the company "PX" and to develop preventive measures.

In the research the monographic method was used to perform the literature analysis and worker's questionnaire was utilized. Ergonomic research methods (Key Item Method (KIM), Quick exposure check (QEC) and Ovako Working posture Assessment System (OWAS) were used to assess the ergonomic risks at the workplaces as well as LEAN methods were used, as 5S principle and Failure mode and effect analysis (FMEA).

Accordingly to the QEC method, despite the other posture indicators that were analyzed, the one of the main risk indicators for the employees of the company "PX" was stress. The work load indicator of technicians with heavy and/or oversized equipment is rated with a III risk category (KIM method results) – during the process of work there is an increased amount of physical activity and possibility of an overload. OWAS method provided essential base for determining physical load indicators at the workplace and the results mainly fall into III risk category.

In order to improve the ergonomic workload and develop practical solutions, the 5S method principles were suggested for the organization and also the FMEA analysis was performed. Recommendations based on the results of the study have been developed and the model of ergonomics indicators and LEAN approach was established during the research. Combining ergonomics load preventive measures with LEAN approach, the waste can get identified very efficiently, and ergonomic risk indicators can be determined and can be reduced significantly.

**Key words:** ergonomics, indicators, LEAN, workload and postures.

**Acknowledgments:** This research has been supported by the project "Ergonomic stress indicators in contemporary technological work environment and possibilities of its improvement in social-technical system "Human-Machine-Environment"", Agreement No. Nr.1.1.1.2/VIAA/3/19/546.

## SafeHabitus – a EU Horizons farm health and safety project

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**Abstract:** SafeHabitus is an EU Horizons funded 4-year project (2023-2026) to strengthen Farm Health and Safety Knowledge Innovation Systems (FHS KIS) and enable EU transition to social sustainability in farming. EU Horizons funding followed an EU COST Action ‘Sacurima’ and an EU- OSHA Foresight report indicating an inferior farm safety and health record to other occupational sectors. SafeHabitus is a multi-actor project involving participants from 12 Member States (MS). It consortia includes end-users, stakeholders and researchers, as well as European bodies and stakeholders with potential to influence EU policy. In addition to Work Package [WP1] on managing SafeHabitus, its specific objectives are: (1) Establish a multi-actor network of EU farmers and farm workers, farming organisations, farm advisors, policy stakeholders, researchers, and other relevant actors in national Communities of Practice (COPs) focused on co-creating knowledge and solutions that improve farmers’ and farm workers’ health, safety and quality of life [WP2]. (2) Improve the understanding and awareness by policy makers, farmer’s organisations, trade unions and health authorities of farmers’ and farm workers’ health and safety at work [WP2 - 6]. (3) Identify the implications of farmers’ and farm workers’ perceptions of their work on the future of the sector and hence on long-term food security [WP4]. (4) Explore the potential of corporate social responsibility initiatives and bottom up innovations that enhance farmer and farm worker health and safety [WP3 – 5]. (5). Develop recommendations for better performing European and national policy, and governance frameworks favouring safer and more inclusive working environments for farmers and farm workers [WP6].

**Key Words:** co-creation, community of practice and farm safety & health.



## Prevention of Occupational Diseases in the Construction Companies of Vidzeme region in Latvia

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**Abstract:** Construction is one of the leading sectors of the Latvian economy. The construction sector in Latvia, similarly as in other European Union countries and global construction industry, is undergoing significant changes. There are new requirements relating to occupational health and safety, environmental protection, energy efficiency, heritage preservation, and adaptation to modern society. The construction industry is also classified as one of the most dangerous industries in compliance with occupational health and safety requirements, therefore it is necessary to identify potential occupational safety threats and the main influencing factors. The aim of the research is to investigate the occupational diseases in the construction industry in Vidzeme region of Latvia and to develop preventive recommendations. The methods used in the research are descriptive (including monographic method) to perform the analysis of previous scientific literature research, including internet resource information and regulatory enactments. Systematic analysis was used to identify shortcomings in regulatory frameworks. A survey was developed and used to find out the opinion of construction workers in small and medium construction companies in Latvia. A statistical method of data processing was used to collect and interpret data and come up with conclusions. The study involved 326 employees from several small and medium sized construction companies from Vidzeme region of Latvia. The research results of the survey show that workers carry weights without using the right techniques, that leads to a variety of injuries and long-term occupational diseases. 25% of the respondents deny the use of assistive devices for weight lifting, but the rest of the respondents indicate that they use various aiding tools for weight lifting and moving. The most used are wheelbarrows and pallet trucks. According to the answers of construction workers, most construction workers know the best working techniques, but do not use them because they overestimate their strength or do not have the appropriate tool to move the weight. The statistical analysis of occupational diseases show that occupational diseases in the construction industry are related to diseases of the nervous system-49%, skeletal-muscular-connective tissue system diseases-28% and poisoning and other external effects-19%. In the survey of construction workers, 34% of respondents stated that they manually carry construction materials, another 19% regularly use their physical strength to lift up building materials on a daily basis. The causes of occupational diseases are related to the employers' lack of knowledge and practical skills of the employees, usually, proper weight lifting and moving techniques are shown only once during the entire working time (admitted by 67% of the surveyed workers). Research results show that the most risky professions in construction work that can cause occupational diseases are operators in concreting and reinforcing and construction and auxiliary workers. Those working in construction are informed about the risks and occurrence of occupational diseases, but 50% of survey participants regularly have a sweaty back, another 20% of respondents state that while working at the facility, one often has a sweaty head, but a quarter of the respondents admit that daily do not use assistive devices to move weights. Study concludes that it is necessary to introduce sensory clothing in the labor protection systems of the investigated construction companies and provide training for employees in correct working postures, thus promoting the reduction of injuries and occupational diseases. In the investigated companies, it is recommended to introduce smartphone apps for the posture control during the work operations. Such approach will help to reduce the spread of occupational back diseases in the future.

Key words: construction, workload, occupational disease and posture.

## **Psychoemotional Stress Influence on the Conveyor Workers: Case Study of Latvian Manufacturing Organization**

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**Abstract:** Today, employees in Latvia and in the world suffer from the negative effects of several work environment risk factors, especially psychoemotional stress. In Latvia, those employed in the processing industry sector suffer the most from static work posture, awkward movements, exposure to noise, vibrations and psycho-emotional overload. According to the data of the State Labor Inspectorate, 1,389 occupational diseases were confirmed in Latvia in 2020, but the diseases related to psychoemotional stress are not counted. Many risks and injuries in manufacturing are supposed to be related to stress at work. The aim of the study is to investigate the impact of psycho-emotional risks on the conveyor workers (hereinafter - packers) in the Latvian manufacturing company X and to develop practical recommendations for risk prevention. Altogether 21 packers of the company participated in the study. Maslach's occupational burnout questionnaire, which consists of 22 statements divided into three subscales: emotional exhaustion, depersonalization, and personal achievement scale. In this scale, respondents marked their feelings according to the frequency of their expression from 0 (never) to 6 (every day). To assess the impact of psycho-emotional risks on the workers, workability was also evaluated, determining the work ability index. Using this method, the individual working abilities of employees are evaluated with the help of a survey. Common statistical methods were used to analyze and represent the research data. The analysis of psycho-emotional stress shows that employees are basically exposed to significant mental stress during work while working at the conveyor line. Maslach's professional burnout survey proved that emotional exhaustion and depersonalization are main characteristic of employees in the age group 41-50 and 51-60 years. The majority (70%) of the surveyed employees have been found to have reduced work abilities, which is evidenced by a low level of personal achievements. Practically all responses indicate that there is a risk of monotony stress for packers. Employees indicate in the survey that they want to develop and change something in their daily work, rather than working in one profession all their lives - as a packer. As a result practical recommendations were developed for the Latvian manufacturing organization to minimize psychoemotional risk at work. Case analysis of the Latvian company proved that psychoemotional stress influences conveyor workers and has a negative effect on worker's work abilities. The developed recommendations are aimed at helping employees prevent fatigue, optimize monotonous work and reduce the risk of depersonalization for employees.

**Key words:** stress, workability, conveyor, manufacturing and workers.

**Acknowledgments:** This research has been supported by the project "Ergonomic stress indicators in contemporary technological work environment and possibilities of its improvement in social-technical system "Human-Machine-Environment"", Agreement No. Nr.1.1.1.2/VIAA/3/19/546.

## **Predictors of Safe Behaviour and Holistic Framework for Promoting Proactive Safety Culture in Healthcare and Nursing Homes**

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**Abstract:** The poor safety culture in nursing homes is attributed to the lack of professional and safety competencies, management commitment, and limited empirical data. The purpose of this study is to identify potential predictors of safe behaviour among care workers and establish a holistic framework for a proactive safety culture in healthcare and nursing homes. The study was conducted in 25 care institutions between September 2014 to December 2017 using mixed-methods with quantitative (NOSACQ-50; CCQ, COPSOQ II) and qualitative (focus-group interview) components. Results revealed challenges with safety systems and management, lack of resources and time, and the importance of leadership and psychosocial well-being. The study identified subcultures of proactive safety culture, including professional competence culture and psychosocial well-being culture. These subcultures aid in identifying weaknesses and improving quality, emphasizing the need for a holistic approach to safety culture in healthcare institutions, particularly in nursing homes. The author's proposition on positive safety culture, based on the theory of situated cognition, highlights the significance of subcultures such as professional competence culture and psychosocial well-being culture in influencing care workers' professional identity and safety behaviour. In conclusion, the importance of these subcultures can be emphasised due to ensuring adequate understanding and positive attitudes towards safety. Adequate care worker training and a culture that supports professional competence are crucial for patient safety and organizational outcomes. Addressing psychosocial risks and promoting a culture of psychosocial well-being can create a safer workplace culture and improve employee performance, job satisfaction, and overall organizational outcomes.

**Key words:** nursing homes, professional competence culture, psychosocial well-being culture, safety climate, safety culture and safety management.

