Proceedings of the EcoSET Closing Conference

12-14 September 2022, Bydgoszcz (Poland)

Organised in the frame of the project

"EcoSET. Ecology, Science, Education and Technology.
Ways to Internationalise the Bydgoszcz University of Science
and Technology in Areas of Research and Education"

Committees

ORGANISING COMMITTEE

Prof. Dr. Marek Bednarczyk – President	Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland
PhD Eng. Magdalena Kolenda	Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland
PhD Eng. Agata Szczerba	Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland
PhD Eng. Magdalena Dobiszewska, Prof. PBŚ	Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland
MSc. Eng. Izabela Kasprzyk	Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland
PhD Eng. Marcin Malinowski	Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland
MSc. Eng. Agata Bukaluk	Faculty of Design, Bydgoszcz University of Science and Technology, Poland
MA Agnieszka Walther	Faculty of Design, Bydgoszcz University of Science and Technology, Poland
Ms Dorota Pomianowska	Faculty of Design, Bydgoszcz University of Science and Technology, Poland

SCIENTIFIC COMMITTEES

Section: Animal science and fisheries

Prof. Dr. Giuseppe Maiorano	Department of Agricultural Environmental and Food Sciences, University of Molise, Italy
Prof. Dr. Eng. Petr Sláma	Faculty of Agrisciences, Department of Morphology, Physiology and Animal Genetics, Mendel University in Brno, Czech Republic
Prof. Dr. Hasan Ónder	Faculty of Agriculture, Department of Animal Science, Ondokuz Mayıs University, Türkiye
PhD Eng. Aleksandra Dunisławska, Prof. PBŚ	Department of Animal Biotechnology and Genetics, Bydgoszcz University of Science and Technology, Faculty of Animal Breeding and Biology, Poland

Section: Civil engineering and transport

Doç. Dr. Ahmet Beycioğlu	Faculty of Engineering, Department of Civil Engineering, Adana Science and Technology University, Türkiye
Dr. Dimitrios Goulias	Civil Environmental Engineering Department, University of Maryland, USA
PhD Eng. Jan Kempa, Prof. PBŚ	Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

Section: Fine arts and art conservation

PhD Erkan Likos   Faculty of Fine Arts, Department
of Industrial Design, Ondokuz Mayıs
University,Türkiye

PhD Teija Gumilar   Faculty of Design, Department
of Design, Bydgoszcz University
of Science and Technology, Poland

PhD Katarzyna Tretyn,   Faculty of Design, Department
Prof. PBŚ   of Interior Design, Bydgoszcz University
of Science and Technology, Poland

HONORARY PATRONAGE

Prezydent Miasta Bydgoszcz

MEDIA PATRONAGE

Polskie Radio PIK
Polska Telewizja TVP3 Bydgoszcz

PREFACE

Dear Colleagues,

We are pleased to welcome you to the EcoSET Closing Conference held at the Bydgoszcz University of Science and Technology, Poland, on September 12–14th, 2022.

The project "EcoSET. Ecology, Science, Education and Technology. Ways to Internationalise the Bydgoszcz University of Science and Technology in Areas of Research and Education" (hereinafter referred to as "EcoSET") is carried out between 1st October 2019 and 30th September 2022 initially by two faculties of the Bydgoszcz University of Science and Technology ("PBS"): Faculty of Animal Breeding and Biology ("WHiBZ"), Faculty of Civil and Environmental Engineering and Architecture ("WBAiIŚ"), and recently also by the Faculty of Design ("WSP") within the International Academic Partnerships Programme of the Polish National Agency for Academic Exchange ("NAWA").

The aim of the EcoSET project is to increase the level of internationalisation in research and education at PBS in Bydgoszcz through EcoSET tasks that include: Organisation of scientific visits, Subsidising common scientific publications and international conferences as well as Organization of the Closing Conference.

The scope of the project includes shared research activities in the following disciplines: Animal science and fisheries (at WHiBZ), Civil engineering and transport as well as Architecture and urban planning (at WBAiIŚ) and Fine arts and art conservation (at WSP). EcoSET is carried out in cooperation with the following Partners:

- Aarhus University, Denmark
- Adana Science and Technology University, Türkiye
- Justus-Liebig-Universität Gießen, Germany
- Mendel University in Brno, Czech Republic
- National Centre for Biodiversity and Gene Conservation, Hungary
- Ondokuz Mayıs University, Türkiye
- Polytechnic University of Bari, Italy
- Tarleton State University, the United States of America
- University of Beira Interior, Portugal

- University of Maryland, the United States of America
- University of Molise, Italy

The aim of the Conference is to present the results of studies undertaken in the frame of the EcoSET Project by international research groups composed of Partners from different participating Universities. This Conference provides opportunities for participants to meet with representatives of Partner Universities, exchange new ideas and experiences, as well as define directions for further cooperation. The Conference will be held at the Bydgoszcz University of Science and Technology campus, which provides an opportunity to present scientific research results and network within the international community.

During the Conference, an official art exhibition of works prepared by employees and students of EcoSET Partner Universities will take place.

The EcoSET Team

Table of contents

ANIMAL SCIENCE AND FISHERIES

CIVIL ENGINEERING AND TRANSPORT

FINE ARTS AND ART CONSERVATION

ANIMAL SCIENCE AND FISHERIES

The effect of incubation temperature on chicken muscle and bone development, performance, meat quality and welfare: a review

Tobias Kettrukat[1], Ewa Grochowska[2], Margrethe Therkildsen[1]

[1] Department of Food Science, Aarhus University, Aarhus, Denmark

[2] Department of Animal Biotechnology and Genetics, Bydgoszcz University of Science and Technology, Poland

corresponding author: margrethe.therkildsen@food.au.dk

Introduction. Commercial rearing of broiler chickens is commonly coupled with the compromised welfare of the animals. Selection on optimal productivity has led to decreased walking ability and associated afflictions like footpad dermatitis. Rapid growth and selection on breast muscle growth have altered the gait dynamics of the birds compared to layer chickens. This puts the locomotory system, especially the leg bones and postural muscles, under considerable stress. It has been shown that changes in the incubation temperature, so-called thermal manipulation, can influence muscle and bone development. The aim of this paper is to review the current literature on the influence of incubation temperature on muscle and bone development, chick quality, performance, meat quality and welfare of chickens, and to draw conclusions on how the incubation temperature can be used as a tool to improve broiler welfare without compromising the production parameters.

Materials and Methods. As the last review on the influence of incubation temperature on chick development was published 30 years ago, this paper focuses on more recent studies. Older studies were included when more recent publications were limited. Most of the reviewed studies were performed on broiler chickens, but experiments on layer chickens were included as well as a study on turkeys.

Results and Discussion. The literature shows that muscle tissue responds to elevated temperature during embryogenesis by proliferation, but this effect depends on the timing, as embryonic muscle development relies on the expression of regulatory factors and cell lines occurring at specific time points. Changes in the expression of myogenic regulatory factors and transcription factors and alterations in muscle fibre size, fibre number, muscle enzymes, and muscle weights have been reported. Furthermore, breast and leg muscles respond differently, especially when different timings are compared. Similarly, leg bone

growth seems to be promoted by elevated incubation temperature, but the effect cannot clearly be separated from overall embryo growth. Data on the influence on bone strength and mineralisation is limited. Performance is inferior when incubation temperature is lowered, while it is possible to achieve higher muscle and body weights when the higher temperature is administered in mid-term embryogenesis. Regarding performance, females are more sensitive to changes in incubation temperature than males. No detrimental effect on meat quality has been shown so far, but changes in meat quality parameters have been reported. Close attention must be paid to the incubation program in terms of chick quality and welfare, as temperature changes over a longer period and temperatures deviating more than 1–2 degrees from 37.8°C compromise hatchability and number of saleable chicks. Still, if applied discontinuously, an improved or unaffected hatchability has been reported for increased incubation temperature during the last days of embryogenesis. Apart from that, an effect on welfare concerning walking ability has not been widely researched but is possible due to the effect on muscle and overall body growth.

Conclusion. Changes in the incubation temperature of hen's eggs affect the development of the embryo and can affect muscle and bone development, performance, and welfare up to slaughter age. The underlying mechanisms that lead to structural changes in the muscles remain to be elucidated. By filling in knowledge gaps and careful setup of the incubation conditions, thermal manipulation can be developed into a tool to improve production parameters and possibly welfare of broiler chickens.

Keywords: broiler, myogenesis, performance, thermal manipulation, welfare

Effects of effective microorganisms (EM) on meat quality and microstructure of the *longissimus lumborum* muscle in pigs

Patrycja Reszka[1], Hanna Jankowiak[2], Joanna Bogucka[3]

[1] Department of Animal Biotechnology and Genetics, Bydgoszcz University of Science and Technology, Poland

[2] Department of Animal Breeding and Nutrition, Bydgoszcz University of Science and Technology, Poland

[3] Department of Animal Physiology and Physiotherapy, Bydgoszcz University of Science and Technology, Poland

corresponding author: patres000@pbs.edu.pl

Introduction. Pork is the most popular meat among consumers in Poland, but it can also be a source of pathogens. Therefore, there is a need to find effective prophylaxis in order to ensure that consumers have access to safe food. In order to meet these expectations, producers use probiotics containing effective microorganisms (EM). The aim of the study was to determine the influence of the EM on meat quality and the microstructure of the longissimus *lumborum muscle* (LL).

Materials and Methods. The study group consisted of 150 piglets (♀F1 Polish Landrace × Polish Large White with ♂F1 Pietrain × Duroc) which were divided into three feeding groups: C, E1, and E2, where C – a standard fodder blend with a full share of post-extracted soya meal; E1 – a 50%/50% mix of pea and lupine/soya bean in I phase of fattening and a 75%/25% mix of pea and lupine/soya bean in II phase of fattening; and E2 – a 50%/50% mix of pea and lupine/soya bean in I phase of fattening and 100% pea and lupine in II phase of fattening. The experimental factor was the addition of the EM Carbon Bokashi probiotic to the diet (C+EM, E1+EM, E2+EM). Animals were slaughtered at a body weight of approximately 115 kg. The obtained results were processed statistically using Statistica 13.1 software.

Results and Discussion. Meat from C+EM group had a lower water holding capacity ($P \leq 0.05$). Meat from pigs fed with EM was harder in the E1+EM group compared to E1 group ($P \leq 0.05$). A beneficial effect of EM was found in the E2+EM group, where less thermal leakage was demonstrated ($P \leq 0.05$). In terms of the microstructure of LL muscle, in the C+EM group, a lower total number of muscle fibres was demonstrated ($P \leq 0.05$). The addition of EM caused an increase in the

diameter of fast twitch fibres in the E1+EM group (P ≤ 0.05). In the same group of pigs, EM caused a lower proportion of fibre fission (P ≤ 0.05). In this study, we did not find any influence of EM on the proportion of normal fibres or the occurrence of giant fibres and fibres necrosis.

Conclusion. In conclusion, the meat quality was satisfactory in all groups of examined pigs. The beneficial effect of EM was found in nutritional variant II, where less thermal leakage from meat was found. Adding a probiotic to pigs' diet resulted in thicker muscle fibres, which was particularly evident in the case of the E1+EM group, and less fibre fission, a common lesion in fast-growing animals.

Keywords: meat quality, muscle fibres, pigs, probiotic

Influence of cow's lifespan and season of milking on milk yield and its composition

Maroš Čobirka[1], Petr Sláma[1], Vladimír Tančin[2], Marta Oravcová[3]

[1] Department of Animal Morphology, Physiology and Genetics, Faculty of AgriSciences, Mendel University in Brno, Czech Republic

[2] Faculty of Agrobiology and Food Resources, Slovak Agriculture University in Nitra, Slovakia

[3] Department of Breeding Systems, Breeding and Product Quality, NPPC – Research Institute of Animal Production, Slovakia

corresponding author: maros.cobirka@mendelu.cz

Introduction. The objective of this study was to evaluate the influence of a cow's lifespan, in other words, the number of its lactations, and the influence of the year season during the milking on milk production and its content.

Materials and Methods. We were observing and evaluating data from a farm in western Slovakia, which consisted of a black Holstein breed. The farm administration has provided login information to the Slovak Breeding Information System, where the records from monthly performance tests are recorded and saved. From there, we collected, processed, and evaluated data from the last few years. During our work with data and its analysis, we used Microsoft Excel and then Statistical Analysis System (SAS) GLM model, with a fixed effect of parity and season.

Results and Discussion. Notable differences were observed mainly in the relation between milk production and parity order. With every subsequent lactation, milk yield increased as well. The difference between the average daily yield on first and fifth lactations was 7.61 kg of milk per day. Implicitly the yield on the fourth lactation was the highest. The same parameters were monitored in relation to the season of milking. We observed statistically significant differences in means of milk yield. Cows milked during cold months in winter and spring have had higher yields than the ones milked during warmer months of summer and autumn. Average milk yield peaked in spring and was 1.02 kg higher than the lowest record, which occurred during autumn. The somatic cell score was as well higher in summer and autumn. The worst parameters of milk yield and composition were observed during the summer season.

Conclusion. By monitoring, evaluating, and interpreting these parameters, we can help breeders to understand the impact of these factors on milking overall, prevent milk losses, increase economic and hopefully prolong the lifespan of cows. The importance of proper management is quintessential. We are aware that these external factors are not the only ones responsible for the milk production changes. However, this research was focused solely on their effect.

Keywords: composition, lactation, lifespan, milk, season

Length of productive life and reasons of culling daughters of bulls with a high immune response

Dariusz Piwczyński[1], Bogumił Sobczyński[1], Julia Piwczyńska[2], Magdalena Kolenda[1], Beata Sitkowska[1]

[1] Department of Animal Biotechnology and Genetics, Bydgoszcz University of Science and Technology, Poland

[2] Faculty of Veterinary Medicine, Wrocław University of Environmental and Life Sciences, Poland

corresponding author: darekp@pbs.edu.pl

Introduction. In 2007 in the USA, a technology called Immunity+ was patented, and nearly five years later, it was made commercially available by the University of Guelph in Canada. The technology allows to identify and select animals with a high immune response (HIR). The aim of the research was to analyse the length of productive life, length of life, as well as the reasons for culling Polish Holstein-Friesian cows that are daughters of HIR bulls.

Material and methods. The study included 2,039 Polish Holstein-Friesian cows from 7 herds, born in 2013–2015, including 447 daughters of HIR bulls and 1,592 of their peers unrelated to HIR bulls. Parents, grandparents and great-grandparents from both sides were identified in the pedigrees of all tested animals. Data were derived from the registration system SYMLEK provided by the Polish Federation of Cattle Breeders and Dairy Farmers (PFHBiPM). Length of productive life and length of life were statistically compiled using multivariate analysis of variance. In the linear model of the analysis, the influence of the following main factors was taken into account: HIR, herd, year of birth, age of cow's first calving and HIR × herd interaction.

Results and discussion. The statistical analysis of the culling reasons was performed by means of a chi-squared test. The statistical analysis showed that the daughters of the HIR bulls, compared to the group of cows not related to the HIR bulls, were characterised by ($P > 0.05$) 2.4 days longer productive life (702.58 vs 700.22 days) and by 3.2 days longer life length (1496, 26 vs 1493.05). In addition, it was found that both compared groups were culling at a similar level for the same reasons ($P > 0.05$). It should be emphasised, however, that the daughters of HIR bulls compared to the group of cows unrelated to HIR bulls were 1.33 pp less often culled due to low milk yield, by 2.59 pp due to udder

diseases. A reverse tendency was recorded in the case of lack of pregnancy and conditions of the reproductive (2.51 pp) and the locomotor systems (2.87 pp).

Conclusions. It should be stated that the length of productive life, length of life, as well as the reasons for the culling of the daughters of HIR bulls from the herd, were similar to their peers unrelated to the HIR bulls.

Factors influencing accumulation of selected metals in spiny-cheek crayfish (*Orconectes limosus* Raf.) tissues

Magdalena Stanek[1], Szymon Różański[2], Bogusław Chachaj[3]

[1] Department of Animal Physiology and Physiotherapy, Bydgoszcz University of Science and Technology, Poland

[2] Laboratory of Chemical Research and Instrumental Analysis, Bydgoszcz University of Science and Technology, Poland

[3] Department of Animal Biology and Environment, Bydgoszcz University of Science and Technology, Poland

corresponding author: magdalena.stanek@pbs.edu.pl

Introduction. Edible crustaceans such as crab, shrimp, crayfish and lobsters are valuable sources of macronutrients and micronutrients essential for humans, such as Ca, K, Mg, Na, Fe, Cu, Zn. Crayfish are frequently considered bioindicators for monitoring water conditions in polluted areas. The degree of accumulation of metals in tissues is influenced by physical and chemical factors, i.e. pH and temperature of the environment, time of exposure, metal concentration and biological ones (i.e. species, size, body condition). The aim of the study was to analyse the effect of age and sex of crayfish on the degree of accumulation of selected metals in the meat and exoskeleton, analyse the correlation coefficient between the concentrated metals and body length and analyse the bioaccumulation coefficient, and the percentage of metals in the water, sediment, meat and exoskeleton. Such complex analyses can improve our understanding of metal absorption as well as enable more accurate estimates of the amount of bioavailable metals present at a given site.

Material and methods. A total of 50 males and 50 females of the spiny-cheek crayfish were caught in autumn after a period of intense feeding. For analysis, the abdominal muscle and exoskeleton were dissected. Water samples were taken from the subsurface layer, fixed with a few drops of concentrated nitric acid, and stored in the refrigerator for analysis. The sediment was collected from the bottom using an Ekman-Grab sampler and was stored in polyethylene bags. Cu, Zn and Ca concentrations were determined in freeze-dried samples after aqua regia digestion (ISO 11466:1995) on Thermo SCIENTIFIC iCE 3000 SERIES spectrophotometer, calibrated using Merck standard solutions (Merck KGaA). The validation of the analysis was conducted on certified

standards – Certified Reference Material ERM®-BB422 Fish Muscle, Certified Reference Material BCR®-670 Aquatic Plant and Certified Reference Material CRM027-050 Sandy Loam 10. Statistical calculations were made using Statistica 13.0 software (StatSoft 13.0). The arithmetic mean (x) and standard deviation (SD) were calculated. Significant differences between the groups were tested with a one-way analysis of variance (ANOVA), and Tukey's test was used for multiple comparisons.

