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University of Natural Resources and Life Sciences | Vienna, Austria | 5 - 7 July

Future Challenges for Cereal Science and Technology

BOOK OF ABSTRACTS

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Best Poster Award

The official journal of ICC, The Journal of Cereal Science will be sponsoring 2 ICC BEST POSTER AWARDS for innovative or exceptional work in whole grain cereals and pseudocereals research. The awardees will be selected from the poster submissions. This support will be in the form of two awards of EUR 500 each for student or postdoctoral researchers and is aiming at encouraging scientific work in the discipline of cereal science and technology research which can be transferred into application.

An independent jury including industry representatives will examine posters presented during the congress and will select the awardees.

The awards will be presented during the Awarding Ceremony of ICC2022.

Best Paper Award

plants by MDPI will be sponsoring 1 ICC BEST PAPER AWARD. The awardee will be selected from the oral submissions. This support will be in the form of one award of EUR 450.-- and is aiming at encouraging scientific work in the discipline of cereal science and technology research which can be transferred into application.

An independent jury will examine papers presented during the conference and will select the awardee.

Welcome Message by the Organizers

Dear Colleagues and Friends,

After a long time attending virtual conferences, ICC in cooperation with BOKU (University of Natural Resources and Life Sciences, Vienna) are organizing the 20th ICC Conference as hybrid event, taking physically place in Vienna and supported by an interactive digital platform.

The conference is held under the auspices of the Austrian Federal Minister for Agriculture, Regions and Tourism, Mag. Norbert Totschnig, MSc. and the Mayor and Governor of Vienna, Dr. Michael Ludwig.

"Vienna ICC Conferences" have become a tradition since the Association was founded in 1955 and since the Headquarters is located there.

The Department of Food Science and Technology of BOKU will host this event. The hybrid format includes benefits for all participants. Attending in person, you will enjoy the event as well known from previous years including all the networking possibilities plus to be connected comfortable to the digital platform, which facilitates to retrieve information, arrange meetings etc. Participating remotely, you'll have access to all content and be able to attend the live sessions, download abstracts and view posters, interact with participants and speakers via chat or video call, and build your own personalised schedule.

The Conference Committees with members from public and private institutions from all over the world will facilitate an interesting program, focused on sustainability and future challenges in the cereal sector by inviting internationally renowned experts. The program will cover aspects and latest developments starting from crop production with special emphasis on the change of climate and its influence of the world nutrition, via cereal processing, nutrition, analytics, quality and safety up to market trends and consumer demands to tackle the needs in the cereal business today and tomorrow.

The ICC2022 will be a great forum for discussions, to convene and collaborate and an excellent opportunity to build new connections and to renew friendships. All stakeholders in the grain food chains are called to support this event by contributing with their expertise and sharing the results of their work in oral and poster presentations as well as panel discussions and tabletop exhibitions.

ICC and BOKU would like to express a warm welcome to all participants from all over the world to join this ICC Conference in the beautiful city of Vienna and we are looking forward to meeting you all in July 2022!

Gerhard Schleining, Chair
Chair Scientific Committee

Regine Schönlechner, Co-Chair
Co-Chair Scientific Committee

Veronika Haslinger
Chair Organising Committee

Welcome Message by the Austrian Federal Minister for Agriculture, Regions and Tourism

Dear ICC2022 Participants,

The ICC Conference 2022 puts a strong focus on the current and future challenges of the cereals sector. In the present situation, security of supply and climate change are issues of crucial importance.

In times of crisis, it is essential to ensure an adequate supply of wholesome, safe food and of raw materials for food production. This is clearly demonstrated by the Russian war of aggression in Ukraine. Security of supply is therefore currently my top priority.

Today, it is no longer obvious that, in an interconnected and globalised world such as ours, the flow of goods linked to food supply can work without any problems. Global cereal production has continuously risen in recent years. From a global point of view, however, there are enough raw materials for human nutrition, animal feeding and industrial use.

One of the main challenges to agriculture and the security of supply today and in the future is climate change, which has a direct impact on agriculture. Rising frequencies of extreme weather events, changes in the distribution of precipitation, and shifted vegetation periods are just a few examples of the impacts that pose enormous challenges to agricultural production worldwide and that affect the quality, quantity and processing properties of the agricultural products.

Successfully tackling these major challenges requires the commitment of all stakeholders of the cereal value chain. It is therefore particularly valuable that the ICC Conference brings them all together. I wish all participants a thriving exchange of ideas and views and a fruitful conference!

Norbert Totschnig

Minister of Agriculture

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ORAL PRESENTATIONS

Abstracts are listed according to the sessions scheduled in the programme

Welcome & Opening Session

O.01 FUTURE FRAMEWORK CONDITIONS OF CEREALS SECTOR IN EUROPE

Martin Schönhart
University of Natural Resources and Life Sciences, Vienna, Vienna, Austria

The international cereals sector is under severe pressures today from high fuel prices, related fertilizer costs or disrupted input and output supply chains. Future framework conditions, however, may aggravate current or impose new challenges on the sector. Scenario thinking can help industry actors to anticipate future situations thereby improving informed decision making and risk management.