**Acknowledgements:** The development of the safety culture framework was supported by Tallinn Health Care College project 1-16/61 'Proactive safety management in healthcare'.

## Sleep hygiene and psycho-emotional load for office employees

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**Abstract:** The development of technology and changes in the world have dramatically increased the psycho-emotional risk exposure for office employees. At the work with computer and digital devices in the offices, employees are exposed to several risk factors of the work environment and one of the most frequent complaints is psycho-emotional stress caused by various issues. There is no denying that sleep is one of the basic human needs, and sleep quality is important for maintaining and preserving good health and wellbeing. Sleep hygiene includes a set of various measures, such as the regularity of waking up and going to bed, that can affect and improve the quality of sleep. Sleep quality is closely related to mental health, as poor mental health can negatively affect sleep quality and vice versa. Reduced psycho-emotional stress is associated with better sleep hygiene and also good sleep hygiene is associated with reduced psycho-emotional stress. Health promotion measures and a work environment that supports sleep health could reduce psychoemotional stress experienced by employees, increase work ability, productivity and reduce the risk of accidents at the workplace. The aim of this study was to investigate psychoemotional load and sleep hygiene importance for office employees.

**Keywords:** office employees, psycho-emotional load, stress, sleep hygiene and work ability.

**Acknowledgments:** This research has been supported by the project “Ergonomic stress indicators in contemporary technological work environment and possibilities of its improvement in social-technical system “Human-Machine-Environment””, Agreement No. 1.1.1.2/VIAA/3/19/546.

## **V LIVESTOCK ENGINEERING**

## **Analysis of environmental conditions in two different Compost Bedded Pack Barn systems for dairy cattle**

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**Abstract:** The objective of this study was to analyse and compare the thermal environment of dairy cattle facilities in an open compost bedded pack barn (CBP) with natural ventilation and closed CBP (without thermal insulation) and climate control system. The research was conducted in a property located in Zona da Mata, Minas Gerais, Brazil. During the summer and for different periods of the day, the following average environmental variables observed inside the facilities were measured: dry bulb temperature, relative humidity and Temperature and Humidity Index (THI). The results were submitted to an analysis of variance to determine the significance of the variables in the different treatments. It was found that the closed and climate control system CBP promoted greater control of the facility's internal microclimate, registering smaller thermal amplitudes and a greater reduction in the animals' exposure time to stressful thermal conditions, compared to the CBP with natural ventilation. However, during summer afternoons, comfort indices indicated moderate stress. It is concluded that the closed CBP, regarding the analysed variables, indicated potential use, provided that a careful study of the climate of the region is carried out before implementation, the factors related to the ambient conditioning and better insulation of the construction are adjusted. The climatic variables inside the open CBP indicated a high stress condition for the animals, suggesting the placement of positive pressure fans and sprinklers properly distributed in the feed alley, to guarantee benefits to the entire area of the animal housing.

**Key words:** animal welfare, housing systems, livestock farming, mechanical ventilation, thermal environment.

**FUNDING:** This research was funded by CNPq, National Council for Scientific and Technological Development – Brazil (n. 422912/2018-2 and n. 150217/2021-8).

**Acknowledgements:** The authors would like to thank the Federal University of Goiás (UFG), Federal University of Viçosa (UFV), Federal University of Lavras (UFLA), and University of Firenze (UniFI), whose support is appreciated. This work was conducted with the support of the National Council for Scientific and Technological Development, Brazil (CNPq), Coordination of Superior Level Staff Improvement, Brazil (CAPES), and Research Supporting Foundation of Minas Gerais State, Brazil (FAPEMIG).

## **Analysis of scrapie resistance and productivity of latvian dark head breed old type sheep compliant to the conservation program of the genetic resources**

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**Abstract:** Since 2002, an active surveillance program for small ruminants against transmissible spongiform encephalopathy (forward TSE) diseases has been implemented in the European Union (Boelaert et al., 2016). In some countries, a very big damage to the economy was caused by the deadly sheep disease of the TSE group – Scrapie (Sawalha et al., 2007; Hautaniemi et al., 2012; McHugh et al., 2022). To realize the predisposition to this deadly sheep disease, monitoring of this disease has been carried out in Europe for several years. Such a program was introduced in Latvia in 2004, with the accession to the European Union, therefore, the monitoring of this potential disease has been carried out in Latvia for several years. In Latvia, this deadly disease has not been detected, therefore until now, few studies have been carried out about the Scrapie genotypes of the Latvian Dark Head sheep breed, and their effect on the productivity characteristics of ewes. The aim of the study is to analyse the first lambing productivity of ewes of the Latvian dark-headed old type breed depending on the Scrapie genotype. The number of ewes to be used for further breeding work is 1,531, or 97.7%. Their average age of use is 5 years, reaching an average fertility of 1.8 lambs. The average fertility of ewes divided into Scrapie genotype R1 group is 1.9 lambs, but ewes that are divided into R2 and R3 risk groups is 1.8 lambs. During the last 10 years, the implementation of the conservation program of the Latvian Dark Head breed of sheep of the old type has been successful.

**Key words:** genotype, Scrapie resistance, genetics resources, ewe's productivity and first lambing.

## Physiological and behavioural parameters of broiler chicks grown under different heating systems

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**Abstract:** This study aimed to compare the internal environment, physiological variables, and behavioural responses of chicks under two different heating systems. The experiment was performed in two commercial broiler houses located in Brazil, where 28,000 male Cobb chicks were housed during the first three weeks of life. One of the broiler houses was heated by an industrial indirect-fired biomass furnace (S1). In addition, another heating system consisting of two furnaces for indirect heating of the air using biomass (wood) as fuel, built by hand with bricks, mud, and dung on an iron structure (S2), was tested. Measurements of the dry bulb temperature ( $t_{db}$ ), dew point temperature ( $t_{dp}$ ), and relative air humidity (RH) were performed. Subsequently, the temperature-humidity index (THI) was calculated. In addition, the physiological variables of the respiratory rate (RR) and cloacal temperature ( $t_{cloacal}$ ) were measured three times a day (8:00 am, 2:00 pm, and 6:00 pm) in four chicks. The behaviours were grouped by dendrograms, in which the similarity of these data was qualified. During the second and third weeks of life, the THI values were below the recommended range. The RR and  $t_{cloacal}$  data were below the recommended comfort values, which may be an indicator that the chicks were subjected to cold conditions. Regarding their behaviour, the chicks exhibited calm, feeding, and sleepy behaviours most of the time. Problems in the heating system inside the broiler house could be observed, possibly affecting the chicks' thermal comfort and welfare, which consequently can result in productive and economic losses.

**Key words:** chicks, behaviour, cloacal temperature, respiratory rate and thermal comfort.

**Acknowledgements:** The authors would like to thank the Federal University of Lavras (UFLA), and University of Firenze (UniFI), whose support is appreciated.



## **Automatic Monitoring of dairy cows' lying behaviour using a computer vision system in open barns**

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**Abstract:** Precision Livestock Farming offers opportunities for automated, continuous monitoring of animals, their productivity, welfare and health. The video-based assessment of animal behaviour is an automated, non-invasive and promising application. The aim of this study is to identify possible parameters in dairy cows' lying behaviour that are the basis for a holistic computer vision-based system to assess animal health and welfare. Based on expert interviews and a literature review, we define parameters and their optimum in form of gold standards to evaluate lying behaviour automatically. These include quantitative parameters such as daily lying time, lying period length, lying period frequency and qualitative parameters such as extension of the front and hind legs, standing in the lying cubicles, or total lateral position. The lying behaviour is an example within the research context for the development of a computer vision-based tool for automated detection of animal behaviour and appropriate housing design.

**Key words:** animal welfare; computer vision; dairy cow monitoring, lying behaviour and Precision Livestock Farming.

**Acknowledgements:** The project is supported by funds of the Federal Ministry of Food and Agriculture (BMEL) based on a decision of the Parliament of the Federal Republic of Germany. The Federal Office for Agriculture and Food (BLE) provides coordinating support for artificial intelligence (AI) in agriculture as funding organisation, grant number 28DK110A20.

## **A Cost-Effective Imaging System for Monitoring Poultry Behaviour in Small-Scale Kenyan Poultry Sheds**

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**Abstract:** The objective of this paper was to develop a low-cost prototype poultry behaviour imaging and analysis system for monitoring intensively-reared flocks suitable for small-scale Kenyan poultry sheds. An image processing and analysis programme was developed using Python programming language and the OpenCV image processing package. This was tested on overhead images of Ross 308 birds collected over a number of days using a Raspberry Pi V2 camera. A second experiment using toy-chicks was conducted with an angled camera (Wansview W3). Linear transformation (LT) and background subtraction (BS) methods were applied and compared for effectiveness at detecting yellow and brown toy-chicks on woodchip bedding. Perspective transformation (PT) was applied and evaluated for its ability to transform the angled images into two-dimensional views. In the first experiment, where white birds were detected against a dark background, LT object detection successfully detected 99.8% of birds in the sampled images. However, in the second experiment, the LT method was just 56.5% effective at detecting the yellow toy-chicks against the light-coloured background. In contrast, the BS method was more effective, detecting 91.5% of the yellow toy-chicks. The results showed that BS detection success was worse for yellow toy-chicks in the far section, detecting 83% as opposed to 100% of those in the near-section. Edge processing of the image processing algorithm was tested on a Raspberry Pi 3 series B+ computer. This prototype provides a solid foundation for further development and testing of low-cost, automated poultry monitoring systems capable of reporting on thermal comfort inferred from cluster index.

**Key words:** background subtraction, cluster index, image processing, linear transformation and poultry.

**Acknowledgements:** This work has been funded by Innovate UK (grant No 47972) and USOMI Ltd. The authors would like to thank Matthew Butler, Richard James, Denis Mujibi, John Bosco and Albert Lumumba for their kind help and support.