Results and discussion. Our analyses indicated that metals accumulated in the following sequence: Zn>Cu>Ca in the abdominal meat samples and Ca>Zn>Cu in the exoskeleton, water and bottom sediment samples. The highest amounts of Zn were found in the meat of 4-year-old females, Cu in the meat of 3-year-old males, and Ca in the meat of 4-year-old males. Based on statistical analysis, both the age and sex of the crayfish were significant factors. Differences in the metal content of the meat between males and females may be due to differing growth rates between the sexes. Females of Penaeus esculentus grow faster than males, so growth dilution of accumulated metals is probably more marked in females. On the other hand, unpublished data concerning Nephrops norvegicus show that males have higher feeding rates than females and the concentration of metals may be higher. The bioconcentration factor for Zn and Cu in the meat and exoskeleton of spiny-cheek crayfish was much higher from water than from sediments, unlike Ca. Only in a few cases did the concentration of metals in the meat and exoskeleton significantly correlate with the crayfish body's total length (TL). Statistically significant correlation coefficients ($P < 0.05$) between Zn and TL in 3-year-old females and 4-year-old males and between Cu and TL ($P < 0.05$) in 3-year-old males were observed. In the case of the exoskeleton, no significant correlations ($P > 0.05$) were found between the concentration of metals and TL.

Conclusion. Factors influencing the differences in the accumulation of heavy metals in crayfish tissues are age, which is equivalent to the time of exposure of the animal to metals, and sex, which determines the moulting cycle and detoxification processes. However, we believe that environmental conditions are very important, especially pH (which affects the degree of bone mineralisation); therefore, this mechanism requires further research. Knowledge of the mechanisms of metal bioaccumulation and the factors influencing it is an important contribution to the environmental monitoring of freshwater ecosystems.

Keywords: calcium, copper, zinc, crayfish tissues

Nanofiber scaffolds for cell cultivation

Petr Slama[1], Terezie Zavadilova[1], Monika Zouharova[2]

[1] Laboratory of Animal Immunology and Biotechnology, Department of Animal Morphology, Physiology and Genetics, Faculty of AgriSciences, Mendel University in Brno, Czech Republic

[2] Infectious Diseases and Preventive Medicine Department, Veterinary Research Institute, Czech Republic

corresponding author: petr.slama@mendelu.cz

Introduction. Three-dimensional (3D) cell culture systems are very important for developing in vitro conditions close to the real situation in tissues compared to two-dimensional systems that can make cell artefacts. This study's objective was to evaluate the suitability of polycaprolactone nanofiber scaffold for cultivating bovine dendritic cells.

Material and Methods. Dendritic cells were developed from blood monocytes. Blood was obtained from jugular vein of milking cows. Monocytes were isolated from blood using histopaque (density 1.077) and magnetic microbeads (CD14 MicroBeads, Miltenyi Biotec, Germany). Monocytes were seeded on nanofibers and cultivated in common in vitro conditions (37°C, 5% CO_2). For the development of dendritic cells, cytokines IL-4 and GM-CSF were used. After one week of cultivation, the cells were observed by scanning electron microscopy (MAIA3, Tescan, Brno, Czech Republic).

Results and discussion. Our results showed that polycaprolactone nanofiber scaffold is suitable for the cultivation of monocytes and developing dendritic cells, which was confirmed by electron microscopy. Lee et al. (2021) also showed a similar result in mouse neutrophils, macrophages and dendritic cells.

Conclusion. The results of the study give us a positive direction for the use of nanofibers for the cultivation of various cells and the study of chemotaxis and phagocytosis.

Keywords: dendritic cell, monocyte, nanofiber, scaffold, three-dimensional cell culture

The effects of *in ovo* injection of the selected prebiotic, probiotic and synbiotic formulation delivered at 18.5 ED on embryonic development, hatchability and quality of day-old chicks

Modou Mangan

Bydgoszcz University of Science and Technology, Poland
corresponding author: modou.mangan@pbs.edu.pl

Introduction. In recent years, poultry farming has emerged as one of the fastest-growing agricultural industries, thus playing a pivotal role in the world economy. The quality of day-old chicks has long-lasting effects on the health and growth performance of the flock. Therefore, in poultry practice, the assessment of day-old chicks and the mortality of the first 7 days of life are major productive parameters in the peri-hatch period. Secondly, there are efforts of *in ovo* technology providers to enable injections of various bioactive compounds using the vaccination time points. The aim of the study was to determine the effects of the selected prebiotic, probiotic and synbiotic delivered *in ovo* on day 18.5 of egg incubation on hatchability and quality of day-old chicks using the automated single egg injector machine. Also, to confirm that *in ovo* injection on day 18.5 can be applicable in poultry hatcheries. Therefore, we hypothesised that the *in ovo* delivery of the selected prebiotic, probiotic and synbiotic on day 18.5 day of egg incubation using the single egg injector machine does not affect the hatchability and quality of day-old chicks and could prove its applicability in the hatchery industry.

Material and methods. The experimental trial was conducted using 500 Ross 308 fertilised eggs with three repetitions creating treatment groups (50 eggs/group). The doses used per egg were: synbiotic 0.5 mg x 10 ^ 3 CFU, 0.5 mg x 10 ^ 6 CFU, 1.0 mg x 10 ^ 3 CFU, 1.0 mg x 10 ^ 6 CFU; prebiotic 0.5 mg, 1.0 mg; probiotic 10 ^ 3 CFU, 10 ^ 6CFU for positive control (only vaccine) and control non-injected, respectively. During this trial experiment, we optimised the prebiotic, probiotic and synbiotic doses delivered into the amnion of Ross 308 broiler chicken embryos on day 18.5 of egg incubation using an automated single egg *in ovo* injector machine. Hatchability was recorded, and the chick quality was assessed and measured using Pasgar score, chick length and weight of day-old chicks. Hatching debris analysis was performed to examine

the possible causes of unhatched eggs. The results were analysed by using the statistical software package SPSS version 16.0 using a one-way ANOVA model p. Significant differences among treatment means were determined by performing a pos-hoc Duncan's multiple range test and Tukey test ($P < 0.05$).

Results and discussion. The results showed that there was no significant difference in hatchability. However, the hatchability was slightly higher in synbiotic 1.0 mg x 10 ^ 3 CFU, prebiotic 0.5mg x 10 ^ 3 CFU and probiotic 10 ^ 3 CFU with 99%, 98.68% 98% respectively. There were no significant differences in the body weight of day-old chicks among groups ($P < 0.05$). The Pasgar score was used to determine the quality of chicks. The probiotic group (Pro 10 ^ 3 CFU) with a score of 9.50 ($P < 0.05$) was shown to be highly significant when compared to synbiotic groups (Pre 1.0 mg x 10 ^ 3 CFU and Pre 1.0 mg x 10 ^ 6 CFU) ($P < 0.05$).

Conclusions. In conclusion, the selected prebiotic, probiotic and synbiotic delivered *in ovo* at day 18.5 of egg incubation using the automated single egg injector machine do not affect hatchability and could improve the quality of day-old chicks.

In vitro effect of curcumin on decorin synthesis in chicken osteoblasts

Ales Pavlik[1], Mikulas Jancov[1], Michala Steinerova[1],
Simona Baldovska[2], Adriana Kolesarova[3], Petr Slama[1]

[1] Mendel University in Brno, Czech Republic

[2] AgroBioTech Research Centre, Slovak University of Agriculture in Nitra, Slovakia

[3] Slovak University of Agriculture in Nitra, Slovakia

corresponding author: ales.pavlik@mendelu.cz

Introduction. *Curcuma longa* L. has long been widely used in medicine to treat various inflammatory conditions and other diseases. These properties are mainly attributed to curcuminoids and the main component of curcumin. Curcumin has been shown to transform into dihydrocurcumin and tetrahydrocurcumin. Curcumin has a wide range of effects, including anticancer, antioxidant, anti-inflammatory and antimicrobial. Recent studies indicate the successful correction of cystic fibrosis-related defects in mice. *In vivo* and *in vitro* studies have shown the ability of curcumin to inhibit carcinogenesis, including in the context of, for example, suppression of mitogen-induced blood mononuclear cell proliferation. It inhibits some protein kinases in cell signalling pathways. The authors of scientific studies have found that curcumin also has a chemopreventive effect. A characteristic feature of curcumin is that it has not been shown to be toxic. The aim of this study was to use isolated chicken osteoblast cells to determine the in vitro effect of curcumin on the synthesis of decorin, one of the non-collagenous bone matrix proteins, which is involved in the process of bone mineralisation and regulation of collagen fibre formation.

Materials and Methods. Several days old broiler chicken of the ROSS 308 hybrid was killed by decapitation. The hind limb was separated, and the skin was removed. This part was decontaminated by immersion in a beaker with 70% ethanol before transfer to a laminar box. Subsequently, the muscle was separated, and the thus obtained femoral bone tissue was used to isolate osteoblast cells. The epiphysis was aseptically separated, cut into small pieces of about 3x3x3 mm and rinsed five times in PBS. DMEM high glucose culture medium with 10% FBS and 1% antibiotics was prepared into a 25 cm^3 culture flask. The bone fragments were transferred to a culture flask. Subsequently, the mitotic activity of the precursor cells was monitored, and when the confluence reached about

80 %, the cells were transferred to other culture flasks and again, at the same confluence, these cells were moved, this time to six-well culture plates. A curcumin solution was prepared by dissolving 4.62 mg in 1253 µl DMSO and then diluting the culture medium to concentrations of 0; 0.5; 3; 5; 10, and 20 µmol·ml^{-1}. These concentrations were used to culture the cells for 10 days after transferring the cells to the plates. After this period, the cells in each well were fixed with para-formaldehyde, their membranes were permeabilised, and any non-specific antibody binding was blocked. The primary antibody – Decorin Polyclonal Antibody (PA1-85833) Sheep IgG and the secondary labelled antibody – Donkey Anti-Sheep IgG (H + L) Alexa Fluor® 488 AffiniPure were used for fluorescent labelling of decorin in cells. An Olympus BX51 fluorescence microscope was used for visualisation.

Results and Discussion. Already during cell culture, it was found that a concentration of curcumin higher than 0.5 µmol·ml^{-1} caused the death of cultured cells. Only at a curcumin concentration of 0.5 µmol·ml^{-1} and the control well were possible to visualise cells by fluorescence. The reason is probably not the actual amount of this phytonutrient, but the concentration of DMSO used to prepare the solution. The obtained fluorescence images show a clear difference in the amount of decorin synthesised by bone tissue cells at a concentration of 0.5 µmol·ml^{-1}, which is higher compared to control cells cultured only in medium.

Conclusion. The results show that curcumin affects decorin production in osteoblasts, but further experiments will be needed to allow the use of other concentrations that were not achieved in this study.

Keywords: bone tissue, broiler chicken, osteoblast, fluorescence

Influence of bacterial components on the course of mastitis

Terezie Zavadilová

Mendel University in Brno, Czech Republic
corresponding author: terezie.zavadilova@mendelu.cz

Introduction. LPS – lipopolysaccharide, a cell wall component of G-bacteria, and MDP – muramyl dipeptide, a structural unit of G+bacterial peptidoglycan, have the ability to elicit an inflammatory response in tissue. The function of neutrophils is to eliminate pathogenic microorganisms during the initial phase of acute inflammation when these cells migrate from the blood to the affected tissue. To maintain homeostasis, a resolution of inflammation is necessary; therefore, neutrophils undergo programmed cell death, apoptosis. Apoptosis is a physiological way of cell death that is genetically controlled, reduces damage to inflamed tissue, and promotes the resolution of inflammation. The resolution is realised by phagocytosis of apoptotic cells by macrophages. This prevents the histotoxic content of the granules from spilling out of the cells. The first step in eliminating apoptotic neutrophils is their identification by macrophages; therefore, biochemical changes occur on the surface of the cytoplasmic membrane of apoptotic neutrophils. The aim of the study was to demonstrate the extent to which bacterial factors are involved in influencing CD14 expression on neutrophiles and their viability.

Material and methods. Neutrophils were obtained by mammary gland lavage and incubated with MDP and LPS. The proportions of apoptotic neutrophils and CD14+ neutrophils were detected by flow cytometry after 30, 60, 120, and 300 minutes of incubation.

Results and discussion. In the course of the study of the CD14 receptor during the inflammatory response of the mammary gland, it was hypothesised for its active participation in the resolution of inflammation, especially for the role of CD14 as a so-called eat me signal for the recognition of apoptotic neutrophils by macrophages. During the incubation of the cells, the proportion of apoptotic neutrophils increased. During incubation with MDP, the proportion of CD14+ neutrophils was statistically significantly higher than the control. After incubation with LPS, the proportions of CD14+ neutrophils were not statistically significantly different.

Conclusion. Cultivation with LPS and MDP slowed apoptosis. A comparison of the proportions of CD14+ neutrophils during incubation with LPS and MDP showed that the proportion of CD14+ neutrophils increased due to these components. LPS is described as an agent with great potential to affect the biological properties of neutrophils. It is therefore surprising that in our study, the effect of MDP on neutrophils was more significant. The influence of LPS and MDP on the course of inflammation should continue to be paid attention to.

A survey on the incidence of breast muscle abnormalities in broiler chickens reared and slaughtered under commercial conditions

Siria Tavaniello, Giuseppe Maiorano

Department of Agricultural, Environmental and Food Sciences, University of Molise, Italy

corresponding author: siria.tavaniello@unimol.it

Introduction. In the last decade, the increasing occurrence of growth-related muscle abnormalities, which mainly affect modern chicken genotypes, termed as White Striping (WS), Wooden Breast (WB), and Spaghetti Meat (SM), has put a strong pressure on the poultry industry and has also challenged the scientific community to understand the mechanisms and the precise etiology of these abnormalities which have a remarkable negative impact on the appearance, technological and nutritional quality, and consumer acceptance of breast meat.

Material and methods. A survey was carried out to estimate the incidence and levels of normal, moderate, and severe cases of WS, WB, and SM conditions under commercial conditions and to evaluate the effect of some *ante mortem* factors on the incidence of the above-mentioned muscle defects. Fillets, from the same commercial lot (Ross 308 reared under conventional intensive system), were selected at 3 h *post mortem* in the deboning area of the commercial processing plant and classified by two experienced persons through manual palpation and visual appearance, according to the presence of muscular abnormalities WS, WB and SM. The fillets were categorised as normal, moderate and severe based on: 1) the size and distribution of the gross white striations on the surface for WS; 2) the diffuse hardened areas and pale ridge-like bulges at the caudal end for WB; 3) the presence of an overall impaired integrity and tendency toward separation of the muscle fibre especially within the cranial part of the fillet for SM. The *ante mortem* variables that were recorded were: sex; feeding (exclusively vegetable or with animal fats); broiler average live weight; age at slaughter; transport time; pre-slaughter lairage time. Data collected from 79 commercial lots were analysed by one-way ANOVA, considering the *ante mortem* factors.

Results and discussion. The average weight of the 15,800 analysed fillets was 715.16g ±155.07. Results regarding the overall incidence of

breast abnormalities can be summarised as follows: i) 34% normal fillets; ii) 43% with at least one of the moderate stage defects; iii) 23% with at least one of the severe stage defects and among these, 16% had only one severe stage defect, 7% had two severe stage defects, and 0.2% had all defects in the most serious stage. Regarding the incidence of the single defect, the WB condition showed the highest incidence: 60,6% (42,5% moderate and 18,1% severe), followed by WS defect equal to 30,9% (21,6% moderate and 9,3% severe); while the incidence of SM condition was equal to 21% (17,4% moderate and 3,6% severe). An exponential increase in the incidence of WS condition was observed with the increase in breast weight; an even more drastic increase was observed for the WB condition in relation to breast weight, while no relationship with the SM condition was observed. Regarding the influence of *ante mortem* factors, the incidence of defects was higher in heavy broilers than in medium ones, especially for the severe stage (respectively: 16.2% vs 4.1% for WS; 27.9% vs 10.8 % for WB; $P < 0.001$). The growth rate of animals had no influence on abnormalities incidence of both medium and heavy broiler categories. Sex, related only to the medium broilers category, did not influence the incidence of WS and WB, while SM in the severe stage showed a higher ($P = 0.000$) incidence in female broilers. Diet, transport time and lairage time at the slaughterhouse have no effects.

Conclusion. As consumer awareness of these abnormalities and the concerns on animal welfare arise, more efforts from poultry producers and scientists are required to reduce the onset and alleviate the severity of the myopathies.

Keywords: breast muscle, spaghetti meat, white striping, wooden breast

Effect of prebiotic supplementation on meat quality traits in female broiler chickens

Mengjun Wu[1], Meng Peng[1], Siria Tavaniello[1],
Katarzyna Stadnicka[2], Giuseppe Maiorano[1]

[1] Department of Agricultural, Environmental and Food Sciences, University of Molise, Italy

[2] Department of Animal Biotechnology and Genetics, Bydgoszcz University of Science and Technology, Poland

corresponding author: m.wu@studenti.unimol.it

Introduction. Worldwide production and consumption of poultry meat increased continuously in recent decades. However, banning antibiotics as growth promoters in poultry production has increased the incidence of some enteric diseases and thus reduced productivity and meat safety. Some natural prebiotics and probiotics were proved to positively affect poultry gut health. The objective of the present study was to explore the effects of dietary supplementation with a commercial prebiotic on female chicken breast muscle quality.

Material and methods. 360 female chicks (Ross 308) were grown to 42 d of age in floor pens and randomly allocated into three groups: C (control group), T1, and T2 groups (n = 10 replicate pens, 12 birds in each pen). The chicks of the control group were fed with the basal diet, whereas chicks of T1 and T2 group were fed with a basal diet supplemented with a commercial prebiotic (DiNovo®, BioAtlantis Ltd., Tralee, Co. Kerry, Ireland), extract of Laminaria spp. containing laminarin and fucoidan at a dose of 840 and 1228 ml/ton, respectively. Water and feed were supplied *ad libitum*. At 42 days of age, 12 randomly chosen chickens per group were slaughtered, and the pectoral muscle (PM) was removed from the carcass for analysis. The pH, colour and water holding capacity (WHC) were measured 24 h postmortem on the right-PM. Total lipids, fatty acid composition and nutritional indices were assessed. Data were analysed by one-way ANOVA. The differences between the means were assessed by the Scheffé test.