This presentation will summarize experiences and results from scenario studies. It analyses the natural and socio-economic framework conditions for and its impacts on European and global cereal production, processing, marketing and demand until mid-century. Results will be based on leading scenario frameworks, i.e. the global shared socio-economic pathways (SSPs) and its derivative for the European agricultural and food system – the Eur-Agri-SSPs (1, 2). The presentation will tackle major socio-economic drivers of change including future demand patterns from a growing population with shifting dietary preferences, technological change in agriculture and food processing or changing policies to protect the climate and biodiversity, particularly the European Agricultural Policy CAP. Thereby, the presentation aims to stimulate a discussion about the sustainable development of the sector during the coming decades.

References:
(1) Homepage of the Eur-Agri-SSPs: https://eur-agri-ssps.boku.ac.at
(2) Mitter, H., Techen, A.-K., Sinabell, F., Helming, K., Schmid, E., Bodirsky, B.L., Holman, I., Kok, K., Lehtonen, H., Leip, A., Le Mouël, C., Mathijs, E., Mehdi, B., Mittenzwei, K., Mora, O., Øistad, K., Øygarden, L., Priess, J.A., Reidsma, P., Schalda

Keywords:
Scenarios, sustainability, cereals sector

O.02 GLOBAL GRAIN MARKETS IN TURMOIL

Franz Sinabell
WIFO, AT

The lecture deals with the recent and long-term development of global markets for cereals. It will present and examine those phases in which the volatility of prices increased strongly due to political events or agricultural policy decisions. Options and measures to stabilise prices will be presented and discussed in the light of current events.

Session 1

Crop Production and Agricultural Challenges

O.03 INTEGRATING CROP MODELLING, PHYSIOLOGY, GENETICS AND BREEDING TO AID CROP IMPROVEMENT FOR CHANGING ENVIRONMENTS

Karine Chenu
The University of Queensland, Toowoomba, AU

Following advances in genetics, genomics, and phenotyping, trait selection in breeding is limited by our ability to understand interactions within the plant and with the environment, and to identify traits of most relevance to the target population of environments. We propose an integrated approach that combines insights from crop modelling, physiology, genetics, and breeding to characterize traits valuable for yield gain in the target population of environments, develop relevant high-throughput phenotyping platforms, and identify genetic controls and their value in production environments. This presentation will use transpiration efficiency (biomass produced per unit of water used) in wheat as an example of a complex trait of interest to illustrate how the approach can guide modelling, phenotyping, and selection in a breeding programme. Transpiration efficiency was identified as a valuable target to improve crops in major producing regions. Phenotyping platforms were built to study the physiology and genetics of transpiration efficiency. Genetic variations for this trait were partly correlated to water saving at high evaporative demand. Associated molecular markers were identified repetitively across trials and in different genetic backgrounds. Promising genotypes with higher transpiration efficiency than modern varieties were also identified as potential parents for further crossing and selection to produce more crop per drop.

We anticipate that the proposed approach, by integrating insights from diverse disciplines, can increase the resource use efficiency of breeding programmes for improving yield gains in target populations of environments in current and future climates.

References:
Chenu K et al. (2018). Integrating modelling and phenotyping approaches to identify and screen complex traits: transpiration efficiency in cereals. Journal of Experimental Botany 69, 3181-3194.
Collins B, Chapman S, Hammer G and Chenu K (2021). Limiting transpiration rate in high evaporative demand conditions to improve Australian wheat productivity. in silico Plants 3.
Collins B and Chenu K (2021). Improving productivity of Australian wheat by adapting sowing date and genotype phenology to future climate. Climate Risk Management, 100300.

O.04 EFFECTS OF ENVIRONMENTAL CHANGES ON PROTEIN COMPOSITION AND FRUCTAN CONTENT OF WHEAT GRAIN

Stefano D'Amico[1], Lisa Call[2], Heinrich Grausgruber[2]
[1] AGES - Austrian Agency for Health and Food Safety, Institute for Animal Nutrition and Feed, Vienna, Austria
[2] BOKU - Department of Crop Sciences, Tulln, Austria

Wheat protein and carbohydrate composition is essential for technological and thus baking properties. However, wheat proteins are also associated with gastrointestinal (GI) disorders, such as celiac disease (CD) and non-celiac wheat sensitivity (NCWS). It is commonly acknowledged that environmental conditions affect key parameters of wheat production, such as yield, protein and fructan content. The term environment comprises climatic conditions, such as temperature and precipitation, and agronomic parameters, i.e., type and amount of fertilization. With change of climate, it is critical to understand the impact of environmental conditions on wheat properties such as yield and quality, as well as consumer health. The objective of this study was to investigate the combined effects of weather and nitrogen fertilization on agronomic traits, protein composition and fructan content of wheat. The traits were assessed in a multi-environment trial (9 test sites in Austria, 2 cropping years, organic and conventional management) with the hexaploid wheat cultivar 'Arnold'. Special attention was paid to compounds involved in CD and NCWS. Results indicate that despite significant differences in weather conditions during the two cropping seasons, changes were not drastic enough to significantly affect wheat protein composition and quality. Furthermore, 'Arnold' is a modern wheat variety that probably shows already greater stability to annual fluctuations in current climatic conditions than old landraces. However, differences among test sites indicate the potential for grain composition change by environmental factors. Understanding the effects of environmental changes may lead to selection and cultivation of improved plant material with reduced potential for GI disorders while maintaining technological properties. However, further studies under standardized conditions should be conducted to verify significance of environmental effects on wheat grain composition.