## **Compost barn system and its influence on the environment, comfort and welfare of dairy cattle**

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**Abstract:** The aim of this study was to evaluate the effect of the thermal environment on behavioral and physiological parameters of crossbred cows of different productivity levels confined in a compost barn system. For this, air temperature ( $T_{db}$ ) and relative humidity (RH) data were measured using sensors/registers and wind speed ( $V_{air}$ ) was recorded with the aid of an anemometer. Subsequently, these data were used to calculate the Temperature and Humidity Index (THI). Bedding material variables (pH and humidity) were also evaluated. The animals were evaluated for physiological variables (respiratory rate – RR and surface temperature – ST), scores (body condition, locomotion and dirt) and behavior. The analyses were carried out on two groups of cows (Group 1: high production vs. Group 2: medium and low production). The average pH of the bedding material was 8.5, within the recommended range. In the case of the physiological responses of the cows, the respiratory rate (RR) of Group 1 indicated better conditions of thermal comfort in the morning vs. the afternoon. The system was efficient in both groups based on body condition score, indicating favorable conditions for the health of the animals. Regarding the behavioral evaluation, Group 1 and 2 were statistically similar and had the longest rumination times, in relation to the other evaluated behaviors. Regarding active periods, medium production were the most active. Regarding idle time, low production spent more time idle than the other animals.

**Key words:** dairy cattle, animal welfare and installations.

**Acknowledgements:** This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior – Brazil (CAPES) – Finance Code 001.

## Potassium Humate in the Feed of Dairy Cows

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**Abstract:** The growing demand of livestock farmers for food additives of natural origin in animal nutrition, led to the research on raw materials from Latvian natural resources. Trials were carried out in the farm “Dukati”, Vitinu Parish, Auce Municipality. Holstein-Friesian Black-and-White cows were selected for the research and assigned by the analogy principle to two treatments groups: trial (T) and control (C); each group consisted of 15 dairy cows. The cows were kept untethered in one common space of the shed. The trial group received potassium humate, which was calculated as 7 g per day per cow in the animal feed that the cows received in the milking robot. During the trial, the yield of the cows from the trial group was from 0.20 kg to 3.47 kg higher on average compared to the control group. In addition, the difference in the yield of the trial group showed an increasing trend ( $P < 0.05$ ). The fat content in milk in both groups of cows tended to increase compared to the beginning of the trial. It should be noted that in the middle of the trial, in the case of the trial group, the fat content in the milk was slightly higher than in the control group. At the end of the trial, if compared to the beginning of the trial, the protein content in the milk of the trial group was higher by 0.15%, and it was by 0.21% higher than in the milk of the control group ( $P < 0.05$ ).

**Key words:** dairy cows, potassium humate, productivity and milk quality.

**Acknowledgements:** The research was done with the financial support of project No.19-00-A01620-000076 “Testing of new feed ingredients from Latvian black peat – potassium humate – included into diets for dairy cows” funded by the Ministry of Agriculture and the Rural Support Service and implemented under the EU EAFRD and the Rural Development Programme of Latvia for 2014-2020, measure 16 Cooperation, sub-measure 16.2 Support for the development of new products, methods, processes and technologies.

## Comparison of sire rams of the Latvian Dark-Head breed according to feed efficiency indicators as the beginning of genomic breeding research

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**Abstract:** In sheep (*Ovis aries*) farming, feed costs are the largest variable cost component. Breeders are showing an increased interest in breeding sire rams with improved feed efficiency characteristics because of the possibility that the offspring will have a higher value of this indicator. The result shows that for one ram, the progeny indicators tend to be variable. Currently, no marker has successfully explained enough of the variability of feed efficiency that they were used as part of a routine improvement program. The aim is to analyze feed efficiency indicators for lambs of sire rams of Latvian Dark-Head (LT; Latvijas tumšgalve) to identify sire rams producing lambs with potentially higher feed efficiency. Fattening data of 48 lambs from 13 sire rams were analyzed to determine the correlation of feed efficiency parameters. The average weight of lambs at birth was  $4.08 \pm 0.56$  kg, while the average weight gain reached  $47.43 \pm 3.17$  kg with an average fattening period of  $73.27 \pm 8.90$  days. A strong and very strong correlation between the studied indicators of feed efficiency was revealed. The correlation between these indicators and live weight gain over for 60 days indicates their economic importance in meat production. Certain phenotypic and genotypic factors cause the influence on their value. The phenotypic influence may consist of environmental and external signs, but the genotypic influence is at the DNA level, which requires further study.

**Key words:** Feed efficiency, lambs, Latvian Dark-Head, selection and sire rams.

**Acknowledgements:** The study was funded by LZP-2021/1-0489 project: "Development of an innovative approach to identify biological determinants involved in the between-animal variation in feed efficiency in sheep farming."

## **Feed efficiency indicators and hormones related to nutrient metabolism in intensive fattened lambs of sire rams of different sheep breeds in Latvia**

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**Abstract:** The feed efficiency increase of each sheep indicates its profitability. Production costs and the environmental impact of animal husbandry are reduced as feed efficiency improves. The gastrointestinal tract is a source of hormones and is important in regulating feed intake and nutrient utilization. The study analyses the relationship between feed efficiency indicators and hormone levels in Latvian sheep breeds. After control fattening, blood samples were taken from 76 lambs, representatives of six Latvian breeds, for seven hormonal analyzes and seven feed efficiency indicators. Feed efficiency, Feed conversion ratio (FCR), Relative growth rate, Kleiber ratio (KR), Residual feed intake (RFI), Residual weight gain, and Residual intake were calculated from daily weight gain and amount of dry matter. Interbreed differences and relationships between indicators/hormones were identified. The best scores of feed efficiency were found for the lamb rams of the Dorper breed; the Latvian black-head was the second according to these indicators. The mean FRC for lambs was determined to be  $5.13 \pm 0.13$  kg with a range of 2.98–10.15 kg; the mean KR was  $18.11 \pm 0.39$  with a range of 8.78–26.88; the mean RFI was in the range of -0.51 to 0.42 kg. A statistically significant difference was found between the breeds for all feed efficiency indicators. Biochemical parameters (IGF-1, insulin, and glucose) were found to be in correlation with feed efficiency indicators. Our results show that Latvian sheep breeds differ in fattening performance. To improve breeds without crossing them, subsequent genetic analysis of breed differences is necessary.

**Key words:** Breeding, fattening, feed efficiency, hormones and Latvian sheep.

**Acknowledgements:** The study was funded by LZP-2021/1-0489 project: "Development of an innovative approach to identify biological determinants involved in the between-animal variation in feed efficiency in sheep farming."

## **VI PRECISION AGRICULTURE**

## Application of UAV multispectral imaging for determining the characteristics of maize vegetation

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**Abstract:** Interest in forage maize (*Zea mays L.*) cultivation for livestock feed has grown in northern conditions. In addition, it is important to develop methods and tools to monitor crop development and other characteristics of the crop. For these purposes UAVs are very efficient and versatile tools. UAVs can be equipped with a variety of sensors like lidar or different types of cameras. Several studies have been conducted where data collected by UAVs are used to estimate different crop properties like yield and biomass. In this research, a forage maize field experiment was studied to examine how well the aerial multispectral data correlated with the different properties of the vegetation. The field test site is located in Helsinki, Finland. A multispectral camera (MicaSense Rededge 3) was used to take images from five spectral bands (Red, Green, Blue, Rededge and NIR). All the images were processed with Pix4D software to generate orthomosaic images. Several vegetation indices were calculated from the five spectral bands. During the growing season, crop height, chlorophyll content, leaf area index (LAI), fresh and dry matter biomass were measured from the vegetation. From the five spectral bands, Rededge had the highest correlation with fresh biomass ( $R^2 = 0.273$ ). The highest correlation for a vegetation index was found between NDRE and chlorophyll content ( $R^2 = 0.809$ ). A multiple linear regression (MLR) model using selected spectral bands and vegetation indices as inputs showed high correlations with the field measurements.

**Key words:** agriculture, maize, multispectral images, UAV and vegetation index.

**Acknowledgements:** The research project was funded by the Maatalouskoneiden tutkimussäätiö (Agricultural Machinery Research Foundation). The field experiment was part of MAKERA –funded project “Tulevaisuuden kestävät karkearehuvallinnat”.



## Using multi-frequency electrical conductivity measurement to determine the selective salinity in a two-component salt solution

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**Abstract:** Digital technologies can help farmers produce safe, sustainable, high-quality food while contributing to the fight against effects of abiotic and edaphic factors. Due to digitalization, a paradigm shift occurred in agriculture, which boosted sensor technology's rapid development, especially soil sensors. Using sensors and the digital knowledge of soil properties, farmers can better understand the needs of the fields and cultivated plants on a micro-scale, thereby saving resources and putting less strain on our environment. The relative salinity of our soils is an important aspect because of the impact on production costs and yield. The future of site-specific crop production is moving towards a sensor-based on-the-go measurement approach because obtaining important soil characteristics quickly and cheaply is still one of the biggest challenges in precision agriculture today. Measuring soil electrical conductivity (EC) could offer an opportunity to overcome these limitations if the different salt components of soil could be separated by analytical methods. In our study, we present a calibration model based on conductometry with which the selective potassium and calcium content can be determined in the laboratory under controlled conditions. Solutions containing  $K^+$  and  $Ca^{2+}$  cations in the concentration determined in the experimental model were mixed and measured by changing the frequency of the measuring current. In this study, measurements proved that a mathematical relationship can be used to describe the relationship between the composition and concentration of the two-component solution, the measurement frequency and the conductivity. The potassium (K) and calcium (Ca) content of the solution can be separated from each other, and a regression calibration curve can be recorded, from which the proportion of potassium and calcium in the given solution can be determined as a function.

**Key words:** multi-frequency, electrical conductivity, soil salinity, digital agriculture, soil sensor

**Acknowledgements:** The authors would like to acknowledge the Hungarian University of Agriculture and Life Sciences, Institute of Technology for the financial support and for providing facilities and infrastructure that enabled this research to be conducted.