Results and Discussion. Neither pH nor colour and WHC were affected by prebiotic administration (P > 0.05), and the observed values were within the range for normal meat with no evidence of muscle defects. Total lipid content was similar (P > 0.05) among groups. Taking into account the fatty acid profile, total saturated fatty acid (SFA) and

polyunsaturated fatty acid (PUFA) contents were similar between experimental groups (P > 0.05). Differently, the total content of monounsaturated fatty acids (MUFA) was slightly higher in C group compared to T1 group (P = 0.088), with intermediate values for T2 group (P > 0.05). MUFA were mainly in the form of oleic acid (C18:1 n-9) which was higher (P < 0.05) in C group compared to T1 group with intermediate values for T2 group (P > 0.05). Nutritional indices, n-6/n-3 ratio, PUFA/SFA ratio (P/S), atherogenic index (AI) and thrombogenic index (TI) were not influenced by prebiotic treatment (P > 0.05). The n-6/n-3 ratio found in the present study is at a distance from the ideal value of 1 and above the recommended maximum of 4. The values of P/S, AI, and TI in the present study were quite beneficial from a nutritional and health point of view.

Conclusion. Commercial prebiotic (DiNovo®) treatment had no negative effect on physico-chemical and nutritional properties of meat from female broiler chickens.

Keywords: Female broiler chickens, meat quality, prebiotics

Application of primordial germ cells and their isolation from chicken blood and gonads

Agata Szczerba[1], Takashi Kuwana[2], Marek Bednarczyk[1]

[1] Department of Animal Biotechnology and Genetics, Bydgoszcz University of Science and Technology, Poland

[2] Shiga University of Medical Science, Setatsukinowacho, Japan

corresponding author: agata.szczerba@pbs.edu.pl

Introduction. PGCs are precursors of reproductive cells and embryonic stem cells of an avian embryo, they are unique because they are the only ones capable of transmitting information stored in the genetic material from generation to generation. Due to this unique feature, they can theoretically be used to save endangered species. Genetic protection of birds is based mainly on in situ technique, i.e. maintaining live collections of birds. It is quite expensive and carries the risk of loss of genetic variability, infectious diseases, or ecological disasters; therefore, this protection should also be supported by an ex situ strategy. This strategy includes the cryopreservation of cells, gametes, or embryos for their later use in the restoration of the species. The protection of endangered breeds of birds requires the preservation of the entire genotype of the animal. Bird oocytes and zygotes are very rich in lipids, which makes them difficult to cryopreserve. For this reason, the conservation of avian genetic resources is essentially based on the cryopreservation of semen. However, the reconstruction of the genotype from the information contained in the semen is not optimal as it requires many successive generations of insemination to restore the breed's genotype and does not preserve that part of the genetic information contained in the W chromosome-specific to the female bird. Accordingly, there is a need to develop new reproductive technologies, using an efficient system of in vitro breeding and further manipulation of PGCs, that will enable the harvest, reproduction, and maintenance of avian reproductive cells. In birds, these cells can be identified already during early embryonic development, i.e. after about 18 hours of incubation. PAS –Periodic Acid Shiff staining is used for their identification, apart from morphological features. It turns glycogen purple. However, this staining is not vital, which prevents further use of the stained cells. Another type of cell identification is immuno-histochemical markers such as SSEA-1 (Stage-Specific Embryonic Antigen-1), and EMA-1 (Embryonic Mouse Antigen-1) antibodies, which

recognise glycoprotein antigens on the cell surface (Nakamura et al., 2007) and CVH (Chicken Vasa Homolog) showing expression characteristic of sex cells. In addition to the above-mentioned markers, a method of double-staining PGCs using antibodies to SSEA-3, SSEA-4, α6, and β1 integrins, as well as STA (Solanum Tuberosum Aglutinin) and DBA (Dolichos Biflorus Agglutinin) lectins, was proposed. These are effective methods but very expensive and require extensive experience in laboratory work and the analysis of the obtained results. It should also be emphasised that the above-mentioned methods of PGCs identification do not ensure their viability; therefore, they reduce their available small pool. The research aimed to develop a comprehensive system enabling the acquisition of a sufficient number of functional PGCs by optimising the method of cell collection and the stage from which the cells will be harvested, as well as effective cultivation to increase their number.

Material and methods. Fertilised eggs from native Green-legged partridge hens were used in the research. The eggs were incubated at 37.8°C for 48–54 hours to obtain the 13–16 HH stage. Blood cells were collected from donor embryos and stained with PKH26 dye. This staining results in labelling the cell membrane with red fluorochrome, which can persist for up to 100 days. After staining, the blood cells were introduced through a microcapillary into the bloodstream of the recipient embryos. All embryos injected with 1 µl of the labelled blood cell suspension were incubated at 38°C for 10 minutes to maintain blood circulation. Embryos showing hemorrhage were removed. After the specified time had elapsed, 1 µl of blood was taken from the recipient embryos to count the stained cells, thus counting all primordial germ cells in the bloodstream at the specified stage. Fertilised eggs from Ross 308 hybrid hens were used in a subsequent experiment. The eggs were incubated at 38°C for 72 hours. From the 18th stage HH embryos, a fragment of the embryo located below the vitelline artery was cut off. The isolated tissues were trypsinised to disperse the cells. The prepared cells were then placed into the wells of a 48-well culture plate previously coated with collagen. The culture was kept at 37.8°C, and the medium was changed every 2–3 days. After passage, the cells were placed in a culture bottle. After the culture stabilised, Mitomycin C was used to stop further fibroblast proliferation. In the next stage, blood was collected from the embryos incubated for 53 hours at the 14–15 HH stage and the gonadal region from the embryos at the 17–18 HH stage. Cell suspensions (cPGCs – circulating PGCs and gPGCs – gonadal PGCs)

were prepared from the collected tissues and applied to the in vitro cultures prepared at that time with food cells – fibroblasts. This way, a double culture of cPGCs on fibroblasts and gPGCs on fibroblasts was obtained. The medium was changed every two days and upon reaching confluence, the culture was passaged. In order to check the migratory capacity of the cultured primary cells, they were stained with the fluorochrome PKH26. The stained cells were then injected into recipient embryos at the 14–16 HH stage. The eggs were incubated for another 5–6 days, after which the gonads of the recipient embryos were isolated and examined under a fluorescence microscope. The presence of luminescent cells in the recipient gonads proved that primordial germ cells, cultured in vitro, retained their ability to migrate from the blood to the gonads.

Results and discussion. The current views on the number of PGCs in embryos and the optimal stage of development enabling their effective isolation were very diverse. Although most previous studies have used popular commercial chicken hybrids such as Rhode Island Red, White Leghorn, and White Rock for inbred lines or local low productivity breeds, the total number of PGCs appears to be lower than for commercial breeds. In our study, it was found that the maximum concentration of cPGC in the Green-legged partridge is 18.6 cPGC/μl, which is a value lower than the maximum concentration of both non-commercial lines (66.9 μl in 14 HH) and the line inbred (26.8 μl in 14 HH). Lower figures (12.1 cPGC/μl in 14 HH) are quoted for endangered native hens in Japan (Kureko Dori). However, it should be emphasised that in our studies, the concentration of cPGCs was measured directly. The total embryonic blood volumes of the Green Leg Partridgelike (Zk) were calculated from the concentrations of PKH26 stained embryonic blood cells that were injected 10 minutes before the blood collection procedure into the same embryos at stages 13 to 16 HH. Both peak and peak levels of the total number of cPGCs were observed at the same stage of development (stage 14 HH). The total number of cPGCs in the entire embryo is determined by the concentration of cPGCs and blood volume. Thus, for the manipulation of Zk-derived PGCs, it is recommended to harvest them from embryos at stage 14 of HH development, and the estimated number of cells present at this stage is approximately 380.

Conclusion. The obtained information may contribute, among other things, to the development of new reproductive technologies that will

enable the acquisition, reproduction, and bio-maintenance of the reproductive cells of this unique breed of chickens. They are of great practical importance as previous research suggests that Zk may be an excellent model for research aimed at, for example, understanding inheritance patterns and gene interaction pathways underlying mixed phenotypes. It is believed that the Green Leg Partridgelike is an unusual bird model for studying the genetic basis of immune responses, especially considering the potentially increased level of immunity in the Zk breed, as well as for the study of the possibility of stimulating the immune system of chickens. These studies also suggest that Zk embryos can be used to implement several other biotechnological techniques. The embryo of the Green-legged partridge is a good donor of embryonic cells and therefore is widely used in genetic manipulations.

Effect of milk thistle on blood parameters of horses

Andrej Bátik

Department of Animal Morphology, Physiology and Genetics,
Faculty of AgroSciences, Mendel University in Brno, Czech Republic
corresponding author: andrej.batik@gmail.com

Introduction. Physical training activity in equestrian sport is one of the most-watched issues of this sport, whether it is from a carriage or racehorses point of view. Much attention is paid to the proper nutrition of horses, which is also the above-mentioned activity, looking for nutritional supplements that will support physical regeneration and psychological resistance to stress. Milk thistle is a well-known herb that fulfils these above conditions. It has antioxidative, hepatoprotective neuroprotective properties.

Materials and Methods. We have therefore included it in the feeding of carriage horses. The horse breed we have chosen is the Czech Warmblood. Milk thistle was added to the feed of the experimental group. The horses worked in pairs. In one pair, there was always one horse from the experimental group and one from the control group. The experiment lasted 56 days. The horses were blood sampled and analysed for various parameters, mainly for stress values in the blood.

Results and Discussion. Statistical results show positive effects of adding milk thistle in the experimental group, which is better able to cope with stress metabolism by utilising substances present in milk thistle.

Keywords: Czech warmblood, stress, physical activity

Egg quality from hens in a free-range system at the beginning or the end of the laying period

Weronika Ragus[1], Jakub Biesek[2], Mirosław Banaszak[2]

[1] Department of Animal Breeding and Nutrition, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, AVIUM Student Scientific Association, Poland

[2] Department of Animal Breeding and Nutrition, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland

corresponding author: werrag000@pbs.edu.pl

Introduction. The production of table eggs in Poland is dynamic. For economic reasons, producers expect laying hens to be in the production cycle for a long time. However, as the hens get older, the quality of the table eggs changes. The study aimed to compare the physicochemical features of table eggs obtained from Lohmann Brown Classic hens at the beginning or at the end of the laying period.

Materials and Methods. In the study, table eggs were obtained from hens kept in a free-range system. The production technology was in line with the technological assumptions for laying hens. The eggs were analysed at 28, 30, 32, 34, and 36 weeks of hens' age (group 1) and 71, 73, 75, 77, and 79 weeks of hens' age (group 2). Twenty eggs per group were analysed at one time (in total 100 eggs per group). The eggs were analysed after being stored for 24 hours at 4°C. By analysing the shape and morphological composition of the eggs, the egg shape index (%) was determined. The eggs were weighed (g) as well as the individual fractions: yolk, albumen, and dry eggshell and their percentage share in the egg were calculated. Physicochemical features were analysed in the study, taking into account: the strength of the eggshell (N), its thickness (mm), and the height of the thick albumen (mm). Haugh units were calculated. The yolk was analysed for colour using the DSM point scale and also with a colourimeter using the CIELab scale (L * – lightness, a * – redness, b * – yellowness). The figures were calculated in the statistical program. Mean values and standard error of the mean (SEM) were calculated. Statistically significant differences between groups were verified using Student's t-test, with a p-value <0.05.

Results and Discussion. Analysing the obtained results, it was found that the weight of eggs obtained from hens aged 71–79 weeks was significantly higher compared to younger hens. Likewise, a higher

weight of yolk, albumen, and eggshell was found, but the egg shape index was lower in older hens. The share of eggshell in the egg (%) was significantly higher in eggs obtained from hens at the age of 28-36 weeks. The percentage of yolk and protein in the egg did not differ significantly with the age of the hens. The strength of the eggshell in both groups was similar; however, the higher eggshell thickness was demonstrated in the group of older hens compared to younger hens. Eggs from younger hens were characterised by a higher height of thick albumen and Haugh units, which testified to the egg's freshness. When analysing the yolk colour, a significantly higher DSM level was shown in the group of older hens, and significantly higher L*, a*, and b* indices were found in the group of hens over 70 weeks of age, which is related to the intensity of the yolk colour.

Conclusions. It can be concluded that table eggs from 71–79 weeks-old hens would be desired by consumers because due to their weight they are classified into class L, and eggs from younger hens to class M. However, in the group of older hens, the egg shape index was below optimal values (73–78%), proving that the eggs were slightly elongated. This is important for transportation and storage. Irregularly shaped eggs are more easily damaged mechanically and can deteriorate faster. The yolk colour was more intense in the older hen group, which is certainly in demand by consumers. It may be related to the fact that older hens stayed longer in the hen house and in free-range, and at the same time had access to plants with a high content of carotenoids (natural pigments, e.g. grass). Considering the egg's freshness, favourable values were found in the group of younger hens (height of thick albumen and HU), indicating the possibility of longer storage of eggs and their suitability for consumption.

Single Step Genomic Prediction of Milk Yield in Polish Holstein Friesian Dairy Cattle

Magdalena Kolenda[1], Beata Sitkowska[1], Hasan Önder[2], Dariusz Piwczyński[1], Burcu Kurnaz[3], Uğur Şen[4]

[1] Department of Animal Biotechnology and Genetic, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland

[2] Department of Animal Science, Faculty of Agriculture, Ondokuz Mayis University, Türkiye

[3] Department of Animal Science, Faculty of Agriculture, Ondokuz Mayis University, Türkiye

[4] Department of Agricultural Biotechnology, Faculty of Agriculture, Ondokuz Mayis University, Türkiye

corresponding author: kolenda@pbs.edu.pl

Introduction. This study aimed to compare the accuracy of Bayesian alphabet (A, B, C, Cp) with the single-step genomic prediction of milk yield in Polish Holstein Friesian dairy cattle.

Material and methods. Genomic data used in the study came from routine estimation of breeding value with the use customised SNP arrays that is done in Poland. Phenotypic data were obtained from the Polish Federation of Cattle Breeders and Dairy Farmers. To estimate the genetic parameters such as heritability and genomic breeding values for milk yield on Polish Holstein Friesian population, 13,481 SNPs were used. 50,000 iteration were used, and the first 5,000 iteration was burned-in. The lactation number (1, 2 and 3) was used as a fixed factor and days in milk were used as a random factor. Two hundred thirty-one SNPs were monomorphic and excluded from the analysis. All analyses were done using GenSel (https://de.cyverse.org/).

Results and discussion. The mean of 2pq was found as 0.376. The heritability values were estimated as 0.547, 0.5309, 0.543 and 0.545 for Bayes A, Bayes B, Bayes C and Bayes Cp, respectively. The coefficients of determinations values were found to be 0.623, 0.619, 0.624 and 0.623 for the same order of Bayesian alphabet. The p-value was estimated as 0.529 for Bayes Cp. The minimum computation time was 278 seconds for Bayes C, and the maximum was 1,741 seconds for Bayes B.

Conclusion. The results, according to the coefficient of determination, show that the best model was Bayes C. Spearman Rank Correlation was

made for animals ranked according to breeding value. As a result, it was determined that the highest correlation was between Bayes A and Bayes Cp (0.239), and the lowest correlation was between Bayes B and Bayes Cp (0.083).

Polymorphisms that change frequencies of genotypes affecting milk yield

Beata Sitkowska[1], Magdalena Kolenda[1], Dariusz Piwczyński[1], Hasan Önder[2], Burcu Kurnaz[2], Uğur Şen[3]

[1] Department of Animal Biotechnology and Genetic, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland

[2] Department of Animal Science, Faculty of Agriculture, Ondokuz Mayis University, Türkiye

[3] Department of Agricultural Biotechnology, Faculty of Agriculture, Ondokuz Mayis University, Türkiye

corresponding author: beatas@pbs.edu.pl

Introduction. The aim of the study was to investigate SNP microarray data and try SNPs that may be associated with changes in milk yield (MY) in full lactation of cows of Polish Holstein Friesian (PHF) of the black and white variety.

Materials and Methods. MY data was obtained for 492 cows and a total of 13,481 SNPs were used for the analysis. GenSel (https://de.cyverse.org/) was used to estimate breeding values (the lactation order was used as a fixed factor, and days in milk were used as a random factor). During this analysis, it was found that several SNPs on the array were associated (according to Bayes A method) with MY and increased the frequency of AA genotypes. We decided to investigate these SNPs further. SNPs were located on chromosome 4 (SNP1; position 101,790,675 according to UMD_3.1 reference genome), chr14 (SNP2; position 1,651,311) and chrX (SNP3; position 92,260,895).

Results and Discussion. For SNP1, most frequent was AA genotype (49%), followed by AB (41.7%). For SNP2 most cows were AA homozygotes (56.9%), and the least frequent was BB (7.3%). For SNP3, all three genotypes were also identified, with the most frequent being AB (49.0%) and the least BB (15.7%) genotypes. In order to evaluate the allele effects on MY, a covariance analysis was used. Days in milk and lactation order were used as covariates. Means were compared with Bonferroni test and Kendal's Tau correlation coefficient was used to evaluate the relationship among alleles (SPSS v.20.0). It was shown that for SNP1 the highest estimated marginal mean for MY (13,812.07 kg) was obtained for cows with AA genotype and the lowest (12,352.89 kg)

for BB. For SNP2 MY was the highest for AA animals (14,045.06 kg), the lowest for BB (lower by almost 7.5%). Similarly for SNP3 (with the highest MY (14,087.47 kg) for AA animals and lower MY (by over 12.0%) for animals with BB genotype. All these differences were significant.

Conclusion. The research shows that microarray genotypic data can be used to search for associations between genes included in the arrays and performance traits.

Keywords: milk yield, microarray, Polish Holstein Friesian, polymorphism

Growth performance and meat quality from chickens fed with aluminosilicates

Zuzanna Brzycka[1], Jakub Biesek[2], Mirosław Banaszak[2]

[1] Department of Animal Breeding and Nutrition, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, AVIUM Student Scientific Association, Poland

[2] Department of Animal Breeding and Nutrition, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland

corresponding author: zuzbrz000@pbs.edu.pl

Introduction. In poultry production, the search for appropriate solutions that affect production efficiency is in progress. As an alternative to non-antibiotic rearing of broiler chickens, probiotics, prebiotics, phytobiotics, and eubiotics were proposed. The potential is demonstrated by aluminosilicates, characterised by a broad spectrum of activity. The research aimed to evaluate the effect of a feeding diet supplemented with halloysite and zeolite mixture on carcass characteristics and slaughter yield of broiler chickens.