Keywords:
Fructans, wheat proteins, environmental conditions, wheat sensitivity, fertilization

O.05 GENOME-WIDE ASSOCIATION MAPPING IDENTIFIES COMMON BUNT RESISTANCE LOCI IN A WHEAT DIVERSITY PANEL

Magdalena Ehn[1], Sebastian Michel[1], Laura Morales[1], Hermann Gregor Dallinger[1], Hermann Bürstmayr[1], Tyler Gordon[2]
[1] University of Natural Resources and Life Sciences, Vienna, Austria
[2] USDA Agricultural Research Service, Aberdeen, ID, United States

Common bunt caused by *Tilletia tritici* and *T. laevis* was successfully controlled by seed dressings with systemic fungicides for decades, but has become a renewed threat to wheat yield and quality in organic agriculture where such treatments are forbidden. As the most efficient way to address this problem is the use of resistant cultivars, this study aims to broaden the spectrum of resistance sources available for breeders by identifying resistance loci against common bunt in bread wheat accessions of the USDA National Small Grains Collection. We conducted three years of artificially inoculated field trials to assess common bunt infection levels in a diversity panel comprising 238 wheat accessions for which data on resistance against the closely related pathogen *Tilletia controversa* causing dwarf bunt was already available. Resistance levels against common bunt were higher compared to dwarf bunt in the panel with 99 accessions showing less than or equal to one percent incidence. Genome-wide association mapping identified six markers significantly associated with common bunt incidence in regions already known to confer resistance on wheat chromosomes 1A and 1B and novel loci on 2B and 7A. Our results show that resistance against common and dwarf bunt is not necessarily controlled by the same loci but we identified twenty accessions with high resistance against both diseases. These represent valuable new resources for research and breeding programs since several bunt races have already been reported to overcome known resistance genes.

References:
Gordon T, Wang R, Hole D, et al (2020) Genetic characterization and genome-wide association mapping for dwarf bunt resistance in bread wheat accessions from the USDA National Small Grains Collection. Theoretical and applied genetics 133(3):1069–1080

Keywords:
Tilletia caries, Tilletia laevis, Triticum aestivum, Resistance Breeding, Genome-Wide Association Mapping

O.06 BARLEY SELECTIVE BREEDING TO PRODUCE HIGH FRUCTAN LINES WITH ALTERED B-GLUCAN AND STARCH MOLECULAR STRUCTURES

Shishanthi Jayarathna[1], Yunkai Jin[2], Gleb Dotsenko[1], Annica AM Andersson[1], Roger Andersson[1], Mingliang Fei[2], Chuanxin Sun[2], Mariette Andersson[3]

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[2] Department of Plant Biology, Swedish University of Agricultural Sciences, Uppsala, Sweden

[3] Department of Plant Breeding, Swedish University of Agricultural Sciences, Lomma, Sweden

Barley is an important crop with great potential in utilizing for food and non-food applications. There is a growing interest in barley as a component of healthy food with a rich dietary fiber profile. Six different cross-bred barley lines and their parental lines, and a reference line (Gustav) were included in the current study. The breeding strategy had the focus to enhance the fructan synthesis activity via the SUSIBA1 (Sugar signaling in barley1) transcription factor and reduce the fructan hydrolysis activity in combination with a starch waxy mutation. We hypothesized that the duo function of the SUSIBA system in regulating carbon allocation affects the contents and molecular structures of the resultant starch and β-glucan in addition to the fructan content. The highest fructan and β-glucan content achieved in novel barley lines were significantly higher compared to the reference cultivar. Based on the fructan synthesis activity, the barley lines were grouped into two, e.g., low fructan synthesis activity and high fructan synthesis activity. Preliminary results indicate that lines with low-fructan synthesis activity resulted in a different composition of structural units of β-glucans compared to the group of lines with high fructan synthesis activity. Those barley lines had the highest starch content, and the detailed structural analysis of the starch revealed that the branching pattern of the amylopectin may be affected by the level of starch synthesis activity. These findings indicate that the control of starch and fructan biosynthesis activity by SUSIBA1 transcription factor also affects starch and β-glucan molecular structure.