## Importance of GIS solutions for beekeepers: a review

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**Abstract:** In today's realities, beekeeping encounters a number of different challenges, including the lack of suitable areas, urbanisation, intensive farming methods etc. In order to meet the current needs, modern beekeeping uses various information technology solutions that support beekeepers in their activities. Among such solutions, the use of geographic information systems and spatial data is relevant. At the time of writing this work, its authors are developing software solution for beekeepers based on Geographic Information System (GIS) and an interactive map within the scientific project named Hiveopolis. To further develop this solution, it is necessary to investigate the current situation related to issues in modern beekeeping and the solutions already available. In this study, a detailed review of solutions was carried out, which, according to the authors, are the most similar in subject matter to their developed solution. During the review, the authors studied the actual problems of beekeeping solved with the help of the considered solutions, and also provided possible ways to improve existing solutions, presenting their developed system. As a result, the study confirmed the relevance of this direction, and also made it possible to identify challenges for beekeeping and possible improvements to existing solutions.

**Key words:** GIS, precision beekeeping, pollinators, decision making, data and Hiveopolis.

**Acknowledgments:** Hiveopolis project has received funding from the European Union's Horizon 2020 research and innovation programmes under grant agreement No. 824069.

## Development of a custom-built RTK-GNSS positioning system for agricultural operations

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**Abstract:** The objective of this research is to assess the positioning accuracy when using a custom built RTK (Real Time Kinematic) station. Setting up a RTK base station with open-source tools is rather straightforward process requiring only few components and basic programming skills. The base station and receiver unit were developed by using a SparkFun GPS-RTK2 Board with U-Blox ZED-F9P module. The board was paired with U-blox Multi band GNSS antenna. The board can use GNSS (Global Navigation Satellite System) satellite signals from Galileo, BeiDou, Glonass and GPS systems. The positioning accuracy was evaluated in various fixed position situations and with the RTK signal during operations in agricultural fields. The RTK correction signal was used in connection with soil scanning measurements in different crop fields of the Viikki Research Farm of the University of Helsinki. For accuracy comparison, measurements were carried out with a commercial network RTK (NRTK) correction signal. The vertical and horizontal accuracy of the positioning signal was evaluated based on the accuracy variables calculated by the receiver. The vertical accuracy was also evaluated by mapping the scanned trajectory on the height map which was obtained from NSL (National Land Survey of Finland) open map data service. The custom-built RTK positioning system accuracy was considered generally precise enough for autonomous field work, but the reliability of the observed accuracy should be confirmed with more extensive measurements. The commercial NRTK signal accuracy was considered very good and reliable also for the vertical direction.

**Key words:** satellite navigation, positioning accuracy, real time kinematics, RTK-station and precision farming.

**Acknowledgements:** This research was funded by the Henry Ford Foundation in Finland.

## **Increasing the sustainability of vegetable crops production by using intercropping**

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**Abstract:** Some scientific reports support the idea of using plant interactions to promote the growth and yielding of vegetable crops. The plant interactions in vegetable production under intercropping conditions were investigated in ERDF funded project “Elaboration of environment-friendly crop growing technologies identified by the Green Deal and their implementation in horticultural production in Latvia (GreenHort)” implemented in Latvia Institute of Horticulture with the aim to introduce strip cropping in the vegetable production. The investigations were carried out at the Institute of Horticulture, Latvia (57°03’44.6’’N, 22°54’53.2’’E), during the growing seasons of 2021 and 2022. The vegetable crops (carrots, cabbage, onions, and pumpkins) were grown in intercropping with agroecological service plants or aromatic plants as companion plants (white clover, marigolds, tagetes, lavender, sage, coriander). The investigated variants were compared with the control, where vegetable crops were grown in monoculture as usual. Each intercrop variant consists of 7 alternating rows (each 0.6 m wide) – 4 rows of service crop and 3 rows of vegetable. There was observed significant influence of the growing system on the plants productivity. The sharpest differences between variants were observed for cabbage – marigold, sage and lavender had a positive influence on the cabbage yield formation, but white clover had an extremely negative influence on the cabbage plant growth. White clover had a negative influence also on carrot and pumpkin productivity. Sage had a yield-promoting influence on the carrot crop. There was not found any significant influence of the agroecological crops on onion productivity.

**Key words:** cabbage, carrot, onion, and strip cropping.

**Acknowledgements:** This study was supported by European Regional Development Fund, Project Nr. Nr.1.1.1.1/20/A/169 “Elaboration of environment-friendly crop growing technologies identified by the Green Deal and their implementation in horticultural production in Latvia (GreenHort)”.

## The content of mobile aluminium compounds depending on the long-term use of various fertilizing and liming systems of Albic Pantostagnic Luvisol

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**Abstract:** Today, climate change is exacerbating the problems of efficient and environmentally friendly use of acidic soils, which are widespread in Ukraine. At the same time, the role of mobile aluminium compounds in acidity formation is also becoming increasingly important. In this regard, chemical amelioration remains a primary and very important factor in the system of resource-saving and environmentally friendly agricultural measures for the efficient and balanced use of acidic soils. Therefore, the main objective of the research is to establish scientifically sound doses of chemical ameliorant that reduce the content of mobile aluminium compounds and ensure environmental safety and high productivity of agrocenoses on Albic Pantostagnic Luvisol. The research was carried out in a long-term stationary experiment established in 1965 with different doses of mineral fertilisers, manure and lime on an Albic Stagnic Luvisol. It was found that with a prolonged application of mineral fertilisers and the use of this soil without fertilisers, the content of mobile aluminium compounds at the end of the X rotation at pH<sub>KCl</sub> 4.20 and 4.42 was 68.4 and 58.5 mg kg<sup>-1</sup> respectively. Under the organo-mineral and mineral fertilisation systems with liming with 6.0 t ha<sup>-1</sup> of CaCO<sub>3</sub> calculated by hydrolytic acidity, the content of mobile aluminium compounds decreased to 7.2 and 6.7 mg kg<sup>-1</sup> of soil respectively. Under identical fertilisation systems with a lime application by pH-buffering capacity (2.5 t ha<sup>-1</sup> CaCO<sub>3</sub>), the content of mobile aluminium compounds is 10.8-10.0 mg kg<sup>-1</sup> soil.

**Key words:** acidity, aluminium, Albic Pantostagnic Luvisol, fertilizers, and liming.

**Acknowledgements:** This study was financed by the National Academy of Agrarian Sciences of Ukraine (NAAS).

## **The selection of maize parent lines within marker assisted selection (MAS) by crtRB1-3'TE marker for Steppe zone of Ukraine**

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**Abstract.** Maize has a large genotypic diversity and a broad scale of economically important traits. Therefore, it is extremely important for breeding to obtain hybrids which can ensure high yield even under severe growing conditions, such as in Steppe zone of Ukraine. This study aimed to determine the optimal allele ratio by crtRB1-3'TE marker in parental components of maize modified hybrids. There were investigated four hundred sixteen maize hybrids which are modified hybrids of heterotic model (Iodent × Iodent) × Lancaster germplasm. SCA (specific combining ability) effects for grain yield and grain moisture content were calculated in maize hybrids with different allele combinations of crtRB1 gene. As results, the stable positive SCA effects were calculated for hybrids with allele combination (296 bp + 875 bp) × 543 bp × 296+875 bp during both 2019 and 2020 (1.23 and 0.99 t ha<sup>-1</sup>, respectively). The lowest SCA effects for grain moisture content were obtained for modified hybrids with allele combination (543 bp × 543) × 296 + 875 bp both in 2019 and 2020 (−0.54 and −0.36%, respectively). The greatest influence SCA effects for grain yield had the interaction of allele combinations and year weather conditions (39%), the impact the allele combinations was 36%. The year weather conditions had the greatest impact on SCA effects for grain moisture content (44%), the allele combination (36%). Thus, it was determined that SCA effects for studied indicators of heterotic model (Iodent × Iodent) × Lancaster under contrasting weather condition are resulted from both genotypes of hybrid parents and favourable allele presence.

**Key words:** *Zea mays* L., carotenoids, crtRB1 gene, favourable allele and SCA effects.

## Measuring and alleviating drought stress in pea and lentil

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**Abstract:** Water deficit in the soil can cause drought stress in plants and drastically affect plant growth and crop yield. Therefore, early detection of drought stress in plants followed by the timely application of agronomic measures to alleviate plant conditions is crucial. This research aimed to study the agronomic practices that could reduce the sensitivity of pea and lentil to drought stress. The practices included (i) soil amendment with moisture retainer (hydrogel), (ii) seed treatment with a growth regulator to promote root formation, (iii) application of a biological formulation to boost soil mycorrhizal biota, and (iv) foliar application of micro fertilisers. The research was carried out in Ukraine in 2015–2020. Drought stress in plants was detected by measuring chlorophyll fluorescence with a portable fluorometer Floratest and calculating the ratio of variable to maximum fluorescence  $F_v/F_m$  of the photosystem. The content of proline, high values of which in vegetative organs point out to stress in plants, was determined by colorimetric analysis using ninhydrin. In pea, the incorporation of hydrogel (Aquasorb) and growth regulator (Mycofriend) combined with seed treatment (Kelpak SC) and foliar application of micro fertiliser (Biovit or Freya-Aqua Legumes) at BBCH 14 led to obtaining  $F_v/F_m$  values from 0.81 to 0.82. Similarly in lentil, the maximum value of  $F_v/F_m$  (0.67) was obtained with the application of all studied agronomic practices, with the correlation coefficient between yield and  $F_v/F_m$  at the flowering stage (BBCH 61)  $r = 0.97$ . In pea, the correlation between yield and  $F_v/F_m$  at the budding stage (BBCH 51) was  $r = 0.99$ . The content of proline in photosynthetic plant organs was species-specific; however, in the control treatment, where plants were exposed to drought, its maximum value was  $1.10 \mu\text{mol g}^{-1}$  in pea and  $1.40 \mu\text{mol g}^{-1}$  in lentil, while with the application of the proposed agronomic practices proline content was only  $0.56 \mu\text{mol g}^{-1}$  in pea and  $0.36 \mu\text{mol g}^{-1}$  in lentil. Obtained strong correlation between proline content in plant vegetative organs and the ratio of variable to maximum fluorescence  $F_v/F_m$  of the plant photosystem indicates that measurement of  $F_v/F_m$  with portable fluorometer might be an effective method of early identification of drought stress in pea and lentil.