Materials and Methods. In the experiment, 500 males of Ross 308 broiler chickens were used. Birds were divided into two groups. In the experimental group (HZ), the mixture of halloysite and zeolite was in proportion 25:75. The aluminosilicates were added to feed, depending on the feeding period, at a level of 0.5% – starter, grower 1, and grower 2 feed, and 1% to the finisher type of feed. Group HZ had 400 chickens. Birds were kept in the replications (pens with 10 birds in each). Feed and water were *ad libitum.* During the 42 days of the rearing period, the body weight and feed intake were controlled. The body weight gain (BWG) and the feed conversion ratio (FCR) were calculated based on these data. After 42 days, 10 birds from the C group and 40 from the HZ group were randomly chosen for slaughter from each pen. The slaughter was done according to the regulations. Carcasses were prepared and stored for 24 hours at 4°C. After this period, carcasses were weighed, and the slaughter yield was calculated. Then, pectoral muscles (m. *pectoralis major* and *minor*), leg muscles (the thigh and shank muscle, trimmed), and skin with subcutaneous and abdominal fat were dissected. One-way analysis of variance and the Tukey test were used.

Results and Discussion. Analysing obtained results, the differences in BWG were found. In group HZ, the lower BWG in the 1st and 2nd feeding periods were noticed (p = 0.035, <0.001). However, after 21 days of

rearing, the BWG was higher in the HZ group (p < 0.001, 0.007), as well as in the whole period of rearing (1–42 days), compared to the C group (p = 0.050). Compared with the C group, FCR was higher in the group HZ in 14–21 days (p < 0.001), but it was lower in the 3rd feeding period (22–36 days) (p < 0.001). Despite the partial differences between the groups in FCR values, no effect of feeding with the addition of aluminosilicates on the feed conversion ratio calculated for the entire rearing period was found. The slaughter yield in both groups was similar (74.89–75.84%). The values of share of pectoral and leg muscles and carcass fatness were not significantly different between the groups (p > 0.05).

Conclusions. Based on the obtained results, the feeding with the addition of halloysite and zeolite in proportion 25:75 and the level 0.5–1% in feed could be recommended due to the beneficial effect on the body weight gain of broiler chickens, without the influence on feed conversion ratio and the slaughter yield of the carcass. The obtained results suggest that the aluminosilicates supported the digestibility and utilisation of nutrients.

Assessment of growth and footpad dermatitis in chickens kept on a different type of pellet bedding

Monika Grzybulska[1], Sebastian Wlaźlak[1], Jakub Biesek[2]

[1] Department of Animal Breeding and Nutrition, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, AVIUM Student Scientific Association, Poland

[2] Department of Animal Breeding and Nutrition, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland

corresponding author: mongrz001@pbs.edu.pl

Introduction. Poland is the leader in broiler rearing. The production of poultry meat is dynamic, and the needs and trends are constantly changing. It is important to limit skin lesions on the soles of the feet of broiler chickens. Paws are part of the raw material that should not have any lesions eliminating it from the sale. The research aimed to evaluate the production results and the presence of footpad dermatitis (FPD) in broiler chickens.

Materials and Methods. Eighty Ross 308 broiler chickens were used in the study. The birds were divided into two groups. Birds were kept in 4 replicates of 10 birds each (in each group). Group 1 was the control group. The chickens were kept on a wheat straw pellet. In group 2, the chickens were kept on a pellet made of wheat straw and coffee husks in a 1:1 ratio. The rearing period lasted 42 days. The chickens were fed under the broiler chicken production technology. There were 3 phases of feeding: starter, grower, and finisher. Food and water were *ad libitum*. Body weight and feed intake were monitored during rearing. Based on the recorded data, body weight gain and feed conversion ratio were calculated. On the day of slaughter (day 42), skin lesions on the soles of chickens' feet were analysed. The Swedish scale was used (footpad dermatitis assessment generally accepted in Europe). The scale has three levels. A score of 0 indicated no or very small superficial changes, slight discolouration of the skin of the sole, and mild hyperkeratosis. Score 1 indicated mild skin changes and discolouration, as well as superficial changes, dark warts, and hyperkeratosis. According to the scale, a rating of 2 indicated severe lesions, ulcerations, and crusts, as well as signs of haemorrhages and swollen soles of the paws. Based on the collected data, the percentage share of individual footpad dermatitis categories in the group was calculated, and the scores were calculated according to the formula: ([100 × (0 × FPD number yielding 0 + 0.5 ×

FPD number yielding 1 + 2 × FPD number yielding 2)]) / (total number of FPD lesions assessed). The data was compiled in a statistical program. Mean values and standard error of the mean (SEM) were calculated, and statistically significant differences were verified using the Student's t-test, assuming a p-value <0.05. The footpad dermatitis data were shown as quantified.

Results and Discussion. Chick body weight was similar in both groups on the day of insertion (37.78-38.00 g). After 42 days, the body weight of the birds was not significantly different (p = 0.559). In group 1, it was shown that birds were 72.32 g heavier than in group 2. Similarly, no statistically significant differences in body weight gain were found between the groups (p = 0.330). The data on the feed consumption parameters were also not statistically significantly different (p = 0.412), and the feed conversion ratio in both groups was almost the same (1.68– 1.69 kg/kg). Analysing the data on footpad dermatitis varies considerably between the groups. In the control group, as much as 47.5% of the flock was characterised by the presence of slight skin lesions, assessed on a scale of 1. In the experimental group, only 5.56% of the flock was characterised by the presence of slight skin lesions on the soles of the feet. On the FPD point scale, the difference between the control (23.75) and the experimental group (2.78) was 20.97.

Conclusions. To sum up, using alternative bedding materials, coffee husks, did not affect the production efficiency expressed in weight gain and feed consumption. However, the undesirable skin changes, called footpad dermatitis, on the soles of the feet of broiler chickens were significantly reduced. The use of pellets made of a mixture of wheat straw and coffee husks can be an interesting solution in alternative production methods, taking into account the welfare of the birds. At the same time, the discussed topic highlights the possibility of reusing waste from other industries, in this case, local coffee roasting plants. Reducing the incidence of footpad dermatitis may impact the producer's increased profit, taking into account the sale of chicken feet.

Keywords: broiler chicken, small-scale farm, coffee husk, wheat straw, production efficiency

The efficiency of broiler ducks production depends on intensive or semi-intensive feeding

Sebastian Wlaźlak[1], Jakub Biesek[2], Marek Adamski[2]

[1] Department of Animal Breeding and Nutrition, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, AVIUM Student Scientific Association, Poland

[2] Department of Animal Breeding and Nutrition, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland

corresponding author: sebastian.wlazlak@pbs.edu.pl

Introduction. Feeding is the most costly factor in the production of broiler ducks. It is estimated that the cost of feeding can be up to 70% of all production costs. At the same time, due to the increase in the prices of feed components, alternative solutions are sought in the aspect of poultry nutrition that could positively affect the economy of production. In response to the challenges of modern broiler poultry production, the study aimed to assess the production results and indicators of the production efficiency of broiler ducks fed with complete feed partially replaced by wheat grains as the semi-intensive nutrition strategy.

Materials and Methods. Two hundred one-day-old Cherry Valley ducks were divided into 4 equal groups in 5 repetitions each. The environmental conditions were in the small-scale standards. The feeding was divided into two periods: starter feed was used from day 1 to day 28, and grower feed was used from day 29 to 49. The first group was the control group (C), in which the ducks were fed with the complete feed (intensive feeding) throughout the rearing period. In the experimental groups, in the last week of rearing, the feed was partially replaced with wheat grain at the level of 10% (W10), 20% (W20), and 40% (W40), respectively (semi-intensive feeding). The composition of the control and experimental feeds were analysed. Body weight (BW) and feed intake (FI) were recorded and the viability was monitored. Based on these data, the body weight gain (BWG), feed conversion ratio (FCR), European Broiler Index (EBI) and European Production Efficiency Factor (EPEF) were calculated. The feed costs per bird in each feeding period and throughout the rearing period, feed costs per 1 kg of live body weight, and profit per 1 kg of the carcass were calculated, and the experimental feed costs compared to the control feed (%) was presented. Costs were calculated according to the prices for the period December 2021-January 2022.

Results and Discussion. In the control and the W10 groups, a higher content of crude ash and crude protein (P < 0.001) was found compared to the other groups. The feed from group C also had a higher content of crude fat and crude fibre (P < 0.001) than in groups W10, W20, and W40. Statistically, significantly higher starch content was found in the W40 group (46.72%). Feed costs per bird were significantly lower in the group, where the feed was replaced with wheat at the level of 20 and 40% during the last week of the rearing period (P = 0.007), and throughout the rearing period (P = 0.019). Costs decreased by 1.59 PLN and 1.89 PLN, respectively (last week of the rearing period), and by 2.01 PLN, and 2.25 PLN, respectively (whole rearing period). The experimental feed costs were significantly lower in the W50 group (P = 0.044) compared to the C group (decrease by 9.24%). A statistically significant higher profit per 1 kg of carcass weight was found in group W40 (P = 0.033), and its increase compared to group C was 3.34 PLN.

Conclusions. Partial replacement of the feed with wheat grains did not adversely affect the production results of broiler ducks. The experimental factor's favourable influence was found in production efficiency indicators, particularly in the case of lower feed costs per bird (groups W20 and W40), lower total feed costs in the W20 group, and increased profit per 1 kg of carcass weight. Considering the above, it is justified to feed broiler ducks with feed partially replaced by wheat grains. It could reduce the cost of the feed and thus the cost of the entire production of broiler ducks. In particular, such a semi-intensive feeding strategy can be used in small-scale farms, where wheat is an easily accessible feed component.

Keywords: waterfowl, feed costs, growth performance, wheat grains, production efficiency

Effect of different housing systems of hens on the eggs quality features after the 80th week of age

Muhammed Şamil Açar, Jakub Biesek, Mirosław Banaszak

Department of Animal Breeding and Nutrition, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland

corresponding author: acar.muhammed@pbs.edu.pl

Introduction. The housing system of laying hens is a controversial topic due to the planned ban on the production of eggs from the cage system. Cage housing is still one of the more popular systems. However, consumers prefer free-range eggs, which is associated with a higher level of hen welfare. The aim of the study was to compare the physicochemical features of table eggs obtained from Lohmann Brown Classic hens, after the 80th week of age, kept in a cage housing system or free-range system.

Materials and Methods. In the study, table eggs were obtained from Lohmann Brown Classic hens, after 80th weeks of age, kept in a cage housing system or free-range system. Hens were 82 weeks of age when the analyses were started. The production technology was in accordance with the technological standards for this type of laying hens. Group C was the group of hens kept in the cage system. The group FR was the group of hens kept in the free-range system. The eggs were analysed at 82, 84, and 86 weeks of hens' age, 20 eggs per group were analysed at a time (in total 60 eggs per group). Eggs were transported from the company to the laboratory in one day and stored for 24 hours at 4°C. The shape and morphological composition of the eggs were analysed. The egg shape index (%) was determined automatically. The whole eggs and the fractions (yolk, albumen, and dry eggshell) were weighed (g). The share of yolk, albumen, and eggshell in the egg was calculated (%). The strength of the eggshell (N) was checked by the Egg Crusher. The micrometre screw measured its thickness (mm). The height of the thick albumen (mm) and Haugh units were calculated by the Egg Analyzer machine. The colour of the yolk was analysed using the DSM point scale (subjective method) and with a colourimeter (the CIELab scale, where L * – lightness, a * – redness, b * – yellowness, objective method). The data were calculated in the statistical program. Mean values and standard error of the mean (SEM) were calculated. Statistically significant differences between groups were verified using Student's t-test, with a p-value <0.05.

Results and Discussion. The analysis of the data showed a significantly higher value of the egg shape index in the FR group compared to the C group (p < 0.001). In the FR group, statistically, significantly lower weight of the yolk (p = 0.044) and, at the same time, a greater weight of the egg shell (p = 0.021), its percentage in the egg (p = 0.004), and its thickness (p = 0.001) were also demonstrated. No statistically significant differences were found in the other features (p > 0.01). The lack of statistically significant differences between the groups in terms of quality features proves that the quality of eggs was at a similar level regardless of the hens' housing system. In both groups, the egg's weight was over 63 g, putting them in category L. The egg shape index in both groups was below 73%, which indicates that the eggs were elongated. In the group of eggs from the cage system, eggs were significantly elongated. The thickness of the eggshell in the FR group may indicate that the eggs are more durable. Despite the visible trends of higher eggshell strength in the FR group (43.07 N) than in the C group (41.49 N), this was not statistically confirmed (p = 0.337). The yolk colour in both groups was at a similar level, which indicates that the content of pigments (carotenoids) in the feed in the cage system was at a level similar to the free-range system, despite access to the plants, such as grass, in the FR group on the free-range.

Conclusions. It is concluded that the housing system of laying hens is of little importance in terms of egg quality in hens over 80 weeks of age. The beneficial aspects of keeping hens in a free-range system should be focused on the quality of the eggs. Still, most of all, it is desirable to the consumers due to the fact that the hens can exhibit most of their natural behaviour.

Functional analysis of differentially expressed microRNAs in immune-related tissues of *in ovo* stimulated chickens with bioactive substances

Ramesha Nirmali Wishna Kadawarage, Aleksandra Dunislawska, Elżbieta Pietrzak, Maria Siwek

Department of Animal Biotechnology and Genetics, Faculty of Animal Breeding and Biology, Bydgoszcz University of Science and Technology, Poland

corresponding author: ramesha.wishna-kadawarage@pbs.edu.pl

Introduction. MicroRNA (miRNA) is a fraction of small RNA molecules which affects the expression of target genes by binding to the 3'-UTRs end of the regulated mRNA molecule, destabilising it and preventing translation. Our previous research showed that *in ovo* stimulation with bioactives changed the expression of miRNAs in the spleen and cecal tonsils in adult chickens. However, the potential functional impact of these epigenetic changes was not known. Increased expression of miRNA can lead to increased silencing of the genes. Thus, we hypothesised that the functional enrichments of target genes of miRNAs which showed an increased expression, might be down-regulated in the spleen and cecal tonsils of chickens. Therefore, the objective of this study was to identify the functional enrichments of differentially expressed miRNAs in the spleen, and cecal tonsils of two distinct chicken strains stimulated *in ovo* with bioactives, in order to identify the potential functional impact of these miRNA changes.

Materials and Methods. On day 12 of incubation, eggs of Ross 308 chicken broilers and Green-legged patridgelike were injected with probiotic- *Lactococcus lactis*, prebiotic- galactooligosacharide and synbiotic- combination of both. RNA was isolated from tissues collected *postmortem* on day 42 of rearing. Analysis of miRNA expression was performed by LNA method for the selected panel of miRNA (miR-1612, miR-204-5p, miR-1674, miR-1652, miR-1598, miR-1996) and calculated using ddCt formula. The miRNAs which were differentially expressed (p value ≤ 0.05) were selected for the functional analysis of the current study. Target genes (target score ≥ 80) of these miRNAs were determined using the miRDB database. The enrichment analysis of target genes was performed using ClueGO (v2.5.7) plug-in within Cytoscape (v3.9.1) using *Gallus gallus* as the reference genome. Over-represented gene ontologies (GOs), Biological processes, Molecular Functions, Cellular Components and Immune System Processes

(updated on 05.06.2022) were identified using a right-sided hypergeometric test with the Benjamin-Hochberg method of multiple testing correction. Significant GOs (mid p values ≤ 0.05) were clustered based on the Kappa statistics (Kappa score threshold is 0.4) and medium network specificity (GO tree interval; minimum = 3 and maximum = 8). Functions of individual genes were identified using GeneCards – the human gene database.

Results and Discussion. The most changes of miRNAs (p value ≤ 0.05) were observed in the cecal tonsils of GP chickens when treated with synbiotics, while only miR-1598 and miR-1652 showed significant differences between the treatment groups in cecal tonsils and spleen of Ross chickens, respectively. Out of 6 miRNAs which showed significant differences between groups, only 2 (miR-1612 and miR-1652) showed significant GO enrichment with 17 and 2 kappa score groups of enriched GOs, respectively. The Kappa score groupings showed that broadly, the functions associated with gene expression or protein regulation, nervous system and immune system were enriched.

Conclusions. These results suggest that *in ovo* microbiome stimulation with synbiotics might regulate the immune functions of the gut via epigenetic mechanisms in different immune tissues in a genotype-dependent manner. Hence, the bioactive substances and genotype should be taken into account for optimising the benefits of microbiome modulation in chickens.

Keywords: cecal tonsils, epigenetics, gene ontology, spleen and synbiotics

Multispecies probiotic supplementation evokes hepatic gene expression changes in pigs

Aleksandra Bełdowska[1], Aleksandra Dunislawska[1],
Marcin Barszcz[2], Anna Tuśnio[2], Agnieszka Herosimczyk[3],
Małgorzata Ożgo[3], Marcin Taciak[2], Adam Lepczyński[3]

[1] Department of Animal Biotechnology and Genetics, Bydgoszcz University of Science and Technology, Poland

[2] Department of Animal Nutrition, The Kielanowski Institute of Animal Physiology and Nutrition, Polish Academy of Sciences, Poland

[3] Department of Physiology, Cytobiology and Proteomics, West Pomeranian University of Technology, Poland

corresponding author: alebel004@pbs.edu.pl

Introduction. Since the European Union sanctioned the legal ban on the use of antibiotics as growth promoters for animals at the beginning of 2006, significantly increased numbers of studies have focused on the development of alternative substances to maintain or improve health and performance of livestock. Probiotics have gained special attention among various bioactive compounds due to their well-documented overall health-promoting effects in pigs. Appropriately selected probiotic strains have the ability to reduce the harmful effects of pathogenic microorganisms and stimulate the development of a healthy microbiota. Bioactive peptides, neurotransmitters, short-chain fatty acids, hormones, and amino acids produced or regulated by gut microbiota may also influence liver gene expression. Liver is a vital organ that plays several key functions in the organism, including protein, lipid and carbohydrate metabolism, detoxification, as well as endocrine, immune, and storage functions. Therefore, the aim of this study was to determine the effect of dietary addition of a multispecies probiotic on the expression of genes coding proteins involved in cholesterol metabolism, bile acids synthesis, energetic metabolism regulation and stress in pig liver.

Materials and Methods. Pigs (eight per group) were fed from the 10th day of life a diet supplemented with probiotic preparation containing: *Lactococcus lactis, Carnobacterium divergens, Lactobacillus casei, Lactobacillus plantarum,* and *Saccharomyces cerevisiae*. The liver for RNA isolation was collected *post-mortem* at the 50th day of life. Relative gene expression analysis was performed by RT-qPCR for the following genes: *ApoA1, Abcc4, BAAT, PPARA, PPARG, CRP, CAT, PRDX5, TXNRD1* and *TfR*.