O.07 BETA-GLUCAN AND ARABINOXYLAN IN BARLEY AND WHEAT GRAINS DEPENDING ON NITROGEN RATE AND CROPPING SYSTEM

Evelin Loit, Banafsheh Khaleghdoust, Maarika Alaru, Indrek Keres, Mailiis Korge, Max Kurg
Estonian University of Life Sciences, Tartu, Estonia

Nearly half of Estonian`s total agricultural output is crop production, mainly cereals. Currently most of it is exported as whole seed, but the goal is to increase the added value created in the supply chain of the agricultural and food sector by 50% by 2030. One option to achieve that would be more efficient use or extraction of valuable components in cereals, such as beta glucans (β-glucan) and arabinoxylans (AX), thus adding value to production in entire cereal sector. Dietary fibres β-glucan and AX found in cereal grains have valuable impact on both, the properties of food and human health. The concentration of those bioactive substances in cereal grains is determined by genetic, environmental and agronomic factors, which could be altered for achieving the highest possible β-glucan and AX content in cereal grains for later processing.

The ambition of our study was to investigate the relationship between plant nitrogen supply and β-glucan and AX accumulation in the grain to develop strategies for increasing the content of those dietary fibers in cereals in the future. The objective of this field crop research was to compare the effect of organic (cattle manure, off-season cover crop) and mineral N (NH_4NO_3; 0, 50, 100, 150 kg N/ha) fertilizers on β-glucan and AX content in barley and wheat wholegrain flours. The grain samples were collected from the long-term field crop rotation experiment located at the Estonian University of Life Sciences in Tartu County (58°22′ N, 26°40′ E) in 2019-2021. The amount of β-glucan in the samples was determined by using mixed-linkage β-glucan assay and AX by using D-xylose assay with enzymatic kits from Megazyme (Megazyme International Ireland, Ltd).The results revealed that barley and wheat β-glucan and AX content was stable and did not depend on N fertilization and cropping system. It depended on the cereal species, as β-glucan and AX content was higher in barley (β -glucan 5-5,5 g 100 g^{-1};AX 4,4 g 100 g^{-1}) compared to wheat (β -glucan 0,5 – 0,6 g 100 g^{-1}; AX 3,3 g 100 g^{-1}). Also, production year had significant impact on barley β-glucan content, being 1% less in year 2020. This data is supporting the idea that β-glucan and AX can be valuable resource to further develop cereal valorization.

Keywords:
Arabinoxylan, beta-glucan, nitrogen, cropping system

Session 2

Grain Nutrition and Health

O.08 CONSUMER TRENDS AND THEIR IMPACT ON THE FOOD AND CEREAL MARKET

Rainer Haas
Institute of Marketing & Innovation, Vienna, Austria

Consumer trends reflect significant overall changes in the society and of individual consumer behaviour. Trend research is based on the theory of weak signals from Ansoff and is frequently used in strengths/weaknesses and opportunities/threats analysis.

For food companies it is a strategic success factor to identify consumer trends as early as possible and to incorporate them in new product development and strategic decision such as the use of new distribution or communication channels. In this presentation dominant mega trends and specific food trends such as curated food, clean food, do it yourself food or plant-based food will be highlighted and illustrated with examples from the food and cereal sector.

O.09 THE "WELLONWHEAT?" PROJECT: NEED FOR HIGHLY CONTROLLED MATERIALS AS STARTING BASE

Fred Brouns[1], Daisy Jonkers[1], Peter Shewry[2], Alison Lovegrove[2], Twan America[3], Hetty van den Broeck[3], Luud Gilissen[4], Zsuzsan Proos[5], Petra Kuiper[5], Jan Philip van Straaten[5], C Friredrich Longin[6]

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[2] Rothamsted Research, Harpenden, Hertfordshire, GB

[3] Wageningen University & Research, Wageningen, NL

[4] BU Bioscience, Plant Sciences Group, Wageningen, NL

[5] Dutch Bakery Center, Wageningen, NL

[6] University of Hohenheim, State Plant Breeding Institute, Stuttgart,, DE

Over the last decade many communications have suggested that the consumption of modern bread-wheat is the cause of a wide range of chronic diseases in the population at large. In addition, that 'ancient wheat types' spelt and emmer as well as sourdough (SD) processing compared to yeast ((Y) are healthieralternatives. Many of the assumptions made are based on in vitro observations in cells/cell lines or animal studies, often after exposure to isolated wheat fractions or components, most frequently gluten. However,raw starch suspensions, wheat gluten and ATI extracts exposed to gut cells lack food processing and digestion influences and are not what we consume in our daily diet. Moreover, in many cases the wheat cultivars from which the components have been extracted, their purity and their molecular characteristics has not or poorly been defined and described. The "wellonwheat?" research consortium aims to study the composition and changes therein that take place during the entire chain of: grain seeding - harvested grains - milled flour - dough making (yeast or sourdough) - baking - bread, allowing for the study of changes due to processing and bread of fully known composition. The entire process is only possible after a careful selection of grains of known genotype and control of environmental influences on the composition of the harvested grain as basal study material. In addition, careful determination of all steps in food processing. Subsequent, metabolomics and proteomics of the obtained grains, flours, doughs and breads, allows to determine the changes that take place as a result of food processing. Numerous baking trials were required to obtain breads of acceptable appearance, taste, flavor and mouthfeel and limited noticeable differences most importantly of yeast vs SD and bread wheat vs Emmer.Following this route, it becomes possible to study the in vivo effects in humans (metabolic, functional, blood, stool analyses and symptoms occurrence) of the test breads and unravel possible symptom causes. Since social media creates expectancies about 'good or bad' and 'modern or ancient', it is also important to address the effects of expectancies on the occurrence of symptoms. Challenges and pitfalls will be addressed.