**Key words:** chlorophyll fluorescence, portable fluorometer, hydrogel, growth regulator and micro fertiliser.

## Carbon and Nitrogen Uptake in Above- and Below-ground Biomass of Cereal Crops in the Integrated Farming System

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**Abstract:** A significant reduction in greenhouse gas (GHG) emissions, as well as technologies that ensure removal of CO<sub>2</sub> from the atmosphere, are necessary to achieve the set goals for the transition to carbon neutrality. During the crop growth cycle, a significant amount of biomass is produced, and carbon (C) and nitrogen (N) are captured both by the harvested crop removed from the field and by residues left on the field. The trials were conducted to find out patterns between crop and residues while trying to figure out the amount of captured C and N. In this study data of the most widely grown cereal crops in Latvia are summarized. The data are representative, obtained in different agroclimatic conditions, they vary both by species and variety, by year and fertilizers applied. The mean amount of biomass from cereal crops left on the field was 1070.9 g m<sup>-2</sup> DM, besides, 906.7 g m<sup>-2</sup> of that was made up of above-ground (AG) residues and 164.2 g m<sup>-2</sup> of below-ground (BG) residues. On average, 471.8 g m<sup>-2</sup> C and 14.3 g m<sup>-2</sup> N were captured, including: 411.2 g m<sup>-2</sup> C and 12.9 g m<sup>-2</sup> N by AG residues; 60.7 g m<sup>-2</sup> C and 1.4 g m<sup>-2</sup> N by BG residues. Regularities between grain yield and residues were found, however, they were not very strong. The dataset should be enlarged to reduce uncertainty. As the data calculated from crop have a greater uncertainty, the GHG inventory should be calculated according to the average AG and BG biomass, which provide more accurate data.

**Key words:** cereal crops, crop residues, harvest index and shoot/root ratio.

**Funding:** This research was funded by European Regional Development Fund: project No. 1.1.1.1/21/A/031 “Evaluation of factors affecting greenhouse gas (GHG) emissions reduction potential in cropland and grassland with organic soils”.

**Acknowledgements:** Contribution of A. Zuševica is funded by European Regional Development Fund project “Evaluation of climate change mitigation options in drainage systems in croplands and grasslands” (No. 1.1.1.1/21/A/030). We are thankful to the project “Improvement of the GHG emissions and CO<sub>2</sub> removals accounting system for management of arable land and grasslands and the development of appropriate methodological solutions” (No. 10 9.1-11/21/1825-e) for support in acquisition of activity data.



## **Spatial and temporal variability of productivity of coffee plants grown in an experimental field located in Três Pontas, Brazil**

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**Abstract:** The coffee grower seeks to increase productivity, as well as reduce the operating costs of his crop. Precision Agriculture (PA) is composed of a cycle of tools and technologies that can bring a good return to coffee growers, seeking to optimize production processes, bringing better yields and minimizing costs. Therefore, the objective of this research is to evaluate the space-time behavior of productivity in a coffee plantation, aiming to apply AP techniques. The study was carried out in a coffee plantation of the species (*Coffea arabica*), cultivar Topázio MG1190, located in the municipality of Três Pontas, Brazil, with an area of 1.2 ha. With the aid of a GNSS RTK, 30 plants were georeferenced, from which their yields were later sampled in the years 2020, 2021 and 2022. The collected data were evaluated in two statistical processes in the RStudio software. The first stage consisted of a one-way analysis of variance with repeated measures, from the results it is concluded that there are differences between the production averages when buying the productivity of the years 2020, 2021 and 2022 and, in addition, the coefficient of variation for the three sets of samples was quite high ( $CV > 30\%$ ) indicating a heterogeneity between the data. The second stage consisted of a geostatistical analysis the data were fitted in a model and interpolated by ordinary kriging; the result was maps of spatial variability. Through these maps it was possible to evaluate the behavior of productivity spatially and temporally, as well as to quantify areas that had higher and lower levels of this attribute. It is concluded that productivity, even in the case of such a small productive area, can vary substantially in space and time, and the use of PA can help producers in decision making regarding management.

**Key words:** biennial, geostatistics and precision agriculture in coffee trees.

## **Diversified cropping systems for promoting the beneficial insects – ground beetles (*Coleoptera: Carabidae*)**

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**Abstract:** In agro-ecosystems ground beetles – carabids (*Coleoptera: Carabidae*) are important as generalist predators of invertebrate pests and weed seeds and as prey for larger animals. This way they contribute to biodiversity and influence the most important ecological processes. Impacts of crop management practices on the carabids are not well described. Carabids were studied in winter wheat which is one crop in the rotation experiment (barley undersown with clover-clover-winter wheat-pea-potato). Carabids were collected with pitfall trap during one week at the end of June 2022. In laboratory, their species was identified. Trapping of carabids during the spiking phase of winter wheat has shown significant differences in carabids activity-density and diversity depending on five different cropping systems. In two conventional systems where pesticides were used the number of carabids was two times smaller in comparison with three organic systems. Activity-density and diversity of carabids was significantly higher in all organic systems and especially in Org II system where winter cover crops and composted manure were used for rotation diversification. The Shannon–Wiener index values, which takes into account the number of species and their relative abundance were 1.24–1.53 in conventional systems, but higher in diversified organic systems (1.60–1.78). Only in organic systems Org I and Org II there were very rare species present, like *Acupalpus meridianus* (Linnaeus) and *Microlestes minutulus* (Goeze). In diversified organic systems the higher activity-density and abundance of carabids could be explained by the diverse plant community as possible source for better food and microclimatic conditions.

**Key words:** organic cropping, winter cover crops, conventional cropping, pesticides and weed.

**Acknowledgements:** The article has been completed with the support of the ERA-NET Core organic FertilCrop, ERA Net Core Organic ALL-Organic projects and grant PRG1949.

## Effect of saptopel fertilizer on the quality of the yield of some field crops

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**Abstract:** Saptopel is specific water body sediments containing a high level of organic matter formed from remains of water biota mixed with mineral components. One of the most promising utilisation ways of saptopel is agriculture where it can be used as soil amendment to improve soil physical properties and thus obtain economically viable and high quality yield of field crops. For three years the experiments were conducted at Priekuli Research Centre of the Institute of Agricultural Resources and Economics. Dehydrated saptopel mass from Lake Bizas was studied as soil biological fertilizer to determine its suitability for use in field crop production. Researches were carried out in organic crop rotation, in the fields of potato, winter rye and field bean. Three different doses of saptopel fertilizer were applied. During the three-year period (2020-2022), the yield indicators of the plant species included in the study were evaluated, and the quality of the yield of these species was assessed. The results of research confirm the positive effect of saptopel on yield quality indicators – protein (field beans), starch (potatoes) falling number and 1000 seed mass (winter rye).

**Key words:** faba bean, saptopel, organic fertilizer, potato and winter rye.

**Acknowledgements:** The research received funding from the EU EAFRD Research application “Study of application of an innovative dehydration technology in saptopel production, application options of the products, produced on the basis of saptopel, in crop and livestock farming” (No. 18-00-A01612-000010).

## **VII RENEWABLE ENERGY**

## Analysis of NO<sub>x</sub> conversion using carbon catalyst

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**Abstract:** Burning fuel releases combustion products into the environment, which contain a wide range of harmful substances, such as nitrogen oxides (NO<sub>x</sub>) and carbon monoxide (CO). One of the ways to reduce harmful substances is to use catalysts. Catalysts are usually made of precious metals, but charcoal can also be used as a catalyst or as reactant. The use of charcoal, which is produced from biomass as a residual product of wood fuel combustion, to reduce NO<sub>x</sub> emissions instead of ammonia or urea, makes this NO decomposition process ecological. The aim of this scientific work is to investigate charcoal as a catalytic and reactant element. Real combustion products from a water heating boiler are used for the research. During the research, the effectiveness of charcoal elements in reducing CO and NO<sub>x</sub> concentrations in combustion products is determined. What temperatures are needed so that charcoal as a catalyst gives the best results are investigated. How the catalyst works at different CO concentrations is investigated. Are investigated how effective can be used charcoal as reactant. To achieve maximum NO<sub>x</sub> reduction efficiency using charcoal, a certain CO concentration must be ensured without the use of additional reagents. With charcoal, the concentration of O<sub>2</sub> in flue gases is less important, because in the presence of O<sub>2</sub> in the flue gas, the oxygen reacts with the charcoal to release CO. However, this reaction is strongly influenced by temperature. If all the above-mentioned factors are properly evaluated, charcoal would reduce excess oxygen and increase CO release, which is necessary for the decomposition of NO into N<sub>2</sub> and NO pollution reduction. Combustion composition studies were performed at different temperatures, with carbon loading. The research results show that at a temperature of 400o C the reduction of NO reaches about 59%. After reaching about 500o C, the reduction of NO reaches about 63%. As the temperature increases, NO decreases to a maximum - after reaching 600o C, the NO decrease reaches 83%. After conducting experimental studies, the effectiveness of pollutant reduction is determined depending on the temperature of the combustion products, the flow rate, the initial concentrations of individual gas components and the type of material under investigation. To study the influence of many and varied variables, the goal is to create an optimal design of experiments, according to which the most information can be obtained. The results of experiments are very promising – charcoal as a reactant can be very effective – all the results showed more than 50% NO<sub>x</sub> reduction. Charcoal is an attractive choice, due to its economic and ecological aspects. More experiments will be held to investigate the possibility of using charcoal as catalyst for NO<sub>x</sub> reduction.