Results and Discussion. Results showed a significant increase in the expression of each gene analysed in response to dietary supplementation with probiotic as compared to the control group. This study confirms the beneficial effects of probiotics on pigs such as improvement of digestive and metabolic processes.

Keywords: liver, microbiome, probiotic

Nested Models with Permutation

Hasan Önder

Ondokuz Mayıs University, Agricultural Faculty, Department of Animal Science, Türkiye

corresponding author: hasanonder@gmail.com

Introduction. F and t-tests are generally used to test the significance of hypothesis and/or model parameters. Even though parametric tests are considerably effective, they can be ineffective when the assumptions needed by the model are not matched, which is a reality for many data sets. In this case, the permutation test not affected by the assumptions can be applied as a non-parametric method.

Material and methods. In this article, the permutation test is compared to the analysis of variance in terms of the P value, and the performance of both tests is studied via animal data. To create different size of samples (12, 18, 24, 30 and 36 lambs of 2, 3, 4, 5 and 6 ewes under 3 rams), randomised sub-sampling was used on the whole data set. To analyse the data, NPMANOVA software written by Anderson was utilised. Restricted permutation of raw data and permutation of residuals under the full model were used.

Results and Discussion. Results from this study indicate that the permutation test yields more reliable results than the analysis of variance in terms of Type I error rate. If the nested factor levels are so low that the number of possible permutations can not give P values less than the chosen significance level, then restricted permutation of raw data must be used. Permutation of residuals under the full model should not generally be used, however, if the sample size is extremely small ($n < 5$).

Conclusion. The permutation test is recommended because of obstructing to make Type I and II errors. In general, restricted permutation will yield a more conservative test, while the test using permutation of residuals will tend to be more powerful. Although this is a more conservative approach, restricted permutations will give the exact permutation test.

Keywords: permutation tests, nested model, type I error rate

Effect of culture temperature during IVM on oocyte maturation and embryo development in Bovine

Uğur Şen

Ondokuz Mayis University, Türkiye

corresponding author: ugur.sen@omu.edu.tr

Introduction. The preovulatory follicles have a temperature of approximately 1.5°C to 2°C less than the ovarian stroma or core body temperature in bovines. Therefore, the aim of this study was to compare the effects of low (36.5°C) and conventional (38.5°C) incubation temperatures on the maturation of bovine oocytes, glutathione peroxidase enzyme activity, 70 kDa proteins and developmental competence of embryos and oocytes.

Material and methods. In experiment 1, oocytes were matured in bicarbonate-buffered TCM–199 for 22 hours in a humidified atmosphere of 5% CO_2 in the air at either low or conventional culture temperature, and nuclear maturation status was determined. In experiment 2, in vitro fertilised oocytes were allocated randomly into a synthetic oviductal fluid medium and cultured in a humidified atmosphere of 5% CO_2, 5% $O2$, and 90% N_2 in the air at conventional culture temperature for 8 days.

Results and Discussion. There were no significant differences between incubation temperatures in terms of oocyte maturation parameters such as cumulus expansion, first polar body extrusion and nuclear maturation. The 70 kDa proteins band size in SDS-PAGE polyacrylamide gel image of bovine oocytes matured at low culture temperature was weak compared to bovine oocytes matured at conventional culture temperature. Bovine oocytes matured at low incubation temperature had significantly lower glutathione peroxidase enzyme activity than those of oocytes matured at a traditional temperature of incubation. Similarly, glutathione peroxidase enzyme activity of blastocysts obtained from oocytes matured at low incubation temperature was significantly lower than those of oocytes matured at conventional incubation temperature. Incubation temperatures during in vitro maturation had no effects on the developmental competence of embryos. Still, blastocysts from oocytes matured at low culture temperature had comparatively higher inner cell mass and low overall and trophectoderm cell numbers ($p < 0.05$).

Conclusion. The results of the present study showed that the maturation of bovine oocytes at low culture temperature might provide a suitable thermal environment for nuclear maturation and subsequent embryo development.

Deciphering the Functionality of PGCs in Epigenetic Inheritance of the Effects Induced by *In Ovo* Chicken Embryo Stimulation

Mariam Ibrahim, Marek Bednarczyk, Ewa Grochowska, Katarzyna Stadnicka

Department of Animal Breeding and Nutrition, Bydgoszcz University of Science and Technology, Poland

corresponding author: miriam.ibrahim@pbs.edu.pl

Introduction. Epigenetic alterations in the germline are of utmost importance given their tendency to impact future generations. In ovo administration of bioactive substances has the potential to trigger epigenetic changes that can eventually improve poultry wellness and performance. Remarkably, these changes can be handed down from generation to generation. In order to better comprehend how induced epigenetic stimulations can often pose long-lasting changes in chicken clades, we aimed to elucidate the mechanisms governing the inheritance of attained epigenetic characteristics in Green-legged Partridge chickens by studying primordial germ cells (PGCs) after the epigenetic impact in ovo.

Material and methods. The work plan to achieve this aim was as follows: three experimental groups (synbiotic and choline-treated and control) are established over four generations, and PGCs are retrieved from each in ovo treatment group. Circulating PGCs are taken from embryonic blood at 14–15 H&H development stage, and gonadal PGCs are isolated from the embryos at 29–31 H&H stage. If feasible, the isolated PGC-containing samples are then subjected to enrichment protocol with fluorescence-activated cell sorting (FACS) to purify and sort PGCs out of somatic/or erythrocytes cells. RNA and DNA genetic materials are isolated from the enriched PGCs population for total cellular RNA sequencing and DNA methylation epigenome studies. We expect that epigenetic modifications acquired in one generation are passed down through PGCs, affecting the phenotypes of future generations. The potential to profitably adjust the chicken epigenome will furnish likely routes to establish robust, healthy chicken species.

Keywords: choline, epigenetic impact, in ovo, inheritance, primordial germ cells, synbiotic

From farm to fork: the role of the pasture on beef quality

Giuseppe Maiorano, Siria Tavaniello

Department of Agricultural, Environmental and Food Sciences, University of Molise, Italy

corresponding author: maior@unimol.it

Introduction. Meat production has increased globally over the past decades and is projected to further increase due to economic and population growth. Meat is a nutrient-dense food that can be considered an evolutionarily appropriate food for humans. However, a growing debate among consumers on meat and meat products is ongoing, presenting such foods as unsustainable, unethical, and unhealthy being associated with the risk of colorectal cancer and cardiovascular disease. In particular, beef meat is currently under pressure since cattle are considered as the food animals with the greatest environmental impacts as compared to monogastric animals or even more to plant-based proteins. Beef is one of the widely consumed protein sources in the world. The variety of beef production and quality is based on a wide range of breeds, feeding and housing systems, and diverse climatic and geographical conditions. The environmental impacts in terms of carbon, water, soil, and biodiversity footprints are highly contextual, and their estimation is often erroneous due to a reductionist use of metrics. In fact, even if pasture systems have a greater environmental impact in terms of greenhouse gasses related to lower productivity, if well-managed, can contribute to ecosystem management making use of marginal land with a several "ecosystem services" such as soil stabilisation and formation, carbon sequestration, nutrient cycling and availability, biodiversity, and wildlife habitat, which cumulatively result in increased ecosystem and economic stability and resilience of inner areas.

Discussion. The objective of this lecture is to argue the advantages that a grazing diet, partially or total, can offer both from the point of view of the nutritional quality of the meat and the environmental sustainability. Animals fed concentrate produce a meat more tender and better flavoured than forage-fed animals. On the contrary, animals fed on pasture (or with fresh forages) produce a darker and tougher meat. However, meat from animals raised on pasture is generally characterised by a better fatty acidic composition (higher content of

unsaturated fatty acids, mainly n-3 fatty acids) and a higher content of natural antioxidants, in particular the vitamin E capable of increasing the shelf life of meat. In fact, vitamin E has an important role in retarding lipid oxidation and increasing the oxidative stability of meat, and it may have a positive effect on preventing the formation of carcinogen substances during the cooking process (in relationship of method, time, temperature), as heterocyclic amines (HCAs) and polycyclic aromatic hydrocarbons (PAHs) dangerous for human health. Recently, our in vitro study seems to confirm this hypothesis.

Conclusion. From our point of view there is a substantial margin for improvement to reduce the environmental impact of meat production and a more careful reading and interpretation of the data reported in the literature is required. However, there are several questions to ask. Two seem very pertinent to us: i) could reducing beef consumption or replacing it with meat produced in the laboratory have a minor impact on the environment?, ii) what impact will a meat produced in a laboratory and cooked at high temperatures have on human health?

Effect of prebiotic supplementation on growth performance and carcass traits of female broiler chickens

Meng Peng[1], Mengjun Wu[1], Siria Tavaniello[1], Marek Bednarczyk[2], Giuseppe Maiorano[1]

[1] Department of Agricultural, Environmental and Food Sciences, University of Molise, Italy

[2] Department of Animal Biotechnology and Genetics, Bydgoszcz University of Science and Technology, Poland

corresponding author: m.peng@studenti.unimol.it

Introduction. Since antibiotics were banned from being added to feed as growth promoters, it has become increasingly necessary to find suitable alternatives to improve animal health, growth, and the safety of poultry products in a sustainable manner. One of these alternatives is prebiotics, which typically refers to selectively fermented nondigestible food ingredients or substances that specifically support the growth and/or activity of health-promoting bacteria colonising the gastrointestinal tract. The present study aimed to explore the effect of two different concentrations of commercial prebiotics as feed supplements on growth performance and carcass traits of female broiler chickens to provide a reference for the application of probiotics as dietary supplements in poultry production.

Material and methods. 360 female chicks (Ross 308) were grown to 42 d of age in floor pens, randomly allocated into three groups: C, control group, T1 group, and T2 group (n = 10 replicate pens, 12 birds in each pen). The chicks of the control group were fed with the basal diet, whereas chicks of the T1 and T2 group were fed with a basal diet supplemented with a commercial prebiotic (DiNovo, BioAtlantis Ltd., Tralee, Co. Kerry, Ireland), extract of *Laminaria spp.* containing laminarin and fucoidan at a dose of 840 and 1228 ml/ton, respectively. Water and feed were supplied on an *ad libitum* basis. Feed intake was recorded on a pen basis at 10, 20 and 40 d, and accordingly, feed conversion rate (FCR) was calculated. At 42 days of age, 12 chickens per group were randomly selected, weighed and slaughtered. The weight of the carcass, pectoral muscle and legs were recorded, and the yield of each cut was calculated, respectively. Data were analysed by one-way ANOVA, and the differences among the means were assessed by the Scheffé test.

Results and Discussion. Mortality was not affected by prebiotic supplementation(P > 0.05). Live weight and food consumption during the first 10 days of life were influenced by the treatment. In particular, the T2 group showed a higher weight gain compared to the control group (P < 0.05), with intermediate values for the T1 group (P > 0.05). Consistently, food consumption was higher in the T2 group than in the C group (P < 0.05). Live weight and food consumption during the periods 10–21 days and 21–40 days, as well as for the overall rearing period, were not influenced (P > 0.05) by the prebiotic treatment. FCR was similar among groups (P > 0. 05). The weight and yield of carcass, pectoral muscle, and legs were not affected by the treatment (P > 0. 05).

Conclusion. Supplementing commercial prebiotics in diets had a positive effect on growth performance in the early period of life of female broiler chickens.

Keywords: carcass traits, female broiler chickens, in vivo performance, prebiotics

CIVIL ENGINEERING AND TRANSPORT

Physical, mechanical, and durability characterisations of rock dust as fine aggregates replacement in cement composites

Magdalena Dobiszewska[1], Orlando Bagcal[2], Ahmet Beycioğlu[3], Dimitrios Goulias[4], Fuat Köksal[5], Maciej Niedostatkiewicz[6], Hüsamettin Ürünveren[3]

[1] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

[2] School of Engineering, Construction Science and Management, Tarleton State University, USA, Department of Architecture and Construction Management, Collin College, USA

[3] Engineering Faculty, Adana Alparslan Türkeş Science and Technology University, Türkiye

[4] Department of Civil and Environmental Engineering, University of Maryland, USA

[5] Department of Civil Engineering, Yozgat Bozot University, Türkiye

[6] Faculty of Civil and Environmental Engineering, Gdańsk University of Technology, Poland

corresponding author: obagcal@yahoo.com

Introduction. Sustainability has become an integral and essential aspect of modern construction worldwide. The utilisation of industry byproducts or waste materials are the subjects of recent researches and studies as a result of increasing stringent environmental requirements. In fact, approximately 2.01 billion tons of municipal solid waste are generated worldwide annually, at least 33% of which is not well managed in terms of being environmentally friendly. By 2050, the amount of municipal solid waste generated worldwide is expected to increase by approximately 70% and reach 3.4 billion metric tons. Further, as the demand for infrastructures, buildings, and housing continues to grow, so does the demand to exploit and utilise depleting resources. Among the potential alternative materials that can be used in cement composite production is rock dust from different geological origins. In conjunction with the rapid increase in concrete production, the demands for natural aggregates are also increasing. To meet the increasing demand for aggregates, natural river sand, regarded as the most appropriate and commonly used fine aggregate in the production of mortar and concrete, is comprehensively exploited.

Materials and Methods. This study was conducted to present an in-depth review of the scientific findings from past studies regarding the use of various geological origins of rock dust in the production of mortars and concrete. Physical, mechanical, and durability characterisation of rock dust as fine aggregate in mortar and concrete mixtures were analysed and evaluated. Particularly, an assessment and review of the fresh concrete and mortar properties such as workability, segregation, and bleeding; mechanical properties, and the durability of hardened concrete and mortar were considered. The characteristics of mineral dusts presented in this review were limited to dusts from limestone, marble, granite, and basalt rocks, which represent the most rock dust in concrete production.

Results and Discussion. Reported studies indicated that the use of non-pozzolanic fillers such as rock dust, in mortar or concrete mixtures increased bleeding and segregation resistance. It was also indicated that the use of basalt powder decreases workability because of the much greater specific surface area. The use of excessive rock dust particles in relation to the voids between cement and sand particles has a reducing effect on pore filling, resulting in an increase in air content due to a reduction in packing density. The relative compressive strength of mortar and concrete with rock powder addition at a different curing age positively affects the mechanical properties. It was observed that as the amount of dust used as sand replacement and the fineness of the dust increases, so does the strength of the mortar. The filler role of stone powder is primarily responsible for the improvement in strength in cement composites with rock dust addition due to heteronucleation of cement in the mixture. Generally, the addition of rock dust has a positive effect on the strength as it fills the concrete voids and reduces the porosity. Consequently, adding different mineralogical origin rock waste demonstrated lower water permeability and reduced water absorption compared with conventional concrete. The decrease in the permeability of cement matrix with the addition of rock dust is generally related to the filler effect, i.e., physical rock dust interaction. The positive effect of limestone powder addition on the reduction of chloride ion permeability in concrete was noticed. Interestingly, it was noticed that there is an increase in the sulfate attack resistance of concrete with an increase in limestone powder amount, despite stated lower chloride resistance.

Conclusion. The addition of rock powder as fine aggregate replacement significantly affects fresh concrete and mortar properties. The

substitution for fine aggregate with rock dust generally leads to a significant decrease in workability. Improved mechanical properties of cement composites were observed when rock powder used as a partial replacement for fine aggregate. Reported results confirmed the positive effect of rock dust on concrete with an increase in the permeability and decrease in water absorption.

Influence of waste basalt powder on some concrete properties

Magdalena Dobiszewska[1], Ahmet Beycioğlu[2]

[1] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

[2] Engineering Faculty, Adana Alparslan Türkeş Science and Technology University, Türkiye

corresponding author: magdalena.dobiszewska@pbs.edu.pl

Introduction. One of the natural raw materials used in the production of cement composites is natural aggregates. Although deposits of natural aggregates lie on the earth's surface or at low depths and belong to common deposits, the shortage of aggregate, especially natural sand, is presently observed in many countries. In such a situation, one is looking for other materials that can be used as a substitute for natural aggregates in mortars and concrete production. During rock extraction and mechanical processing, and due to their sorting, large quantities of waste material are produced in the form of rock dust. Similar dust waste is produced during the drying process of the aggregate used to produce mineral-asphalt mixtures and at stonemason facilities. Storage of this type of fine material poses serious environmental problems. Dust released into the atmosphere significantly contributes to the accumulation and harmful dispersion of fine solids in air, water, and soil.

Materials and Methods. This study evaluates the use of waste basalt powder obtained during the production of mineral-asphalt mixtures with basalt aggregate as a replacement for sand to enhance concrete properties. The concrete mixtures were prepared with the use of ordinary Portland cement CEM I 42.5R. As a coarse aggregate (CA), the gravel of the group of fractions 2/16 was used, and as a fine aggregate (FA), river sand was used. To obtain the desired workability of concrete mixtures, the high-range water-reducing (HRWR) admixture was added. The influence of basalt dust on technological properties of concrete mixtures, compressive strength, water absorption, permeability, and microstructure of hardened concrete with basalt dust additive were analysed. To analyse the effect of basalt powder on the properties and microstructure of concrete, four concrete mixes were prepared. Reference concrete, i.e., concrete without waste basalt powder was named C0 and concretes with different amounts of basalt powder

replacing 10%, 20% and 30% of the sand by mass were named C10, C20 and C30, respectively

Results and Discussion. Incorporating dust in the concrete mix leads to a change towards a less liquid mix consistency, as well as to a deterioration of workability. Gradual substitution of sand with basalt dust leads to the sealing of aggregate composition, which results in lower air content in the concrete mix and thus lower porosity of hardened concrete. As the basalt dust content increases, the air content decreases significantly. The addition of basalt powder as a replacement for sand, improves the compressive strength of concrete and decreases water absorption and permeability. The addition of basalt dust reduces the number of large capillary pores and increases the content of small pores, which leads to the microstructure sealing of the hardened cement paste. The most important and dominant mechanism of beneficial basalt dust interaction is related to the filler effect, i.e., physical interaction. Very small particles of basalt powder fill the space between cement and aggregate grains, which results in reduced porosity of the cement matrix. It was proved that the addition of basalt dust reduces the number of large capillary pores and increases the content of small pores, which leads to the microstructure sealing of the hardened cement paste and thus to a permeability decrease. As a result, cement composites with basalt dust additive feature higher strength. Other phenomena also occur, apart from the physical effect of basalt dust on the microstructure of the cement matrix. The surface of basalt dust grains is the active centre on which heteronuclei of mainly C-S-H phase are formed.