Keywords:
Bread wheat, emmer, spelt, bread processing, study criteria

O.10 THE “WELLONWHEAT?” PROJECT: COMPARISON OF "ANCIENT" AND MODERN WHEATS PROCESSED USING YEAST AND SOURDOUGH SYSTEMS

Peter Shewry[1], Alison Lovegrove[1], Abigail Wood[1], Amy Plummer[1], Jessica Evans[1], Jane Ward[1], Antoine America[2], Hetty van der Broeck[2], Hanna Hogenboom[2], Luud Gilissen[2], Roland Mumm[2], Zsuzsan Proos[3], Petra Kuiper[3], Jan Phillip van Straaten[3], Friedrich Longin[4], Annika Andersson[5], Daisy Jonkers[6], Fred Brouns[6]

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[3] Dutch Bakery Centre, Wageningen, NL

[4] University of Hohenheim, Hohenheim, DE

[5] Swedish University of Agricultural Sciences, Uppsala, SE

[6] Maastricht University, Maastricht, NL

The composition of bread is determined by a combination of factors. Firstly, the grain composition which is determined by genetics, environment (including climate, soil and agronomy) and the interactions between these factors. Secondly, the milling processing, notably flour yield, and the breadmaking system (including yeast and sourdough fermentation). We have therefore compared the compositions of flours, doughs and breads produced from commercial samples of emmer (blend of three varieties), spelt and bread wheat (both blends of five varieties). The grains were milled under controlled conditions and breads produced using yeast and sourdough systems in three replicates. Samples of the flours, doughs and breads were then analysed to determine dietary fibre components, polar metabolites and protein profiles by proteomics.

Breadmaking using the sourdough and yeast systems resulted in changes in composition from flour to dough to bread including increases in organic acids and mannitol in the sourdough system and increases in amino acids and sugars (released by hydrolysis of proteins and starch, respectively) in both processing systems. The concentrations of fructans and raffinose (the major endogenous FODMAPs) were reduced by yeast and sourdough fermentation, with yeast having the greater effect. Both systems resulted in greater increases in sugars and glycerol in emmer than in bread wheat and spelt.

Proteins were extracted by two different extraction protocols displaying remarkable differences in the selective extractability of a subset of proteins contrasting sourdough versus yeast fermented bread. Multivariate analysis displayed different responses of several classes of proteins like gliadins, glutenins, globulins and amylase/protease inhibitors.

O.11 WHOLE GRAINS- NEW DEFINITIONS AND THE ROLE OF FIBRES AND OTHER BIOACTIVE COMPOUNDS

Jan-Willem van der Kamp, Maria Wiese
TNO Healthy Living, Microbiology and Systems Biology group, ZEIST, NL

Whole grains are an important pillar of healthy and sustainable diets. Internationally accepted credible whole grain definitions are necessary to ensure that all global stakeholders have shared standards, and that consumers find them clear, credible, and useful. Based on widely accepted definitions and new developments, the global Whole Grain Initiative published (*Nutrients* 2022 *14*(1) https://doi.org/10.3390/nu14010138) generic definitions for whole grains and whole-grain food, ratified by the leading scientific associations in this area: ICC, the Cereals & Grains Association and the Healthgrain Forum.

The definition of whole grain as food ingredient sets criteria for grain species to be included and for processes. All cereal grains of the Poaceae family used for human consumption are included as well as the widely accepted pseudo-cereals amaranth, buckwheat and quinoa, since this may contribute to an increased whole grain intake.

The whole grain food definition sets minimum levels for calling a product a whole-grain food (≥ 50% whole grain ingredients based on dry weight) and for designating whole grain front-of-pack (≥ 25% whole grain ingredients based on dry weight). These criteria are important for ensuring that the presence of whole grain is not indicated front-of-pack when the actual whole grain level is low and dietarily not significant.

The Whole Grain Initiative urges that these consensus definitions be adopted as the basis for definitions used by national regulatory authorities and for health promotion organisations worldwide to use in nutrition education and food labelling.

In many dietary guidelines the presence of dietary fibre in whole grains is highlighted and their role for realizing the recommended daily intake of at least 25-30g fibre, being adequate for normal laxation and contributing to reduced risks for life style related diseases. Similar risk reductions are observed for a daily whole-grain intake of about 50g/day, containing for wheat, the most widely consumed whole grain, 5 – 6 g fibre. This indicates the beneficial role of the wide range of other bioactive compounds in whole grains such as minerals, vitamins, folate, choline, betaine, phytosterols, tocopherols and last but not least – polyphenols –compounds with anti-oxidant and increasingly recognized prebiotic properties.