**Key words:** combustion, NO<sub>x</sub> formation, catalyst and charcoal.

**Acknowledgments:** Kaunas University of Technology.

## Analysis of the Power Balance of a Solar Catamaran

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**Abstract:** Significant changes are expected in the percentage distribution of vehicles in the world over the next decade. It is planned to gradually replace conventional internal combustion vehicles with electric drive ones, thereby reducing environment impacts and the production of gases contributing to the greenhouse effect. It is necessary to foster similar trends regarding watercraft, replacing the internal combustion engines with electric motors. An experiment used a solar-powered catamaran equipped with a standard electric motor Minn Kota Endura 34, a 450 W monocrystalline solar cell and a 40 Ah lithium iron 12 V battery. A pyranometer was used to measure solar energy. The experiment used a data logger GL 220 that measured the energy flow to the battery and the electric motor. The experiment was conducted in Jelgava on 5 July 2022, with the maximum altitude of the sun reaching 56.7°. The experiment identified that at an average solar intensity of 500 W m<sup>-2</sup> on a sunny day, the solar catamaran could be moved by means of solar energy without discharging the batteries at all power settings.

**Key words:** charging, motor power, solar intensity, solar catamaran and solar panel power.

## **The Role of Energy Management in the Agricultural Sector: Key Prerequisites and Impacts**

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**Abstract:** Agriculture is one of the most energy-consuming sectors in the EU's economy. Implementing sustainable agriculture to reduce GHG emissions and increase energy efficiency through energy management is a crucial strategy to tackle climate change. In this paper, the role of energy management in the agricultural sector is studied, and experiences from Europe and the world have been considered. Literature analysis regarding the chosen topic has been conducted, including the methodology of energy management plan development and its implementation in the case study of Latvia. Data from Latvia's agricultural and other sectors have been analysed and compared. Latvia's Inventory Report regarding GHG emissions in the agricultural sector was reviewed, and all emission sources in the agricultural sector were highlighted. The primary purpose of the study is to find out if energy management were introduced in an agricultural company, what would be the potential GHG emission, energy savings and additional advantages. Two companies working in Latvia were surveyed, and potential emission and energy consumption reduction measures in agriculture that would be applied to companies were developed. The research showed that by implementing the basic principles of energy management, it would be possible to reduce the average energy consumption by 17%. If measures are applied to reduce GHG emissions from agricultural companies, the average emissions would be reduced by 43%.

**Keywords:** Agriculture, Benchmarking, Indicators, Energy efficiency, GHG emissions and Sustainability.

**Acknowledgement:** This research is funded by the Latvian Council of Science, project CO2 Deal: Effective Valorisation of CO2 for Decarbonised Regional Development, project No. lzp-2020/1-0302.

## **An Analysis on Hybrid Renewable Energy Potentials in Ogun State, Nigeria**

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**Abstract:** The geographical location of Ogun State, Nigeria bequeaths it with diverse renewable sources that can be harnessed for the benefits of its citizens. This study evaluates the State's energy sources endowment and the potentials for hybridization to achieve energy sufficiency. The methodology of the study involved comprehensive literature review and experiential knowledge garnered through many years of research tours throughout the state. Results of the study showed availability of abundant sunshine for solar power, sizable rivers with suitable topography for mini hydro, and large amounts of biomass from forest industry wastes, agricultural wastes and household wastes that are utilizable for the production of biofuels and other bio-based commodities. Outcomes of this research would be found useful by existing and would-be energy producers, investors and governmental agencies that are intending to diversify their energy mix.

**Key words:** Bioenergy, Hybrid Energy System, Hydro, Renewable Energy, Solar Energy, Sustainable Energy and Wind Energy.



## **Psychrophilic plug-flow digester with assisted solar heat – small-scale system feasibility**

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**Abstract:** Paper discusses using a low-temperature biogas reactor with a solar support system technology as a management tool of biodegradable waste in small scale. A feasibility study looks at primary factors affecting anaerobic digestion process and solar heat production, design examination of a solar heating for anaerobic digester and possible technology application, also defines the multilocality of biogas, illustrates diffusion of innovation for diversification of biogas production. Analysis confirms solar heat increases efficiency and production of biogas, decreases costs and toxicity of digestate. Results show that for implementation of technology in rural areas further research in socio-economic, sourcing of feedstock and customization is needed.

**Key words:** plug-flow, anaerobic digester, solar heat, low-temperature, multilocal.

## **VIII FOOD SCIENCE & TECHNOLOGY**

## Evaluation of fatty acids composition in amaranth pasta for a vegan diet

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**Abstract:** The growing interest of consumers in vegan products creates a demand for new nutritious products. Amaranth seeds are characterized as a nutritious product due to the content of proteins, fats, etc. Taking into account the high-quality fats and their amount in amaranth seeds, the study aimed to analyse the profile of fatty acids in amaranth pasta, which was developed for a vegan diet. Seven samples of amaranth pasta and their blends with oat or buckwheat flour were analysed in the study. The preparation of samples for analysis was carried out according to LVS EN ISO 6498:2012, fatty acids composition, and the amount was determined using the GC/MS analytic method. The highest total fat content was determined in the AMF sample – 5453.62 mg 100 g<sup>-1</sup>, followed by the AM+OATF\_15% sample – 4988.14 mg 100 g<sup>-1</sup> and AM+OATF\_30% sample – 4772.93 mg 100 g<sup>-1</sup>. The percentage distribution of fatty acids – saturated/mono-unsaturated/poly-unsaturated fatty acids in the amaranth pasta sample and its blends showed that the proportion of unsaturated fatty acids was over 70%. The highest PUFA/SFA ratio was determined for AM+OATF\_30%, AM+BWF\_15%, and AM+BWF\_30%. Quantitatively, the most essential fatty acids were oleic acid, linoleic acid, and palmitic acid. The triterpene squalene was detected with a probability of 90% in all amaranth pasta samples. The developed pasta for a vegan diet contains good-quality fat.

**Key words:** amaranth, fatty acids, buckwheat, oat, pasta andvegan diet.

## **Rowanberries (*Sorbus Domestica*) and black chokeberries (*Aronia Melanocarpa*) by-products for value added pectin with microwave assisted extractions**

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**Abstract:** Rowanberries (*Sorbus domestica*) and Black chokeberries (*Aronia melanocarpa*) are source for valuable juice, cider, marmalade and jelly production, and this process leaves a remarkable quantity of by-products (BP) in forms of pomace which accounts for up to 80% of the raw material. This by-product represents a rich source of biologically active compounds especially in the forms of different pectic polysaccharides. The pectin extracted from commercial fruits such as citric fruits, apples etc., demonstrated to have high medicinal properties, effective as edible films and coatings and also useful in texture improvement and gel production in food industry. However, the many of the under-utilised fruits have received little attention for extraction and characterisation of its high value pectin in their by-products. Moreover, the commercial extraction process involves strong acids and high temperature to obtain and leads to loss of many bioactive components in pectin, these components are often compensated by addition of synthetic antioxidants and colorants. The aim of the research was to extract pectin from Rowanberries and Black chokeberries by-products. Extraction was performed with weak organic acid (0.1 N citric acid) thus minimizing the impact of the environment and optimizing extraction time by assisted microwave energy (1000 W; time 15 min). Pectin yield in Rowanberries reached  $6.65 \pm 0.19$  g 100 g<sup>-1</sup> and in Black chokeberries  $11.40 \pm 1.50$  g 100 g<sup>-1</sup>. Galacturonic acid content (GalA >50%), Ash content (< 7 %), degree of esterification (DE >50%) of obtained pectin were determined. By-products and pectin were analysed for neutral sugar composition by HPAEC-PAD. Glucose and galactose were the main neutral sugar monosaccharides in pectin samples. Content of total phenolic compounds (TPC mg GAE g<sup>-1</sup>) and antiradical scavenging activity of samples was determined with method based on scavenging activities of the stable 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical. Free and total phenolic acids were quantified by saponification with High Pressure Liquid Chromatography (HPLC). The chemical structure of pectin was characterized by Fourier Transform Infrared Spectroscopy (FT-IR) and rheological properties of gels from pectin were determined. The quality of the obtained pectin from Black chokeberry and Rowanberry by-products in terms of their high biological activity and high content of glucuronic acids indicated that the products have the potential to be used as natural ingredients in various food and pharmaceutical products.

**Key words:** Antiradical scavenging activity, by-products, chokeberries, phenolics, pectin, rheology and rowanberries.

**Acknowledgements:** This work has been supported by the European Regional Development Fund within the Activity 1.1.1.2 “Post-doctoral Research Aid” of the Specific Aid Objective 1.1.1 “To increase the research and innovative capacity of scientific institutions of Latvia and the ability to attract external financing, investing in human resources and infrastructure” of the Operational Programme “Growth and Employment” (No.1.1.1.2/VIAA/4/20/656).

## Quantification of saponins in soybean-based yoghurt alternatives: a simple task?

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**Abstract:** Plant proteins can be isolated from different crops, for example soybean (*Glycine max* L.), pea (*Pisum sativum* L.), oat (*Avena sativa* L.), etc. Although other crops are increasingly used to produce vegan dairy and milk alternatives, soybeans are still one of the most used crops for food and feed. Besides proteins, legumes contain other nutrients, as well as saponins, which are known as antinutritional factors and can interfere with the absorption of nutrients in the gastrointestinal tract. In addition, saponins may contribute to the unpleasant bitter taste of soybean products. Saponins are diversified class of amphiphilic molecules, which are widespread in the plant kingdom. Soybean seeds contain triterpenoid saponins, e.g. soyasaponin Aa, soyasaponin Ab, soyasaponin Ba, soyasaponin Bb, etc. The aim of present work was to develop and validate the analytical procedure based on hydrophilic interaction liquid chromatography coupled to mass spectrometric detection (HILIC-MS) methodology for quantification of major soyasaponins in solid and liquid food matrices. The novelty of the presented method involves the usage of the internal standard asperosaponin VI for more reliable and precise mass spectrometric measurements. In addition, a considerable attention was devoted to the sample preparation techniques, to be applicable routinely at analytical laboratories. Analytes were effectively chromatographically separated using a BEH Amide column with gradient elution with ultrapure water containing 0.1% formic acid and acetonitrile with 0.1% formic acid as the mobile phases. During validation of the method, the linear range, limit of detection and limit of quantification, precision, matrix effect and recoveries were investigated for soybean-based yoghurt alternatives. Saponins in soybean-based yoghurt alternatives: a simple task?