Conclusion. Presented research results and conducted analyses allow to state that basalt dust, currently treated as production waste, can be used to produce mortars and cement concrete as partial sand replacement. Such use of this waste is technically, economically, and ecologically justified and in line with the principle of sustainable development, as it makes it possible to reduce the use of natural resources to produce cement composites and effectively manages the waste.

Keywords: concrete, compressive strength, microstructure, permeability, waste basalt powder, water absorption

Matrix description of constitutive relations of non-linear materials

Tomasz Janiak

Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

corresponding author: tomaszj@pbs.edu.pl

Introduction. The paper presents a matrix method of describing non-linear properties of structural materials or structural elements and their selected applications. It is a numerical, discrete description where elementary mathematical functions are not used. The purpose of the paper is to confirm that the developed matrix description of material properties in selected applications is better and more versatile than methods based on the description with explicit mathematical functions.

Materials and Methods. The concept of matrix description of material properties is discussed on the example of material stiffness represented by the elongation elasticity coefficient (Young's modulus). During the analysis of non-linear static matters of mechanics, it is assumed that it is a function of one variable: strain or stress. With matrix description of stiffness, tabular stiffness functions are created, dependent on strain and stress simultaneously. This way, it is possible to store more information about the material, including, e.g. partial history of strain and stress. The paper also presents the fundamentals of the numerical algorithm necessary to use the matrix description of material properties in construction analyses. This algorithm has been implemented in proprietary computer programs.

Results and Discussion. After presenting theoretical assumptions of the matrix description, selected matrix applications have been shown. The first step was to create matrices describing the stiffness of three hypothetical materials, including but not limited to a material with a distinct yield strength (e.g. structural steel) and a hyper-elastic material (e.g. a rubber-filled compound). Next, simulations of bar tensile tests, cyclic tension and relief stress bar tests, and tension and compression bar tests (resulting in a hysteresis response) were performed. A statically indeterminable system consisting of three bars connected with a cross-beam as a rigid body was also solved. The last example was related to a statically indeterminable double-span reinforced concrete beam. In this case, stiffness matrices of beam cross-

sections were developed, taking into account the concrete and longitudinal bars. The analysed beam was solved earlier, so it was possible to verify that the algorithm was correct.

Conclusion. The developed concept of matrix description of material and structural element properties and the algorithm enabling the use of such matrices proved to be effective both in simulations of simple strength cases and in solving specific, practical problems in the construction field. The basic features of the presented approach are: no limitations resulting from the use of elementary mathematical functions when describing material properties and taking into account more details related to material information. The matrix description of material properties can be significantly developed and used for complex non-linear analyses in the field of construction and other scientific disciplines. The matrix description of material characteristics allows for a very good compatibility of the constitutive relation with the experimental research in the entire research range. Similar effects were also obtained by other scientists using spline functions and taking into account the dependence of stiffness on one variable. The departure from the explicit application of mathematical functions is particularly important because most non-linear analyses are performed using numerical techniques anyway. The examples presented in the paper clearly show one more important feature of the matrix method of describing the properties of materials – universality. Many scientists specialise in the study of one type of material (e.g. hyper elastic materials). The matrix description unifies the procedure for various types of materials, at least in the field of static analysis. Introduction to the description of a larger number of variables also gives hope for such unification in case of more complex analyses, e.g. time-dependent.

Analysis of the possibility of using rock dust as a cement substitute in the production of cement composites

Magdalena Dobiszewska[1], Orlando Bagcal[2], Ahmet Beycioğlu[3], Dimitrios Goulias[4], Fuat Köksal[5], Błażej Płomiński[1], Hüsamettin Ürünveren[3]

[1] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

[2] School of Engineering, Construction Science and Management, Tarleton State University, USA, Department of Architecture and Construction Management, Collin College, USA

[3] Engineering Faculty, Adana Alparslan Türkeş Science and Technology University, Türkiye

[4] Department of Civil and Environmental Engineering, University of Maryland, USA

[5] Department of Civil Engineering, Yozgat Bozot University, Türkiye

corresponding author: blazej.plominski@pbs.edu.pl

Introduction. The building materials industry has a large environmental impact. Cement and concrete production consumes huge amounts of fossil fuels and natural resources and is very energy intensive. Due to the technological process of producing clinker and high carbon consumption, the cement industry emits significant amounts of carbon dioxide into the atmosphere. Therefore, materials are currently being sought that can partially replace cement in the production of building materials, especially concrete. This will contribute to reducing the consumption of natural resources and energy as well as CO_2 emissions. Various mineral additives are commonly used in the cement industry as main ingredients of cement. Cement mortars and concretes with mineral additives have better properties compared to composites made of Portland cement without additives. Mineral additives improve the rheological properties of the concrete mix and the physical properties of concrete and contribute to increasing the durability of cement composites.

Materials and Methods. In the world literature, research results prove the possibility of using various geological origins of rock dust as a partial substitute for cement. The article reviews the world literature on the use of limestone, marble, basalt, granite, and quartz rock dusts as substitutes for cement. Description of rock dusts, analysis of the effect

of dusts on cement hydration, technological properties of concrete mix, mechanical properties and durability of concrete are presented.

Results and Discussion. Two factors greatly influence the cement hydration with rock powder. The first one occurs when cement is partially replaced with inert rock dust. This leads to an increase in the places for crystallisation of cement hydration products, which accelerates the hydration. The second factor influencing the hydration mechanism of cement with the addition of rock dust is related to the heteronucleation of hydrates on the surface of the rock dust, which also leads to the acceleration of cement hydration. Rock dusts are used in concrete mainly as inert additives, i.e., fillers. Their positive impact on some properties of mortar and concrete is mainly related to the filler effect, which results in sealing the cement matrix and thus improving the mechanical properties and durability. The influence of rock dust on the properties of cement composites depends primarily on the share of rock dust and its specific surface. Partial replacement of cement with rock dust generally leads to a deterioration of the strength of mortars and concretes, which is obviously related to the reduction of the cement content. However, with some small content of dust in the cement mass, ranging up to 5% to 20%, the strength increases in relation to the strength of the composite without the addition of dust. The strength increases with the increase of the specific surface of the rock dust. The influence of the grain surface of the additives plays a large role in shaping mainly the early strength of cement composites due to easier formation of hydrate nuclei, especially in the C-S-H phase.

Conclusion. The fine-grained dusty material acts as an inert filler that contributes to a better filling of inter-grain voids in the composite. The result is a compact microstructure of the cement matrix, its lower porosity, and thus greater strength. As a result of easier nucleation of the additive grains, the degree of hydration of the clinker phases and thus the volume of the hydration products increases, which leads to a reduction in porosity. Evenly distributed in the cement matrix, rock dust particles fill the capillary pores, resulting in a dense microstructure of the matrix and thus greater strength of the hardened cement paste. It also has a positive effect on the durability of cement composites. Based on the presented analysis of the literature, it can be concluded that rock dust can be used in the production of cement composites as a partial replacement for cement.

Keywords: rock dust, cement composites, strength, durability, waste management

Spatial multi-criteria analysis for walking suitability assessment

André Nogueira[1], Bertha Santos[2], Jorge Gonçalves[3], Jan Kempa[4], Jacek Chmielewski[5]

[1] Department of Civil Engineering and Architecture, University of Beira Interior, Portugal

[2] Department of Civil Engineering and Architecture, University of Beira Interior, Portugal and CERIS, Instituto Superior Técnico, Universidade de Lisboa, Portugal

[3] Department of Civil Engineering and Architecture, University of Beira Interior, Portugal and CITTA, Faculty of Engineering of the University of Porto, Portugal

[4] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

[5] Faculty of Civil Engineering, Cracow University of Technology, Poland

corresponding author: bsantos@ubi.pt

Introduction. The current climate and environmental emergency, along with the increasing road congestion in urban areas, make mobility and sustainability a priority in recent transport policies. It is therefore essential to change citizens' behaviour towards the use of more sustainable transport modes, such as walking, articulated, when needed, with other public transport modes. For this change to take place, especially when commuting, cities must be provided with viable alternatives to a private car, namely through the provision of high-quality pedestrian infrastructure adapted to people's needs and cities' characteristics. This last point is particularly important in hillside cities, where walking requires additional effort. In view of the above, the present work aims to contribute to the promotion of soft mobility in urban areas by creating an instrument to support the walking suitability assessment of existing pedestrian infrastructure.

Methodology. A spatial multi-criteria approach was used in which three explanatory variables (criteria) were considered: the location of the trip generating poles, the population density, and characteristics of the pedestrian network, with special emphasis on the sidewalk/road slope. Given the road slope impact on walking speed and physical effort, the proposed methodology incorporates this factor to allow a more realistic definition of the trip generating poles' influence areas. All variables are evaluated using a set of spatial and network analysis tools

available in Geographic Information Systems (GIS) and combined in a multi-criteria analysis using a weighted linear combination method to obtain a measure of the infrastructure's suitability for walking (0 to 100 score). In the multi-criteria analysis, weights are assigned to each of the variables based on the results obtained in surveys carried out within the local population and a panel of transport specialists, allowing the approach to be modelled to a specific urban area and population needs.

Results and discussion. The proposed instrument was validated through a case study within the urban perimeter of the hillside city of Covilhã (Portugal). The multi-criteria analysis was performed for 3 combinations of variable weights (70% trip generating poles (GP) and 30% population density (PD), 60% GP and 40% PD, 50% GP and 50% PD), resulting in three walking suitability maps. The result obtained for the combination 70% PG and 30% DP, considered as the most representative by Covilhã City Council's representatives, classifies 22.2% of the network with medium to very high walking suitability (score from 41 to 100) and 77.8% with low to very low suitability (score below 40). The lowest suitability values were found essentially in the pedestrian network located outside the trip generating poles' influence areas and in areas with low population density. From the results obtained, it is possible to conclude that the variable with the greatest effect on the walking suitability values is the trip generating poles' location, influenced by the slope of the network segments. This decision support tool can also identify the main urban expansion areas, corresponding to the urban areas with high walking suitability but relatively low population density.

Conclusion. The approach provides a decision support tool that municipalities can use to understand their territory's mobility potential better, supporting authorities for a better allocation of human and financial public resources to achieve a higher share of pedestrian mobility through high-quality walking infrastructure.

EU and Portuguese strategic vision for cycling

Isabel Matias[1], Bertha Santos[2], Jorge Gonçalves[2], Jan Kempa[3], Jacek Chmielewski[4]

[1] Municipality of Covilhã, Portugal

[2] Department of Civil Engineering and Architecture, University of Beira Interior, Portugal

[3] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

[4] Faculty of Civil Engineering, Cracow University of Technology, Poland

corresponding author: jorge@ubi.pt

Introduction. Sustainable mobility can be defined as the ability to meet society's need to move freely, gain access, communicate, trade, and establish relationships without sacrificing other essential human or ecological values, today or in the future. This vision can be achieved following fundamental principles such as preserving the natural environment; maintaining the health and safety of human beings; supporting a healthy economy, aiming at social equity and the well-being of all; meeting the population's travel needs; minimising infrastructure, access, and mobility costs; and ensuring energy efficiency and the long-term viability of transport systems. Sustainable mobility has become a central topic for reflection and debate when defining active urban policies, and cycling has played an important role in sustainable urban development in the last decade as an alternative capable of reversing the trend on private car use in urban areas. The present work intends to assess the evolution of cycling mobility strategies and support programs promoted by the EU in the last decades, as well as how Portugal has been responding to this challenge. The central issue in pursuing more sustainable development has been substituting motorised transport modes. To achieve more efficient and less polluting mobility systems, cities have been implementing policies supported by sustainable urban mobility plans to influence the citizens' modal choice, such as using bicycles. However, for a real change in behaviours, it is necessary to create conditions for this transition to occur, namely in terms of cities' spatial organisation and their infrastructures, which should be suitable for soft modes of circulation. Regarding the cycling mode, the planning and design of cycling networks must meet the basic principles of continuity and coherence and must ensure safety to encourage citizens to use them.

Methodology. Considering the mentioned cycling mode potential, the methodology adopted in this study is based on the analysis of the evolution of documents that support the main strategies for promoting and implementing cycling at the EU level. A review of how Portugal reacted to the European guidelines is also presented, namely with the documents supporting cycling mobility, strategies and incentives promoted by the central government.

Results and discussion. The study verified that the EU's concern with urban mobility issues and sustainability emerged with greater expression at the beginning of the 21st century. Several important documents focused on urban mobility have developed in the last 15 years. These strategic documents evolved from the discussion on the best approach to improve urban mobility, to define guidelines for a less polluting, smarter, safer, competitive, and resource-efficient transport system, resulting in a vision for sustainable urban mobility across the EU. The first ones specifically focused on promoting the use of bicycles to create a cycling culture in the European space appeared in 2017. The entire documentary framework produced in the EU on urban mobility and cycling has resulted in the implementation of a significant number of national cycling strategies in European countries until 2020. In the first decade of the XXI century, Portuguese legislation and strategies were developed to define priorities for sustainable urban development and mobility policies implementation, focused on less polluting modes and constituting a reference for the application of European funds. In 2015, the government established a committee to promote national green growth in which cycling importance, as a particularly efficient urban mobility mode, was highlighted, aiming to increase its share in urban trips and its articulation with public transport modes. By 2019, more documents were published to promote cycling public policies, recognising cycling as a fundamental part of the mobility chain, specifically for urban and interurban short distances trips.

Conclusions. Comparing European and Portuguese regulations, there is an increase in official cycling documents from 2015 onwards at the European level and from 2018 in Portugal, showing some degree of maturity in implementing and encouraging this mode of transport. In general terms, Portugal has followed EU policies and strategies with an average 3-year span between the EU and Portuguese regulations and recommendations. Despite all initiatives to promote active mobility, the 2021 Portuguese Recovery and Resilience Plan (PRR) does not mention

active mobility, cycling or walking. Such omissions can compromise the international and national commitments that the Portuguese Governments have assumed, such as the Paris Agreement on climate change, the Bikeable Portugal 2030 Strategy, the National Strategy for Cycling Active Mobility 2020-2030 (EMNAC) and the Roadmap for Carbon Neutrality 2050.

Keywords: sustainable mobility, urban mobility, active mobility, cycling strategies

Novel cement composites based on organic and inorganic aggregates from waste recycling

Andrea Petrella[1], Francesco Todaro[1], Sabino De Gisi[1], Michele Notarnicola[1], Magdalena Dobiszewska[2]

[1] Department of Civil, Environmental, Land, Building Engineering and Chemistry, Polytechnic University of Bari, Italy

[2] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

corresponding author: andrea.petrella@poliba.it

Introduction. Waste management is considered an important issue to face the need for a more sustainable and continuous supply of materials and energy over the years. The sorting operations for municipal and industrial solid waste result in the formation of by-products which can be reused in other socio-economic activities, thus representing the so-called 'secondary raw materials', a resource that can be easily reused without modification of the peculiar characteristics. An application of the secondary raw materials is to prepare environmentally sustainable cement composites based on recycled waste as aggregate, the latter of industrial, construction, municipal and agro-food origin. Specifically, the rheological, mechanical, thermal, microstructural, and wetting properties of lightweight cement mortars with end-of-life tire rubber, glass, expanded polystyrene, polyethylene terephthalate and wheat straw were studied to characterise the conglomerates for indoor and outdoor non-structural applications.

Materials and Methods. The cement mortars were prepared with CEM II A-LL 42.5 R (Buzzi Unicem, Barletta, Italy). End-of-life tire rubber (TR) was obtained after shredding in small particles (0–0.5 mm, 0.5–2 mm), porous glass (PG) was obtained from separate collection and separation of municipal and industrial solid wastes (0.5–2 mm), expanded polystyrene (EPS) resulted from grinding of industrial scraps (1–2 mm), while polyethylene terephthalate (PET) was recycled from bottle scraps with grains in the range of 1-2 mm. Wheat straw was used with cuttings of variable length (0.4–0.6 cm, 1.3–1.7 cm, 3.4–3.7 cm, 5.8–6.2 cm). The aggregates were added as a partial and total replacement of the conventional sand aggregate, and the mortars were prepared with 225 g of water and 450 g of cement. The consistency of the fresh mixtures was evaluated by the flow-test. The specimens in the hardened state were mechanically characterised (MATEST device, Milan, Italy) after preparation of 40 × 40 × 160 mm prisms, cured for 28 days, to which flexural and compressive tests were carried out. The samples were also

thermally characterised by the ISOMET 2104 device (Applied Precision Ltd, Bratislava, Slovakia) after the preparation of 10 cm × 50 mm cylinders cured for 28 days. The microstructural characterisation of the samples was carried out by a FESEM-EDX Carl Zeiss Sigma 300 VP (Carl Zeiss Microscopy GmbH, Jena, Germany) electron microscope.

Results and Discussion. The unconventional cement mortars were characterised in the fresh state by a decrease of workability with the increase of the aggregate dosage and in the hardened state by lightness and thermo-insulation. The thermal conductivity of the composites based on end-of-life tire rubber (TR), porous glass (PG), expanded polystyrene (EPS), and polyethylene terephthalate (PET) was 80–90% lower (0.2–0.4 W/mK) than the conventional sand mortars (~2W/mK), despite the mechanical strengths. Moreover, the presence of glass also improved the mechanical strengths of the samples keeping the values of thermal conductivity substantially stable due to the high stiffness and closed porosity of the aggregate. The composites with end-of-life tire rubber, expanded polystyrene, and polyethylene terephthalate also showed hydrophobic behaviour due to the low water absorption. Accordingly, these conglomerates may be suitable for non-structural thermo-insulating products, with specific reference to inside and outside elements. The wheat straw conglomerates also resulted in thermo-insulating (0.15–0.25 W/mK) with low mechanical strengths in comparison with the sand-based references. At the same time, the addition of another aggregate as perlite improved the mechanical strengths with any modification of the thermal conductivities since the porous nature of the siliceous material. These conglomerates may be suitable for non-structural thermo-insulating products, with specific reference to indoor applications due to their high wettability and water absorption. The thermal and mechanical results of the organic waste composites can be explained by the presence of the low density organic aggregates in the conglomerates together with the limited adhesion to the cement paste which were responsible for a strong decrease of the specific mass and increase of the porosity.

Conclusion. The recycling of industrial, construction, municipal and agro-food waste was obtained by a safe and environmentally friendly process since pre-treatment of the renewable aggregates and complex or expensive procedures were not adopted. Moreover, the lightweight properties can be effective for the production of thermal insulating elements such as masonries and plasters.