It should also be noted that such compounds, when present together in the food matrix may result in broader beneficial effects [Kristek, 2019](2).

References:
Van der Kamp, J.-W.; Jones, J.M.; Miller, K.B.; Ross, A.B.; Seal, C.J.; Tan, B.; Beck, E.J. Consensus, Global Definitions of Whole Grain as a Food Ingredient and of Whole-Grain Foods Presented on Behalf of the Whole Grain Initiative. Nutrients 2022, 14, 1
Kristek, A., Wiese, M. et al., Oat bran, but not its isolated bioactive β-glucans or polyphenols, have a bifidogenic effect in an in vitro fermentation model of the gut microbiota. British Journal of Nutrition, 2019, 121, 549-559

O.12 COMMUNICATING WHOLE GRAIN CONTENT TO CONSUMERS: WHAT THE LATEST RESEARCH TELLS US

Caroline Sluyter
Oldways Whole Grains Council, Boston, United States

The Oldways Whole Grains Council has been educating consumers about whole grains for nearly 20 years, and they have witnessed the ways consumer demand and manufacturer innovation have shifted the whole grain landscape in significant, positive ways over that time. This session will share insights from a newly published study of Whole Grain Stamped products and explain what this research shows us about whole grain trends in both the US and Latin America. Findings from the Oldways Whole Grains Council's latest consumer survey data will reveal what consumers are looking for on the label when they are shopping for whole grain foods, and what other product attributes are important to shoppers in addition to whole grain content. The more we understand what drives consumption and where the barriers to increased intake still exist, the better off we will be when it comes to marketing whole grains and communicating their benefits.

Keywords:
Communications, whole grain trends, consumer insights, marketing

O.13 HEALTHCARE COST SAVINGS ASSOCIATED WITH INCREASED WHOLE GRAIN CONSUMPTION

Kevin Miller
General Mills, Minneapolis, United States

Higher intakes of whole grain in the diet are associated with reduced risk of several diseases including heart disease, diabetes, and certain cancers. In the recent Global Burden of Disease Study, diets low in whole grains were the second greatest dietary risk factor behind high sodium intakes. Efforts to increase whole grain intake may have a significant impact on public health, but also spending. Recent research in the US, Australia, Finland, and Denmark have examined the healthcare cost savings in their respective populations if adults were to consume more whole grains in their diet. Health economics are a useful tool in policy making decisions. These data indicate savings range from millions to billions of dollars could be saved annually. Investment in Dietary guidance, public education and other tools to increase whole grain consumption can yield significant dividends.

Keywords:
Whole grain, health economics, policy, dietary guidance

O.14 WHICH FOOD POLICIES TO PROMOTE WHOLE GRAIN CONSUMPTION?

Gabriel Masset
Nestlé SA, Vevey, Switzerland

Globally, consumption of whole grain is below recommended levels and low whole grain intake has been identified as the first dietary risk factor for global DALYs attributable to diet[1]. Several food policy tools exist that could help promote the consumption of whole grain. The symposium will cover several examples of food policies and programs that havetargeted whole grain intake. Proposals from the Whole Grain Initiative will be presented, together with current gaps in knowledge that can prevent the adoption of policies.

Firstly, the promotion of whole grain in food-based dietary guidelines will be discussed, highlighting the variety of messaging on whole grain, in particular for quantitative intake recommendations. Secondly, a brief overview of educationaland promotional campaigns regarding whole grains will be presented. The possibility of front-of-pack labelling including whole grain as well as whole grain content claims will be analysed in various jurisdictions. Finally, the challenge of reformulation will be assessed, and some concrete examples presented.

The coordination and harmonisation of such policies and the participation of all stakeholders is necessary to have an impact in terms of whole grain product availability and consumption.The example of the Danish Whole Grain Partnership will be presented as a successful campaign on whole grain. This public-private partnership led to an increase of the average whole grain intake within the Danish population from 36 to 82 g/day in 15 years [2].

By collecting scientific evidence on the health benefits of increased whole grain consumption as well as providing the means to translate such evidence into food policy tools (e.g.whole grain definitions), the Whole Grain Initiative's aim is to ensure whole grains are adequately and consistently considered in all food policies. A harmonisation of measures and guidelines on whole grain will enable an environment that incentivises manufacturers to propose products with higher whole grain content while providing clear and consistent messages to the general population.

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O.15 DEVELOPMENT OF RESISTANT STARCH FROM RICE AND EVALUATION OF ITS BIOACTIVE PROPERTIES

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The rice starch generally contributes to the glycemic load. The consumption of low glycemic index foods could contribute to reduced incidence and prevalence of cardiovascular disease, diabetes, obesity etc. The higher levels of postprandial glycemic exposure have been implicated in the development of chronic metabolic diseases; particularly type 2 diabetes and cardiovascular disease. Resistance starch (RS) is not digested in the upper gastrointestinal tract being resistant to alpha amylase. It is rather fermented by probiotics in the lower gut and behaves as dietary fibers. The resistant starch is performed to depolymerize the native starch by physical and chemical modification methods. Moreover, the consumption of resistant starch produced from different types of rice reduces glycemic index value which have beneficial implications for obesity, type 2 diabetes, glucose release applications as well. Among different resistant starches, retrograded resistant starch (RS3) has great commercial importance and health benefits. Lintnerized process followed by autoclaving is found one of the effective ways to develop resistant starch, especially RS3 from the rice grains and starch. Two different types of rice, namely Pathumthani RD31 and Berry Rice from Thailand were used to produce RS3 and evaluated for their bioactive properties including glycemic behavior. Interestingly, the Pathumthani RD31 starch which was treated by autoclave after lintnerization had the highest resistant starch content (65%) with lower glycemic index (46%).