**Keywords:** plant proteins, plant-based foods, bitterness, soyasaponins and *Glycine max*.

**Acknowledgments:** This study was supported by ERDF and Estonian Research Council via project RESTA16.

## Volatile organic compounds and their generation in sourdough

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**Abstract:** Sourdough technology is involved in bread making process for improving the sensory, rheological, nutritional and shelf life characteristics of bakery products. More than 540 volatile organic compounds (VOCs) and other flavour precursors belonging to the chemical classes, such as aldehydes, ketones, esters, acids, alcohols, terpenes and others, have been identified in sourdoughs and sourdough breads. The synthesis of VOCs is microbial species-specific, originating mainly from fermentation process. VOCs can be used as indicators to characterize microbial processes. Other additional sources of VOCs in sourdoughs are lipid oxidation and browning reactions, the latter of which occurs during the production of dried starter cultures. The purpose of this article is to provide an overview of the composition of VOCs and their effect on the sensory properties of sourdough bread, and to describe the most common extraction methods of VOCs used in the studies of sourdough and bread aroma profile. Long-term propagated sourdough VOCs have been less studied compared to volatiles found in bread crust and crumb or sourdoughs started with defined starter culture(s) due to their complexity and diversity in metabolic pathways, including sophistication of the analytical methodology of VOCs. The relation between sourdough microbiota and its volatile profile is not fully understood and therefore, their variability and precise role as a bread flavour enhancer is not yet known in detail.

**Key words:** lipid oxidation, proteolysis, sourdough fermentation and volatile profile.

**Acknowledgements:** This work was supported by the Estonian Ministry of Education and Research programme „Support for research and development on resource valorisation“ ResTA focus theme „Food: Innovative valorisation of food and food ingredients“ research project RESTA28 „Valorisation of cereal and oilseed crops“.

## Traditional applications of invasive plants in their native habitats

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**Abstract:** Invasive plants are a major threat to biodiversity and are of high concern in many countries, EU and even globally. This issue is also accompanied by the high costs of alien species control and eradication activities. Although development of control and eradication measures are with high importance, studies of their composition and potential applications in different fields must be considered in terms of bioeconomy. In order to use plant biomass collected as a result of eradication or for prevention of further expanding of these species, studies of their potential for energy production, as source of valuable phytochemical compounds and other potential applications should be studied. Therefore, considering traditional uses in the native habitats of invasive plants, current knowledge on invasive species must be developed with a multi-disciplinary approach including cross sectoral perspectives. One of the tools to identify possible applications is to study their traditional usage where these plants are native indicating potential directions for further studies of these plants where they are invasive. The aim of this study was to collect knowledge and analyse information on invasive plant phytochemical compounds that have higher application potential by literature analysis included in scientific databases (Scopus, Web of Science, ScienceDirect, Google Scholar, and others) and non-scientific literature. Such widely occurring invasive plants as Canadian goldenrod (*Solidago canadensis*), Canadian waterweed (*Elodea canadensis*), Sosnowsky's hogweed (*Heracleum sosnowskyi*), Himalayan balsam (*Impatiens glandulifera*), wild cucumber (*Echinocystis lobata*), Japanese knotweed (*Fallopia japonica*), and blue lettuce (*Lactuca tatarica*) were studied. Studied plants contain phytochemical compounds which can be successfully used for bio-based applications, moreover some of studied plants are considered as edible in their native territories.

**Key words:** invasive plants, phytochemical compounds, traditional applications, usage.

**Acknowledgements:** This work was supported by the European Regional Development Fund under project number 1.1.1.2/VIAA/1/16/001, Post-doctoral research project number 1.1.1.2/VIAA/4/20/723.

## **IX VEHICLES AND FUELS**



## **Innovative approach to real-time diagnostic of bolted joints and elastic couplings to prevent their fractures**

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**Abstract:** Failure of fasteners can lead to undesirable consequences. Fatigue failure of machine parts is difficult to predict and prevent. Vehicles and agricultural machinery include various systems such as engine, transmission, and many other systems that are fixed and connected using fasteners. Without a doubt, the performance of an individual system depends on the design of its kernel. But for the system to work, it must be properly fixed. Premature failure of bolts is subject of interest of engineers. The purpose of this study is to identify the causes of the failure of the fixing bolts and develop device and algorithm for early detection of conditions that might lead to bolt failure. The experimental data is collected analysing bolts and elastic couplings of electric passenger trains. Laboratory studies included the measurement of tensile strength, hardness, microanalysis of the metal structure and chemical analysis of failed old and new bolts. The authors present various visual and numerical results from this study. It also provides detailed conclusions about the causes of failure and recommendations for the selection of bolts for critical mechanical connections under dynamic loads and variable temperatures. The authors have developed a device that can be used in mechanical engineering, shipbuilding and other industries to control the deformation, vibration and shocks acting on a bolted joint. This device for monitoring the load and vibrations of bolted connections allows to constantly collect and analyse data during the operation of the vehicle in order to reduce the number of unscheduled repairs of vehicles due to its damage, as well as to reduce the number of accidents or other incidents. The authors also have developed a method and algorithm for calculating and evaluating the influence of external factors on the shell of a rubber-cord coupling. The study is based on statistical, material, and mathematical analysis of unexpected failures of rubber couplings. A numerical analysis of the operating conditions of the couplings before failure was performed. Torque, centrifugal force, shear stress and radial load acting on the coupling are calculated. The authors propose a technique that will allow for axial, radial or angular deviations to reduce the gaps of the elastic element. The results obtained are encouraging and prove that the use of an impact force measuring device and real-time data analysis can be cost-effective and can eliminate the problem of bolt and elastic coupling failure in one go, as well as reduce the cost of operating and repairing vehicles.

**Key words:** failure, fatigue, reliability, fracture, bolt and diagnostics

**Acknowledgments:** ESF Funded Project.

## **The Theoretical and Practical Aspects of the Hydrogen-Enriched Natural Gas for Operation of Small Internal Combustion Generator Sets**

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**Abstract:** Since share of renewable energy source (RES) will dramatically increase in next few years in Baltics States energy accumulation become very important. Latvia had developed natural gas infrastructure with huge underground gas storage. Green hydrogen can be mixed with already available natural gas flow. The presented paper considers two main impacts of hydrogen-enriched natural gas (HENG) application for small petrol generator set with electrical power output of 4 kW. Firstly, will be estimated decarbonisation effect of HENG application with different concentration of hydrogen taking in account that generator set will be topped by fly gas heat recovery unit. So standard generator was converted in microgeneration unit. Second task was to check need for conversion of internal combustion engine depending on concentration of hydrogen in HENG. The engine was instrumented with cylinder pressure measurement system. Combustion analysis provided an insight into the stability of combustion, combustion phasing and ignition advance requirements regarding maximal brake torque and knock. The results of presented paper can be used for modernisation of existing cogeneration facilities to ensure safe distributed energy generation into environmentally friendly decarbonized fuel as HENG.

**Key words:** green hydrogen, decarbonisation, methane, combustion and microgenerator.

**Acknowledgments:** Latvian State Funds.

## **Methanol-HVO blends for efficient low-temperature combustion: analytical research on fuel properties**

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**Abstract:** Next-generation low-temperature combustion (LTC) engines can accommodate ultra-high efficiency with near-zero NO<sub>x</sub> and PM emissions. Reaction kinetics is the governing mechanism in LTC. Onboard fuel reactivity control is, thus, becoming an interesting concept that ultimately provides pathways toward a fully fuel-flexible engine. No matter the technical realisation – in-cylinder blending or pre-blending/emulsification – the reactivity control requires fuels with complementary properties. Methanol and hydrotreated vegetable oil (HVO) seem to be one of the most promising, yet under-studied combination for LTC engines. They are both renewable and can be mixed together. Methanol's high knock resistance and large latent heat of evaporation enable a wide engine load range, with a propensity to reduce NO<sub>x</sub> emissions and mitigate thermal or mechanical stress. The same properties on the other hand require highly reactive fuel to enable the mixture to self-ignite controllably in LTC conditions. HVO is amongst the most reactive renewable alternatives and its clean paraffinic structure further mitigates particle matter formation. Importantly, in pre-blending HVO emulsification can resolve the lubricity issues of methanol. In this paper, the aim was to study the engine-relevant properties of HVO-methanol fuel blends. The analysed properties were the distillation properties, density, kinematic viscosity, cetane index, and flash point. Based on the results, the suitability of the chosen blend shares for LTC concepts was evaluated.

**Key words:** CI engines, fuel blending, HVO, LTC and methanol.

# **X WASTE RECOVERY**

## Knowledge of Packaging Waste among Czech cities

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**Abstract:** The residential sector generates around 14% of the overall waste production in the Czech Republic. This essential share requires special attention to analyse with particular emphasis on citizen education. Thus, this research is dedicated to citizens' awareness about packaging waste to increase their knowledge. The experiment was conducted in the form of a survey, and students from a university were asked to estimate the weight of the packaging waste presented to them in term to verify their knowledge about packaging waste. This experiment featured different groups of students over time. The result showed no difference in knowledge between these student groups over time. The long-term home study caused by COVID-19 did not appear to have affected students' knowledge of packaging waste. This study showed students' actual knowledge about packaging waste and highlighted the gap and importance of education in waste management.

**Key words:** education, packaging waste, residents and survey.

**ACKNOWLEDGEMENTS:** This study was supported by Intern grant agency of Faculty of Engineering, Czech University of Life Sciences Prague with no. 2021:31180/1312/3104.