Keywords: cement mortars, mechanical strength, microstructural properties, thermal insulation, waste recycling

Modeling of coupled thermodiffusion using the space-time finite element method

Magdalena Sosnowska, Adam Podhorecki, Adam Grabowski

Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

corresponding author: magdalena.sosnowska@pbs.edu.pl

Introduction. A space-time finite element method based on the direct space-time discretisation technique is developed for solving coupled thermodiffusion problems. The spatial and temporal domains are discretised by considering the time scale as an additional space dimension. The full space-time approximation can be considered an extension of the finite element method over the time domain and allows to treat spatial variables in the same way as the time variable. This approach has been applied both to linear and nonlinear problems, e.g., in the field of thermoelasticity, diffusion, viscoelasticity, composite materials, and contact issues. The main motive of this work is to apply the approach of solving coupled thermodiffusion equations efficiently, using a space-time finite element method.

Materials and Methods. According to the classical theory of heat conduction, the conduction of heat in a material only depends on the temperature gradient. This uncoupled theory ignores the effect of other elastic properties of the element. The Biot's theory was the first attempt to consider the mutual interaction of thermal and mechanical fields during thermo-mechanical loading. Based on the Fourier's law, this approach considers the elastic effects on the heat conduction and vice versa. Also, diffusion in solids was initially treated as if it had no influence on body deformation and temperature gradient. To have a quite realistic simulation for diffusion in solids under thermal and mechanical loadings, the interaction between diffusion and thermoelasticity should be considered in.

Results and Discussion. A deformable solid body has been considered. The body in a non-deformed and strain-free condition is at a constant temperature and has a constant concentration of the diffusible substance. Under the influence of surface forces and mass forces, due to the action of heat and mass sources inside the body and/or as a result of temperature change and equalisation of the diffusible substance concentrations in the considered area, the body experiences

displacements, deformation, stresses, the temperature and the diffusible substance concentration change. The considered linear initial –boundary issue of coupled thermodiffusion is described by the set of equations. Using the boundary and initial conditions, the physical equation and making appropriate transformations, the equations of the virtual time-work are obtained in which the couplings of deformations, temperature and diffusion are visible. The analyses are illustrated and confirmed by numerical experiments.

Conclusion. Thermodiffusion, as a branch of solid mechanics, includes studies on the coupling of the deformation field, temperature and concentration of the diffusible substance. In the construction, many phenomena in the field of thermodiffusion can be distinguished, for example, hygrothermal processes or surface thermochemical treatments. Space-time finite element method is a promising approach for producing efficient and highly accurate solutions to partial differential equations. Nonstationary discretisation and adaptive techniques are not the only positive features of the space-time approach. It can be concluded that the present space-time finite element approach can be used as an alternative method of the finite element method approach with Newmark scheme to solve the coupled thermodiffusion problems. The presented formulations can be easily adapted to non-linear thermal diffusion.

Effect of silica modulus on fresh and hardened properties of geopolymer mortars

Hüsamettin Ürünveren[1], Ahmet Beycioğlu[1],
Magdalena Dobiszewska[2], Izabela Kasprzyk[2]

[1] Engineering Faculty, Adana Alparslan Türkeş Science and Technology University, Türkiye

[2] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

corresponding author: hurunveren@atu.edu.tr

Introduction. Civil engineering has been one of the most important factors that constantly renews and develops throughout the transition period of human history to modern society and affects living standards throughout history. Considering the CO_2 released by cement, one of the most important components of the construction industry, and the excessive amount of energy used during cement production, the issue of reducing cement use and developing economic and environmental-friendly binders attracts more and more attention with each passing day. Increasing environmental awareness worldwide has a very important effect on the material selection and production of these materials. Accordingly, materials such as fly ash (FA), blast furnace slag (GBFS), and silica fume (SF), which are known as industrial waste, have started to be used as by-products in concrete production within the scope of recycling studies. Due to environmental awareness and the amount of CO_2 that occurs in cement production, an alternative binder design has recently started to take place in the literature by using industrial waste materials directly instead of cement rather than using them as cement substitutes. While amorphous inorganic polymers called "geopolymer" are formed as a result of the reaction of aluminosilicate fly ash with alkali activators, hydrated calcium silicate similar to C-S-H gel in cement-based binders is formed as a result of the reaction of blast furnace slag. The aim of the study was to determine the effect of Ms modulus on workability and strength properties of geopolymer mortars.

Materials and Methods. Within the scope of this study, CEN standard sand was used in the production of mortars, Na_2SiO_3 and NaOH as activators and fly ash binding powder, the usability of which was determined in previous studies in the production of geopolymers. It is important to know the chemical specifications of sodium silicate and

sodium hydroxide, since geopolymer will be produced according to the study's silica modulus (Ms) calculation. Spread diameters of the produced mortar samples were measured with the cement flow table, then placed in molds and subjected to thermal cure at 100℃ for 1 day.

Results and Discussion. Results show that in the fixed mortar volume, the amount of dry mix used (by weight) decreased as the Ms modulus increased, while the amount of activator (by weight) increased. The same applies to the increasing % Na_2O in the fixed Ms Module. Mortar samples exhibited better spreading ability properties with the activator/dry mix ratio increasing in the same way with increasing Ms modulus. When the strength data is examined, with the increasing activator/dry mix ratio, an increase in strength was observed with an increase in Ms modulus at 6% Na_2O concentration. The increase in Ms modulus at 8% Na_2O concentration gave the best strength value at 1.4 Ms modulus, and it was seen that it started to decrease after this rate. At 10% Na_2O concentration, decreases in strength were observed with the increase in Ms modulus. As a result of the study, the flow diameters and strengths of the fresh mortars were measured. The workability was not effective at 6% and 8% Na_2O concentrations in the produced mortar samples.

Conclusion. In summary, a high Na_2O concentration at a low Ms modulus had a positive effect on strength, while an increase in Na_2O concentration with an increase in Ms modulus had negative results in strength.

Keywords: geopolymer, silica modulus, flowability, compressive strength

Compressive strength of electrically cured geoplymer mortar

Hüsamettin Ürünveren[1], Ahmet Beycioğlu[1], Izabela Kasprzyk[2], Magdalena Dobiszewska[2]

[1] Engineering Faculty, Adana Alparslan Türkeş Science and Technology, Türkiye

[2] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

corresponding author: abeycioglu@gmail.com

Introduction. Sustainability is among the most popular concepts in modern societies. Sustainability is an issue that directly concerns the field of civil engineering as it concerns many disciplines. In this respect, sustainable material technologies should be handled carefully, especially in the production of building materials. It is known that the most consumed building material in the world is concrete. The Global Cement and Concrete Association (GCCA) reports that 14 billion cubic meters of concrete are cast each year. Concrete is a mixture of sand, gravel, crushed rock and/or other aggregates held together by a hardened paste of cement and water. Cement is the main material of concrete production. Cement production is an energy and carbon-intensive process. Hence, they are a noteworthy contributor to global anthropogenic CO_2 emissions. The cement industry has always been among the greatest CO_2 discharge sources, with 900 kg CO_2 released with each production ton of cement. Cement production alone accounts for as much as seven per cent of global CO_2 emissions in the world, which means three times the emissions produced by aviation.

Materials and Methods. The issue of developing economical and environmentally friendly binders by reducing the use of cement attracts more and more attention day by day. It is one of the new generation binders called "geopolymer", which is formed as a result of the reaction of aluminosilicate powders with alkali activators. Geopolymer is a type of binder that is relatively new compared to traditional portland cement and is produced as a result of the activation of aluminosilicate-rich materials with various alkalis. Geopolymer concrete is considered an innovative material that is a viable alternative to traditional Portland concrete or cement used in many civil engineering structures.

Results and Discussion. This study investigated the strength development of geopolymer mortars with electrical curing. For this purpose, geopolymer mortars were produced using different Ms modules (1.0–1.8) and electrical curing was applied to the produced geopolymer mortars at different time and voltage values. In the production of mortars, NaOH and Na_2SiO_3 were used as activators and fly ash as binder powder. Mortars produced with 1.2 – 1.4 – 1.6 Ms modulus and 10% Na_2O ratio were subjected to electrical curing at 20, 25 and 30 volts for 6 and 12 hours and their strength performances were observed.

Conclusion. Results showed that electrical current with low volt was insufficient in mixtures with low Ms modulus. As the Ms modulus increased, conductivity increased, and an increase in strength was observed in geopolymer mortars with both 6-hour and 12-hour electrical curing. The highest strength of the mortars was obtained at 25 volts with 12 hour application period. Furthermore, it has been observed that voltage values of 25 volts and above lead to rapid but insufficient strength gain of the geopolymer mortars due to the higher conductivity of geopolymer mortar. In addition, it was observed that the increase in the Ms modulus decreased the strength values in general. The preliminary findings of this experimental research show that future studies on the production of high strength geopolimer concrete with electrical curing will be beneficial.

Keywords: sustainability, geopolimer mortar, fly ash, electrical curing, compressive strength

Beam buckling analysis using the finite element method

Izabela Kasprzyk, Adam Podhorecki, Adam Grabowski

Faculty of Civil and Environmental Engineering and Architecture,
Bydgoszcz University of Science and Technology, Poland

corresponding author: izabela.kasprzyk@pbs.edu.pl

Introduction. The subject of buckling of beam elements of structures is still present in everyday life. Many construction disasters result from the loss of stability of certain structural elements under the influence of various types of loads. Beam structure may experience a loss of stability either under the influence of exceeding a certain critical force or under the influence of a suddenly applied load which results in buckling and, consequently, a catastrophe. The reason for the loss of stability may also be the relevant critical frequencies of forced vibrations. The state of motion induced by longitudinal compression, during which deflections tend to increase unlimitedly, is called the dynamic buckling of a beam. These deflections are in fact limited; however, with a sufficiently intense load, they can reach unacceptable values, which can lead to permanent deflection of the beam. Geometric equations, physical equations, equilibrium equations, boundary and initial conditions constitute a local formulation of the initial-boundary problem. The application of the finite element method (FEM) requires a global (complete) formulation of this issue. Usually, it consists in introducing variational principles in such a way that a function is built first, and then there is a demand that it has to meet the appropriate minimum conditions. However, one can skip the stage of building a functional and apply, for example, the principle of virtual work.

Materials and Methods. In the paper, a pre-stress-free curved bar (with a small curvature) with a given function of initial deflection $w_0(x, t_0)$ is considered. The beam is homogeneous, with a volumetric density ρ, linearly elastic and isotropic with the characteristics E, G, invariable cross-sectional area A and moment of inertia I, which is loaded with a conservative force that varies in time P(t). Under the influence of the force P(t), the initial state of the beam deforms, vertical displacements w(x, t), and horizontal displacements u(x, t) appear.

The displacement state is described by three functions:

> u (x, t) – axial displacement,
> w (x, t) – transverse displacement of the central axis perpendicular to the bending plane; the so-called total deflection,
> ψ (x, t) – cross-section rotation angle in relation to the axis 0y.

The components of the state of displacements u(x, t), w(x, t) and the parameters of the force P(t) causing the loss of the beam's stability are searched for. It is assumed that the displacements in (x, t) can be significant. The influence of shear deformations on the beam curvature and all components of inertia forces are considered. The state of the presented system in the time interval t ∈ <0, t_1> is examined. Therefore, an initially – boundary issue is considered. After formulation of the virtual work equation and the equation of motion and aggregation (globalisation), the final equation in a matrix can be written as follows:

$$\underline{M}\,\ddot{\underline{r}} + {}^{L}\underline{K}\,\underline{r} + \underline{P}\,(\underline{r}) = 0$$

where

$$\underline{P}\,(\underline{r}) = [\,{}^{N}\underline{K}\,(\underline{r}) + {}^{NN}\underline{K}\,(\underline{r},\underline{r})]\underline{r} + {}^{L}\underline{F} + {}^{N}\underline{F}$$

For an unequivocal solution to this differential equation, two initial conditions are needed $\underline{r}(t = 0) = \underline{r}_0$, $\dot{\underline{r}}(t = 0) = \dot{\underline{r}}_0$. The Newmark numerical method is used to solve this equation.

Results and Discussion. The paper contains a computer program that verified the correctness of the formulated equation of motion. The computational model of a beam subjected to a compressive load was programmed in a proprietary program in C++. After entering the necessary data and entering the initial deflection of the beam (0.001 m), the critical force that causes the beam to buckle was calculated. Several examples of buckling were calculated, and the critical force was investigated depending on the assumed cross-section of the beam and the value of the assumed initial curvature. The value of the critical force was analysed based on the number of finite elements adopted. The influence of individual components of the equation of motion on the loss of stability was also analysed.

Keywords: finite element method, beam buckling, equation of motion

Parametric study on the sustainability assessment of rock sand as cement and FA replacement in concrete for roadway construction and rehabilitation

Dimitrios Goulias[1], Yunpeng Zhao[1], Magdalena Dobiszewska[2], Paweł Modrzyński[3]

[1] Department of Civil and Environmental Engineering, University of Maryland, USA

[2] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

[3] Faculty of Management, Bydgoszcz University of Science and Technology, Poland

corresponding author: dgoulias@umd.edu

Introduction. The construction and rehabilitation of road pavements involve large amounts of natural resources, such as raw construction materials, water and energy. With the ever-increasing use of recycled materials in roadway construction, significant environmental and economic benefits can be achieved. Among these materials, rock dust from the production of aggregates can play a key role in the sustainability of road infrastructure. The use of rock dust as a valid alternative to fine aggregate and/or cement in concrete is being explored. Particularly for road construction, the potential benefits of using rock dust in concrete have further emphasised the need to assess its contribution to generating sustainable rehabilitation strategies.

Materials and Methods. Waste dust generated in the production process of asphalt mixtures with basalt aggregate was used as a partial replacement for fine aggregate and cement. About 5% of rock dust is produced during mixture production. This means about 5,000 tons of waste dust is produced annually in each average asphalt mixture plant. The study analysed the compressive strength and elasticity modulus of concretes made by replacing (by mass) 10% and 20% of fine aggregate with basalt powder and additionally concrete, where basalt dust was simultaneously replaced with sand (in the amount of 10% and 20%) and cement (in the amount of 5% and 10%). Concrete mixtures were produced with Ordinary Portland Cement CEM I 42.5R in accordance with European Standard EN 197. Natural river sand as a fine aggregate (FA) and gravel with a 16.0 mm maximum size as a coarse aggregate

(CA) were used. Coarse aggregates were classified into two different particle size groups: 2 to 8 mm and 8 to 16 mm.

Results and Discussion. This study examines the results from a parametric study to assess the life cycle economic and environmental impact benefits when using alternative percentages of rock dust as either fine aggregate replacement in concrete and/or cement replacement. The parametric study was developed for a roadway construction representing real in-service conditions. Based on conducted research it was found that basalt dust used as a partial sand substitute and and at the same time as a partial replacement for cement, has beneficial effect on the physical properties of concrete. The most important and dominant mechanism of beneficial basalt dust interaction is related to the filler effect, i.e., physical interaction. Very small particles of basalt powder fill the space between cement and aggregate grains, which results in reduced porosity of the cement matrix. As a result, concrete with basalt dust additive features higher compressive strength.

Conclusion. The results indicate that the use of rock dust in concrete provide significant economic and environmental benefits. In addition to the LCA analysis, sustainability metrics were used to provide a relative rating between the alternative rehabilitation strategies where variable levels of rock dust are used. The results are expected to promote further use of these materials in roadway construction and the analysis approach is transferable to regions with similar construction practices. Such use of this waste is technically, economically, and ecologically justified and in line with the principle of sustainable development, as it makes it possible to reduce the use of natural resources to produce cement composites and effectively manage the waste.

Keywords: concrete, life cycle analysis, rock dust, sustainability

Prediction of compressive strength of electrically cured geopolymer mortars by fuzzy logic model

Serdar Yıldırım[1], Ahmet Beycioğlu[1], Magdalena Dobiszewska[2], Hüsamettin Ürünveren[1]

[1] Engineering Faculty, Adana Alparslan Türkeş Science and Technology University, Türkiye

[2] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

corresponding author: syildirim@atu.edu.tr

Introduction. Today, developments in any discipline can reveal useful methods for other disciplines. As a result of the rapid developments in computer science, many new approaches have emerged in artificial intelligence methods, and these approaches have attracted attention in many different engineering fields. When evaluating artificial intelligence methods in terms of civil engineering, it is seen that these approaches are mostly used in the field of concrete technology. Concrete is one of the principal materials for different types of buildings and structures. The use of concrete in constructing buildings, roads, bridges, dams, power plants, retaining walls, water tanks, ports, airports, etc. is inevitable from the economical and technological point of view. Concrete is a composite material composed of cement, water, fine aggregate, coarse aggregate, and some additives/admixtures. These ingredients have very important effects on concrete's physical and mechanical performances and are used as input parameters for predictive studies on concrete performances. Artificial intelligence-based computational techniques are generally useful to estimate the complex and nonlinear behaviour of different parameters of concrete performance. Thereby, several researchers have implemented these artificial intelligence techniques for concrete performance prediction. Since it is related to properties such as characteristic strength, permeability, durability, etc., the curing of concrete is very important for concrete construction. It is required to be applied in a sufficient period to achieve the expected properties of concrete. There are different types of curing methods applied to the concrete. In general, water curing, steam curing, wet covering, formwork curing, and membrane curing are mostly used. Nowadays, electrical curing has become popular, especially in scientific studies.

Materials and Methods. This study uses a fuzzy logic model for predicting the compressive strength of geopolymer mortars containing NaOH and Na_2SiO_3 as activators and fly ash as binder powder. For this purpose, geopolymer mortars were produced using different Ms modules and electrical curing at a different time and voltage values. Mortars produced with 1.2 – 1.4 – 1.6 Ms modulus and 10% Na_2O ratio were subjected to electrical curing at 20, 25 and 30 volts for 6 and 12 hours.

Results and Discussion. The data used in the modelling process were obtained experimentally. In the fuzzy logic model, Ms modulus, electrical curing voltage and electrical curing application time period were used as inputs, while the compressive strength of mortars was output. Experimental results showed that electrical current with low volt was insufficient in mortar mixtures with low Ms modulus. As the Ms modulus increased, conductivity increased, and an increase in strength was observed in geopolymer mortars with both 6-hour and 12-hour electrical curing. Fuzzy logic modelling results were compared with the experimental results, and the results of modelling were found very close to the experimental results. As a result, it is seen that fuzzy logic systems have strong potential for predicting the performance of electrically cured mortars. It can be an alternative approach for evaluating the mechanical properties of mortars under electrical curing.