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O.16 DOES GLUTEN STIMULATE WEIGHT GAIN

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Observations from animal and in vitro laboratory research, as well as some anecdotal evidence, have led to a bread public concern that gluten consumption stimulates weight gain in humans. In addition, it is suggestedthat gluten withdrawal from the diet induces weight loss. In the recent report "Sustainable healthy diets: guiding principles", FAO & WHO conclude: "Studies have consistently highlighted associations between low intakes of plant-based foods, high intakes of animal and ultra-processed products and poor health outcomes. The report emphasizes the importance of increasing plant food consumption, including whole grains. In this light it is important that concerns about grains, gluten, weight gain and related chronic diseases are addressed thoroughly. Two mechanisms have been suggested suggested: 1 gluten derived peptides expressing opioid activity (gluten exorphins) drive appetite and food consumption and 2) a decrease in resting energy expenditure (REE). To induce such effects in vivo, gluten peptides must be absorbed intact in sufficient quantity, remain stable in blood to allow for sufficiently long- lasting biological activity and bind to receptors involved in appetite and satiety regulation. At present data on quantitative absorption, stability and longevity of gluten derived peptides in the blood stream are lacking. Although di and tripeptides may pass from the gastro-intestinal tract into blood in extremely low quantities, they are subject to a rapid degradation by plasma and vasculum bound aminopeptidases, resulting in very short half-life times (1-3 minutes) and extremely low plasma levels (picomolar concentrations, <1% of intake) as has been observed for blood pressure (BP) lowering by ACE inhibiting di/tripeptides. BP lowering effects observed in vivo have been linked to interaction with opiate receptors in the myenteric plexus of the small intestine causing vasodilation of mesenteric arteries and modifying Na and fluid fluxes. Effects of gluten peptides on appetite stimulation by local gut receptors have not been shown. REE as measured at single time points appear to have low predictability in terms of long-term weight gain and no plausible mechanism has been proposed for such an effect on metabolism. The level of overweight observed in various countries appears to be independent of the level of per capita wheat consumption and abundant observational evidence in humans shows that the level of gluten consumption is neither related to daily calorie intake nor to BMI.

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Keywords:
Gluten, body weight, bioactive peptides, exorphins

O.17 MEASUREMENT OF STARCH IN CEREAL AND FOOD PRODUCTS

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Over the past 50 years, methods for the measurement of the total starch content of cereal and food products have used enzymatic procedures, rather than acid, for the hydrolysis of the starch. Solubilisation of granular starch achieved by heating samples in water/ buffer or DMSO at 80-100°C or with potassium or sodium hydroxide at 4-20°C. Depolymerisation of starch is achieved with a temperature stable a-amylase added during or after heat treatment. Amyloglucosidase has been universally employed to hydrolyse maltodextrins to glucose. In this presentation, I will describe a simple procedure for starch measurement which employs the knowledge gained over the past years. Parameters likely to affect accurate measurement, such as insolubility, chemical modification, isomerisation of released glucose and accuracy of glucose determination procedures, will be discussed. Reference will also be made to specific measurement of resistant/digestible starch and damaged starch.

For the measurement of total starch, a modification of AOAC 996.11 is employed. In the Rapid Total Starch (RTST) method, samples containing "non-resistant" starches are suspended in acetate buffer (pH 5.0), plus calcium chloride and incubated at 100°C for 15 min/ cooled to 50°C and incubated with amyloglucosidase for 30 min. Solutions are appropriately diluted and analysed for glucose using glucose oxidase/peroxidase (GOPOD) reagent. For samples containing resistant starch, the NaOH procedure is employed where samples are first suspended and stirred in 1.7 M sodium hydroxide at 4°C for solution is 30 min, neutralised with sodium acetate buffer to a pH of ~ 5.0 and thermostable a-amylase and amyloglucosidase added and the tubes at 50°C for 30 min to effect starch hydrolysis to glucose. The stability and purity of the enzymes employed, the lack of isomerisation of glucose or maltodextrin, and the linearity of the glucose standard curve with GOPOD reagent are vital.

Nutritionally, the levels of digestible and resistant starch are of greater relevance than total starch. These parameters are measured by controlled hydrolysis of starch in the food sample with a mixture of pancreatic a-amylase and amyloglucosidase with stirring at 37°C, pH 6.0 for 4 h. Subsequently, measurement of the released glucose is a measure of digestible starch. Resistant starch is captured in the insoluble fraction and hydrolysed using methods similar to those employed for total starch solubilisation, hydrolysis and measurement.