## Simultaneous nutrient and organic matter removal from wastewater by aerobic granular sludge process

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**Abstract:** Aerobic granular sludge (AGS) technology offers several benefits, such as simultaneous removal of nutrients and organic matter from wastewater, stronger granule structure, excellent settleability, and high resistance to toxicity. However, the formation of granules can take a long time and needs to be dense and stable. In this study, the formation of aerobic granules in sequencing batch reactors (SBRs) using a granular activated carbon (GAC) and aluminium sulphate coagulant were evaluated for the simultaneous removal of nutrient (phosphorus (TP) and nitrogen (TN)) and organic matter (chemical oxygen demand (COD)) from wastewater. The reactors were continuously operated for 107 days and were fed with synthetic media and real domestic sewage. However, adaptation process with the synthetic wastewater led to relatively slow granulation process (sedimentation rate of sludge flocks was  $3 \text{ m h}^{-1}$ ). During the experiments, there was no visible formation of granules in SBRs based on the analysis of the sludge samples, only the formation of aggregate structures similar to flocks. However, the results showed that total phosphorus (TP) removal efficiency was over 90% in SBR operated with aluminium sulphate. However, COD and total nitrogen (TN) removals were higher in GAC SBR, 75% and 10%, respectively. Thus, even if granules are not developed yet, the system is working efficiently. The results of this study could be useful in the development of AGS technology for full-scale wastewater treatment plant.

**Key words:** aerobic granular sludge, nutrient removal, organic matter, sequencing batch reactor and wastewater treatment.

**Acknowledgements:** The work has been funded by ERDF Project “Waste to resource technology development using sewage sludge as raw material”, No. 1.1.1.1/20/A/041. We thank Janis Neilands, Kaspars Neilands for technical assistance; and Ltd. Riga water for support during this research.

## Processing of Latvian peat and waste coffee as a biocomposite material for the oil spill collection

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**Abstract:** Every year there are oil spills into water and soil. The total amount of oil products spilled into the water in 2021 was around 10 000 tonnes. There is a growing demand for adsorbents of natural origin that are renewable, effective, and able to treat contaminated water resources as quickly as possible. One such material is peat coffee biocomposite pellets. The paper describes peat-spent coffee ground (SCG) composite material in granule-shaped production and characterization. In this research homogenized peat (HP) as an efficient, natural binder was used. The SCG in different proportions (12w%, 14w%, 35w%, 50w%, 45w%, 65w%, and 85w%) with HP were used for the different types of SCG-HP granulated sorbents. The sorption of the oil products (fresh and used motor oil) was studied. Sorption studies showed the maximal adsorption (capacity) was noted at 63 g/g for 85w% SCG-HP granules. These granules range in size from 2 to 6 mm with an overall porosity of 56–61%.

**Key words:** Bioadsorbent, peat biocomposite, oil spill, sustainable production and waste recycling.

**Acknowledgements:** This research/publication was supported by Riga Technical University's Doctoral Grant programme.

## Use of calcium/iron oxide composites for sorption of phosphorus from wastewater

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**Abstract:** The development of an effective, low-cost and natural sorbent is of great significance for phosphorus removal and recovery from small and medium size industrial and municipal wastewater. Commonly used phosphorus removal methods are costly and thus rarely applied in the small-scale WWTPs. This research was aimed at preparing and characterising three different calcium/iron composites for evaluating their sorption performance for the removal of phosphorus from aqueous solutions and domestic wastewater. The obtained composite materials belonging to Brownmillerite mineralogical subgroup were characterised by the Powder X-ray Diffraction (PXRD), specific surface area analysis by Brunauer-Emmett-Teller (BET) method and scanning electron microscope (SEM). It was found that for aqueous solutions the sorption process is pH- dependent, showing the optimal sorption conditions for phosphorus removal at pH 3 to pH 6. However, all three proposed composites significantly increased the pH of wastewater. All three tested materials adsorbed phosphorus from wastewater. Maximal phosphorus adsorption capacity from the domestic wastewater was 17.75 mg g<sup>-1</sup>, 8.25 mg g<sup>-1</sup> and 4.46 mg g<sup>-1</sup> for CaFeOxide, CaFeHydr and CaFeReg respectively. In further research it is planned to develop an environmentally friendly and cost-effective phosphorus recovery technology with the potential to apply the used sorbent as a slow-release fertiliser in agriculture.

**Key words:** Brownmillerite, Srebrodolskite, natural inorganic sorbents, phosphorus removal, resource recovery, wastewater treatment.

**Acknowledgements:** This research is funded by the fundamental and applied research project of the Latvian Council of Science “Unused Latvia's natural mineral resources for the development of innovative composite materials for phosphorus recovery from small municipal and industrial wastewater treatment plants to implement the principles of circular economy (CircleP”, No. lzp-2021/1-0090). Funding for the research was also received from the project No. #006 “Improving quality of BSR waters by advanced treatment processes” (AdvIQwater), which is co-financed by the European Union from the Interreg Baltic Sea Region programme.



## Recycled polypropylene-poly(lactic acid) blend as a polymer matrix for food packaging composites

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**Abstract:** Poly(lactic acid) (PLA) is a known biodegradable thermoplastic polymer with potential usage in various industrial areas from medicines to food packaging. Recycled polypropylene (rPP) is produced from PP wastes and has different practical applications including food packaging. Along with benefits of its polymeric properties, rPP has some drawbacks such as insufficient mechanical strength and low biodegradability. The latter limits its use in packaging due to high environmental requirements. PLA is characterized by higher mechanical properties than rPP and fully decays in soil, but it is a brittleness polymer with poor impact strength and a high cost. To compensate for the drawbacks of both polymers, they can be modified by blending in the melt. The rPP/PLA polymer samples were obtained by blending rPP and PLA using a two-screw extruder with the following injection molding. The growth of PLA content in the samples increased their tensile and bending strength and both modulus in comparison with neat rPP. At the same time, the presence of PLA significantly reduced the ability of the obtained samples to deform. The hydrophobic properties of the rPP/PLA samples were evaluated using the Washburn method and water sorption test. Comparing the hydrophobic properties of the initial polymers and the obtained rPP/PLA samples showed that the blending of PLA with rPP at the defined mass ratio led to an increase in the contact angle values and a decrease in the adhesion work of the obtained samples relative to neat PLA. The enhanced contact angle values of the rPP/PLA samples were in agreement with their reduced ability to sorb water vapor. The impact viscosity testing showed that a low amount of PLA in the blend positively affected the impact viscosity of the rPP/PLA composite samples. Developing wood-polymer composites (WPC) based on rPP/PLA matrix reinforced with wood residues may be considered one of the promising and economical modes for obtaining eco-friendly materials for food packaging. The properties of the obtained WPC samples filled with wood sawdust depended on the rPP/PLA mass ratio, the filling degree and technological parameters.

**Key words:** recycled polypropylene/poly(lactic acid) blend, mechanical properties, contact angles, wood-polymer composite and food packaging.

**Acknowledgments:** This study was funded from the Base Financing of the Latvian State Institute of Wood Chemistry.

## Study of the carbonization process for the plant waste utilisation

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**Abstract:** In agriculture and the food industry, large amounts of vegetable waste are generated annually: straw, corn waste, nut shells, fruit kernels, etc. The problem of their disposal is extremely acute, and regularly people use the simplest methods that do not require further processing of this type of waste. An efficient way of recycling is to make sorbents out of it. In modern conditions of deficit and rising commodity prices, the search for new, cheapest methods is becoming more and more urgent. The origin of vegetable waste is an excellent annual renewable raw material base. Walnut shells and corn cobs were used as raw material samples for the production of sorbents. The carbonization was carried out at temperatures of 300, 400, 500, 600 and 700 °C. Researched properties of raw materials: moisture, ash content and yield of volatile components. The dependency of the sorbent yield on the final temperature was determined, the ash content and the sorption activity by iodine were determined. Based on the results of the study, the high quality of the sorbent obtained was noted. In this way, the use of plant waste as raw material for the production of sorbents allows not only to solve the problem of waste recycling, but also to obtain a high-quality product and reduce its cost.

**Key words:** plant waste origin, utilisation, carbonisation, sorbents and the sorption activity.

**Acknowledgements:** This research/publication was supported by Riga Technical University's Doctoral Grant programme.

## **Life cycle assessment of fish feed for oil alternatives - environmental impact of microalgae, rapeseed and fish oil**

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**Abstract:** Fish is an inexpensive source of high-quality protein as well as valuable micronutrients. Increasing the volume of fish and producing more fish feed is necessary to ensure the necessary consumption. One of the main components of fish feed is oil, the most crucial lipid source in fish feed. Fish oil is easily digestible and contains essential fatty acids, but replacing fish oil with alternative oil might make the fish feed more sustainable. Vegetable oils can replace fish oil due to reduced costs due to continued growth in production volumes, high availability and better economic value. Soy, linseed, rapeseed, sunflower, palm and olive oils are often used in fish feed. Also, microalgae oil is rich in essential fatty acids and a long-lasting alternative to fish oil. Important is not only the environmental impact of oil alternatives but also how these alternatives maintain or even improve the overall composition and quality of fish feed and products. An LCA assessment was performed to determine the environmental impact of microalgae, rapeseed oil, and fish oil. Where LCA system boundaries are “cradle to gate” and a functional unit of 1 kg of oil. LCA inventory is data from a literature review and SimaPro Ecoinvent database. The results obtained from LCA are based on PEFCR impact assessment categories. The LCA results show that the single score value for microalgae oil is 1.00E+00 mPt, for rapeseed oil 3.55E-01 mPt and fish oil 1.61E-01 mPt. It should be noted that the comparison presented reflects a generic comparison of alternatives, as the input data is derived from the literature analysis and the Ecoinvent v3.8 database.

**Key words:** fish feed, fish oil, LCA, microalgae oil, PEFCR and rapeseed oil.

**Acknowledgements:** The research has been supported within the framework of the European Regional Development Fund project No. 1.1.1.5/17/I/002 “Integrated national level measures for strengthening interest representations for research and development of Latvia as part of European Research Area” by funding project No. 23-11.17e/21/165 “Non-Food Organic Resources-based feeds optimised for salmon until post-smolt stages”(NON-Fôr).

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