Keywords: geopolymer mortar, electrical curing, compressive strength, fuzzy logic modelling

Modelling of the concrete properties by artificial intelligence methods

Esen Yıldırım[1], Ahmet Beycioğlu[1], Izabela Kasprzyk[2]

[1] Engineering Faculty, Adana Alparslan Türkeş Science and Technology University, Türkiye

[2] Faculty of Civil and Environmental Engineering and Architecture, Bydgoszcz University of Science and Technology, Poland

corresponding author: eyildirim@atu.edu.tr

Introduction. Civil engineering structures can be listed as buildings, roads, bridges, dams, power plants, retaining walls, water tanks, airports, etc. Structural engineers are responsible for designing these structures and generally use concrete as the main material. In concrete research, it is not always easy to perform laboratory experiments to observe the physical, mechanical and durability properties of concrete. As a result of the difficulty in doing experiments, different modelling methods based on soft computing have become popular in the past two decades, and many researchers have used these modelling methods to obtain a variety of data on the properties of concrete. Computer-based simulation of properties of concrete generally involves the development of a mathematical model by using experimental data. In the literature, it is reported that fuzzy logic, artificial neural network, response surface methodology etc. may offer a promising alternative. These methods are known as artificial intelligence. FL is a useful technique to embody human-like thinkings into a control system and it is a very popular modelling approach. FL was brought to literature for the first time in 1965 by L. A. Zadeh. In this approach, Zadeh developed a new mathematical set theory instead of Aristotelian logic, which only contains two definite and two different possibilities (1 or 0). It needs only to set a simple controlling method based on engineering experience. Therefore, it is particularly useful in complicated structural systems. FL has been developing since 1965 and has become most successful in application day by day. ANN is an artificial intelligence method that is used to simulate the structural or functional aspects of biological neural networks. After an effective training process, ANN can exhibit amazing capability in modeling the human brain. In general, ANN model consists of a number of interconnected group of artificial neurons, each of which is fully connected to the other through connection weights. These weights, present the effect of an input

parameter in the previous layer on the process element, can be adjusted to produce an output needed. ANN, sometimes called the black-box modelling approach, is an adaptive system that can change its model according to relevant information that flows through the network during the learning phase. ANN can be used to model nearly any complex relationships between inputs and outputs in data. RSM is one of the experimental design methods used to optimise engineering or industrial problems. The RSM was introduced by George E. P. Box and K. B. Wilson in 1951. The main goal of RSM is to use a sequence of designed experiments to obtain an optimal response. This kind of statistical method is very useful to investigate the best relationship between the dependent and independent parameters in experimental design and to determine their optimal use.

Materials and Methods. In this presented study, Artificial Neural Network (ANN), Fuzzy Logic (FL) and response surface methodology (RSM) were described and their applications in concrete technology were demonstrated via some example studies gathered from the literature.

Results and Discussion. Results show that the Artificial Intelligence methods can be very useful for laboratory studies to decrease labour efforts, materials consumption, cost and time period.

Keywords: concrete, fuzzy logic, artificial neural networks, response surface methodology, modelling

Everyday use of drones in modern civil engineering

Michał Stopel

Faculty of Mechanical Engineering, Bydgoszcz University of Science and Technology, Poland

corresponding author: michal.stopel@pbs.edu.pl

Introduction. Over the last few years, the development of technology related to unmanned aerial systems has made it difficult to imagine a branch of industry or services in which no application for this type of device has been found. It is no longer surprising that unmanned aerial systems are commonly used for marketing, property surveillance, modern agriculture, or transport. It is no different with civil construction. In this area of human activity, drones can be used in many ways. Starting from the supervision of the construction site, an inspection of building structures, in particular in difficult conditions or at high altitudes, to the measurement of deformation of buildings and cooling towers, the development of orthophotos for investment planning, or the creation of spatial models of buildings. Taking into account the pace of development of technologies closely related to unmanned aerial systems, it is not difficult to imagine that the examples of applications mentioned are expanding day by day.

Methodology. The article aims to summarise published data focused on drone usage in broadly understood civil engineering. It focuses on the period of the last 5 years and shows growing interest in the matter of drone usage and how it has influenced modern civil engineering. The articles were searched through online scientific bases such as Web of Science, PubMed, Scopus, Google Scholar, and ScienceDirect. Furthermore, more cross-reference was done, and the snowball technique proposed by Jalali and Wohlin, 2012, was used to find more articles on a similar topic related to modern civil engineering and the use of unmanned aerial systems (UAS).

Results. Selected scientific papers provide a certain overview of the population of various types of studies. Some of the selected works refer to the case study focusing on a specific application of unmanned aerial systems in the civil engineering area. Some of the works, similar to this study, are a review of previously published articles in regard to modern civil engineering and the use of drones and try to answer the question of what will be the further development of drone-related technologies and try to find previously unused areas of application. In particular,

articles that consisted of case studies are of particular interest. Such studies are readily read not only by academics and significantly contribute to the rapidly increasing use of unmanned aerial vehicles in industries related to construction.

Conclusion. Summing up, the review of the latest scientific research from the last five years indicates a dynamically growing interest in unmanned aerial systems' use in civil engineering tasks. The applications demonstrated in the study cover the period from planning through preparation of the construction site, its supervision to the assessment of the condition of the building, and marketing which is closely related to the subject, especially to residential construction. In addition, decreasing social concerns related to the widespread use of drones were demonstrated, which is associated with the dissemination of the presence of drones in many different aspects of everyday life and more and more formalised rules for the use of this type of aircraft. The conducted review allows drawing conclusions that with such a dynamic development and widespread use of drones, there is a need to conduct broadly understood research on the safety of the aerial operations, particularly operations performed on the construction site.

Keywords: civil engineering, drones, unmanned aerial system

FINE ARTS AND ART CONSERVATION

Exploring New Quality and Aesthetics of Wet Type of Bathroom in Southeast Asia Using Bamboo Fibers

Desy Teja Gumilar

Faculty of Design, Bydgoszcz University of Science and Technology, Poland
corresponding author: teija.gumilar@pbs.edu.pl

A wet room is a conventional type of bathroom available in almost every household in Southeast Asia. The people's specific way of carrying out daily personal hygiene and other washing activities using an open water tub in the bathroom is accompanied by a high level of humidity that often leads to poor condition or high maintenance of bathroom equipment. The European way of shower and bath, regarded as a dry type of bathroom, has been adopted in many Southeast Asian houses but hardly fulfils its intended function due to different ways of bathing and washing and incompatible water-supply infrastructure. The lack of sufficient water pressure towers or pumps leads to failed shower function; the limited water resource also leads to a mostly idle bathtub. As a result, the trouble-free conventional water scoop and an open tub full of water are indispensable regardless of the type of bathroom. The aim of this study is to explore new solutions through creative experiments in modern design to improve the quality and aesthetics of a bathroom made with sustainable materials while maintaining the comfort of using conventional water scoop and tub for bathing and washing activities of the people in this region.

Like in Europe, ceramic tiles and fibreglass are Southeast Asia's most common materials chosen for bathroom and water tubs. The region is known for its tropical climate and abundant sources of sustainable materials, such as palm trees, bamboo and teakwood. Bamboo, in particular, is the fastest growing material with extraordinary utility and durability. Over a decade, there have been extensive discussions on ecological and sustainability aspects of bamboo fibre, as well as new developments in woodworking technologies, such as creating bamboo panels in various sizes and forms and creating consumer products from flooring to tableware. But the use of bamboo material for bathroom equipment is still underdeveloped as most people still have a poor appreciation of their aesthetic values. The lack of modern design that can elevate the standing of bamboo for bathrooms leaves customers overlooking European-style equipment, despite their incompatibility with local culture and infrastructure.

Ironically, bamboo has gained popularity and respect in Europe, where it can't be naturally cultivated due to the different climate.

As an industrial designer, the author created a design concept of three sets of equipment for the wet type of bathroom with prefabricated bamboo panels that can be applied in Southeast Asian houses. The functional sets are designed for small, medium and large bathrooms, respectively. In this study, modern design is the key factor in creating a new market and raising people's awareness regarding the quality and aesthetics of a bathroom made with ecological and sustainable materials.

Design concepts are presented in 3D simulation. As in every industrial product, the realization of concepts of new products surely requires capital investment, e.g. on the production lines, marketing and distribution, but as long as its economic value is convincing, such investment would be viable.

New artistic orientation shaped by technological developments

Engin Güney

Fine Arts Faculty, Ondokuz Mayıs University, Türkiye

corresponding author: engin.guney@gmail.com

New media technologies, which emerged with the development of computer, internet and mobile technologies and brought many transformations in cultural processes, offer new tools and a new environment to artists, unlike the art production methods used in the past. Artists, too, are constantly striving to improve the possibilities offered by new technologies. The first of these expansions is the conscious breaking of codes. In artworks using digital technologies, while robots were trying to draw pictures through software, now there is a tendency towards conscious interventions and manipulations in works made with a post-digital understanding. The digital art evaluates the possibilities offered by mechatronics. In contrast, in post-digital art, we observe the attitude of turning toward human-like processes by making a malfunction in the mechatronics. Today, unpredictable outputs are achieved with errors/glitches by making random code distortions to produce unpredictable variations. The second expansion is hybrid orientation, where humans and machines or living organisms and computation systems are brought into a single system. Autonomous applications are made in combination with artistic works based on machine-human collaboration and features such as intuition, experience, nature and emotion that are not found in the machine. In the post-digital age, where the lines between virtual experience and physical life experience disappear, artists create performances with augmented reality and virtual reality applications. Art is reinterpreted with different ideas and different tools used in every period. In today's techno-cultural structuring, the artist pushes the limits of creativity in the search for new meanings. These technological innovations, which have become a determining factor of perceptual changes, offer new areas of creativity by being included in the art production process. In the study, new creativity areas offered by digital technologies are evaluated. The main purpose of the research is to explain the trends in art, which is a dynamic element, by associating them with technological developments and cultural transformations.

Today, the perception of art, artist attitude, art style, production styles and creativity areas have been transformed. Evaluation of the use of digital technologies in art constitutes a sampling area for the

explanation of perceptual, behavioural and productive changes. In the study, the title „Techno-culture" will make a general evaluation of the cultural change that has taken place with the penetration of new media technologies into all areas. The relationship between cultural transformation and technological development will be explained. Under the title of „Post Digital Art", the reasons for the tendency to achieve unpredictable results in digital applications will be explained. Hybrid approaches in the art will be examined on the axis of perceptual changes-transhumanist-posthumanist thoughts. The new areas of creativity that virtual reality offers in art, its effect on the creativity and style of the artist and its relationship with post-digital culture will be explained through examples.

Artistic actions that were seen in the past and are compatible with the culture continue today. In post-digital culture, the boundaries between „virtual" and „real" spaces and „machine" and „human" disappear. On the one hand, people do not use the questioning aspect of their minds that makes them superior; they become machines, and by being separated from the „real", they move toward „virtual". On the other hand, humans tend to humanize machines and make virtual spaces as realistic and attractive as possible. As long as this continues, the border between „machine" and „human" is being violated, just as the border between „virtual" and „real" spaces is gradually eroding. „The art of glitch", in which there is a tendency to take advantage of the glitches by making mistakes with deliberate interventions to reveal the humanoid side of the machine, is evaluated within the scope of post-digital art. In digital art, art is created through software/programs. With artificial intelligence, robots or machines try to take pictures. In studies conducted with a post-digital approach, there is a tendency towards manipulations with conscious interventions. In other words, the algorithm in digital art has been replaced by a change in the algorithm and codes in post-digital art.

Examples reveal the relationship of art with the cultural structure in which it flourishes. The perception of reality, time and space will be intertwined in the future. Technology will be much more advanced and widespread than today, computer and software technologies will develop, virtual reality experiences and corporate applications in virtual media will increase, and people will adopt a mechanical structure with silicon and steel. It shows that the parallelism between culture and art will continue in the future, where efforts to create a human generation will be undertaken, and ideological considerations will shape efforts such as gene interventions.

Keywords: Digital technology, glitch art, post-digital age, virtual reality art

Material selection on furniture in terms of ecological aspect

Erkan Likos

Fine Arts Faculty, Ondokuz Mayıs University, Türkiye

corresponding author: erkan.likos@omu.edu.tr

Over the past centuries, industrial design has not only modernized our lifestyle and living environment, but has also accelerated the consumption of resources and caused significant damage to the world's ecological balance. According to the Global Forest Resources Assessment (FRA) 2015 conducted by the Food and Agriculture Organization (FAO) of the United Nations, the world's forest area declined from 31.6% to 30.6%.

The main idea of green design is to achieve the expected quality level with longer service life and reduced resource consumption. Earlier, material selection methods have mostly been cost-oriented. With the increasing public concern for sustainable development, material selection is required to follow green design principles, improve product quality, and streamline production processes, thereby relieving adverse environmental and human impacts. Environmental factors should be taken into account at the earliest possible stage of product development and design. The establishment of criteria for selecting materials with low environmental impact during wood-based furniture design is an important aspect of furniture manufacture. One of the concerns and responsibilities of designers is to wisely choose the materials in the interior design and furniture, using materials that can be recycled and are environmentally friendly.

Eco-design is the first step. From there, it is necessary to continue working to obtain furniture without toxic materials and with 100% recycled and recyclable materials. Recycled plastic (polypropylene) furniture is commonly used in sustainable furniture. In addition to polypropylene in the design and manufacture of furniture, other materials (wood, steel, etc.) that also allow us to classify furniture as ecological are used. The fact that a piece of furniture (a chair, a bench, a table) is more or less sustainable depends on its life cycle, its duration and the subsequent management of its waste. That is what differentiates sustainable furniture from conventional one. The circular economy is based on the use of resources. It is a system that attempts to reduce both

the use of raw materials and the generation of waste. It is the idea to reuse and recycle, always adding value. In the case of furniture, the idea is that if a piece of furniture reaches the end of its life, its materials can continue to be part of the economy, giving life to another piece of furniture.

ECO-CULTURE and ART: A New Aesthetic Imagination and Process Management for Sustainability

Metin Eker, Erkan Likos

[1] Fine Arts Faculty, Ondokuz Mayıs University, Türkiye

corresponding author: erkan.likos@omu.edu.tr

The new world is transforming the concepts it inherited from the past. Especially and primarily, culture brings life to the new ecologies of these transformations. With new concepts coming, culture reveals its ecological destruction. Art as a cultural production mechanism is rethinking and practising its relationship with culture with new aesthetic contents.

Eco-culture makes both cultural ecologies and ecological culture scopes dynamic. It focuses on aesthetic transformations to benefit from art for sustainability. The eco-culture scope in which it gains character in eco-system, eco-tourism, eco-psychology and eco-pedagogy seem to have the potential to offer us new projections for the future and perspectives.

There are recommendations for collaboration with inter-aesthetics and eco-culture, integrated geography, interactive culture, dynamic globalization and fluid daily life comfort.

This study enriches with recommendations the advantageous position of eco-culture and art in sustainability and potential within an aesthetic system process.

Keywords: eco-culture, cultural transformations, ecological culture

The New Sustainable Tourist Model
for the Elbląg Canal

Julia Wleklińska

Faculty of Design, Bydgoszcz University of Science and Technology, Poland
corresponding author: julia.wleklinska@gmail.com

The project showcases the revival of tourist traffic in the area of the Elbląg Canal, which is to be integrated with the terrains located along the waterway by introducing a new sustainable tourist model allowing for optimal use of the region's charms and attractions. The presented project is a result of over five-years-long doctoral research. It showcases the possibility of revival of tourist traffic in the Elbląg Canal water system area by replacing the existing tourist model with a new one. The choice of this reservoir is deliberate. It is a unique system of interconnected canals and lakes on a Polish scale. Thanks to the use of an original 19th-century technology that facilitates overcoming significant differences in terrain elevation: the inclined planes are also unique on a global scale as no other such constructions survived. The Elbląg Canal has great potential – although neglected for decades, it has undergone a process of renaturalization – endemic plant species have reappeared, as well as new ones for which the conditions along the canal have proved to be favourable for development.

The assumption and thesis of the project were to show that adopting a new tourism concept aimed at revitalizing the region is possible only if the designer respects the place itself, its surroundings, the existing nature, as well as culture and tradition. The project included considerations of the concepts crucial for the design practice: landscape, tourism, cultural tourism, sustainable development, and slow tourism. Bibliographic studies, field studies and own observations, as well as the comparative studies of the selected navigable canal revitalization projects from around the world that I have undertaken, related to the above-mentioned concepts, are used to create design assumptions for the tourist land infrastructure in the form of small architectural objects, which can be tailored to the needs, but also the surroundings to minimally interfere with the beauty of wild nature. This concept also involves the study of a completely new means of transport adapted to the specificity of the canal but also the needs of users, including a new type of tourists who would like to come to this place to spend time on the canal and be able to stop for further venture inland.

Proposed design solutions in the form of sustainable tourism and sanitary infrastructure facilities made of upcycled shipping containers, a new type of electric-powered vessel adapted to the specificity and scale of the canal, and designated mooring spaces and accessible bicycle and pedestrian routes would allow for the introduction of small and evenly dispersed objects in the area of the reservoir. They do not dominate the landscape but allow for fuller use not only of the currently inaccessible sections of the canal but also to draw on the rich heritage of the entire region. Such restrained measures will prevent the degradation of the canal landscape and its nature, as they assume the use of the reservoir in its present state without the need for drastic removal of the quays and dredging of the canal bed while removing the underwater ecosystem. Due to the complete, gradual elimination of the existing old massive (in the canal scale) cruise ships, the need to strengthen quays with reinforced concrete will disappear, as well as the risk of water contamination with fuel leakage, noise and exhaust gas pollution.

The proposed functional and stylistic solutions constitute a summary of the research and analysis carried out during my doctoral studies. They are characterized by generality and elementary nature; however, it is a deliberate action as they constitute a set of guidelines suggesting the direction of development of the micro-harbour project, excursion routes and a network of vessels, taking into account the influence of the broadly understood landscape, as well as the intended functions. The drawn sketches express the overriding design idea; however, they are not finished designs. It should be emphasized that the creation of a concept by a designer allows for the consideration of the issues of the impact of culture, landscape and nature on the designed forms and, at the same time, shows how the designed objects would affect the environment and how to achieve harmony in this field.

Keywords: canals, design, landscape, sustainability