The level of mechanically damaged starch in milled wheat flours is the major variable in flour that affects water absorption in the preparation of dough. Consequently, specific measurement of damaged starch is important. This is achieved by controlled

hydrolysis of damaged starch with a purified fungal a-amylase with subsequent hydrolysis of these maltodextrin to glucose, which is measured with GOPOD reagent.

In summary, this presentation will describe the controlled use of bacterial, fungal and pancreatic a-amylases for measurement of key starch fractions.

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O.18 IDENTIFICATION OF REDUCTION STRATEGIES FOR AMYLASE/TRYPSIN-INHIBITORS (ATIS) IN FOODS: DEVELOPMENT OF A LC-MS/MS METHOD

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Non-coeliac wheat sensitivity (NCWS) is an inflammatory disease with numerous gastrointestinal and extraintestinal symptoms. Apart from gluten proteins and fermentable oligo-, di-, and monosaccharides and polyols, amylase/trypsin-inhibitors (ATIs) are postulated as triggers of NCWS. ATIs are compact, cysteine-rich proteins of the albumin/globulin fraction, located in the endosperm of cereals and resistant against digestive enzymes of insects and mammals. In humans, they can activate the innate immune response via the toll-like receptor 4 leading to typical symptoms for NCWS.

Until now, ATIs were only quantitated in various wheat species. The aim of the current study was to expand the quantitation possibilities to barley. Therefore, a liquid chromatography-tandem mass spectrometry (LC-MS/MS) method for the absolute quantitation of ATIs in barley was developed. The method was applied on a sample set of 181 different barley accessions, comprising 113 two-row spring barleys (malting barley) and 68 six-row winter barleys (feed barley) of worldwide origin, grown together in Gatersleben, Germany. Spring barley is mainly used in the beer brewing process, whereas winter barley is used for feed, which requires a high protein content and high yields.

The developed LC-MS/MS method was used for the absolute quantitation of 10 different, barley-specific ATIs (e.g. amylase inhibitors, CM-types, subtilisin and chymotrypsin inhibitors) in the flours of the sample set. High precision (Horwitz Ratio 0.58-2), high recovery (95-121%) as well as low limits of detection (0.01-4.39 µg/g) and quantitation (0.04-14.62 µg/g) were received. The barley accessions showed differences in the absolute content and the proportions of the different ATIs. The total ATI content ranged from 1.25 to 4.67 mg/g in flour. The highest contents were determined for the barley dimeric α-amylase inhibitor (BDAI-1; 2.32 mg/g) and the CM-type ATI CMd (0.88 mg/g). Additionally, BDAI-1 had the highest proportions in the flours (up to 53.44%), followed by the CM-types (CMa, CMc, CMd and CMe; up to 24.05% each). In most of the spring barley accessions a higher percentage of BDAI-1 (>30 %) was present than in the winter barley accessions (<20%).

This work successfully quantifies ATI contents in barley accessions even at low contents. Identified barley accessions with low ATI contents can be used further on as raw materials for products suitable for people affected by NCWS as well as for future breeding. The results are an important step towards ATI quantitation in processed foods, like beer and bread.

Keywords:
Non-coeliac wheat sensitivity, barley accessions, mass spectrometry, amylase/trypsin-inhibitor

O.19 HEALTH BENEFITS OF PLANT FIBRES TO MEET THE DIETARY GUIDELINES

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In history of human nutrition cereal fibers have always played a central role for healthiness and satiety. Non or low-processed cereal food products were rich or high in fibers helping the consumer to get their daily and essential load of this nutrient. As this main components in the daily fiber uptake taste, bite and of course the overall quality of food were influenced by their content and processing status. In a chemical and structural characterization, the main fiber components were cellulose, hemicellulose, lignin and arabinoxylans. Embedded in the plant tissue together with other plant substances, like minerals or secondary plant substances, these fibers displayed their function and need for human nutrition. Non-digestible and/or whole and partial fermentable the upper and lower human gastrointestinal tract required this portion of fiber and its physiological impact.

In the last eight to ten decades the consumption of food has been changed. With an ongoing progression in food technology, the physical and chemical or processing eliminated the fiber content more and more from raw material for a typical diet. While eating 150 years ago 80 – 120 grams of fibers per day in our nowadays world the average fiber uptake is in the Western world often below 20 g per day. When in the past brown bread containing whole meal flour and diverse kernels delivered a huge part of daily fiber load, a while and soft sandwich bread reveals different parameters in their listing of the nutritional declaration.

The consumer is the decision maker! Standing in front of the supermarket shelf or looking at the rich assortment of good in a bakery shop his choice is going more and more to white and soft bakery goods.

The question is now how to bring back the benefit of cereal fibers with their importance on the wholesomeness of humans? In the fiber definition of the Codex Alimentarius and also the European Union we find beside the intrinsic also extracted and synthetic fibers. In a long discussion to develop a fiber definition, the Codex understood that fibers has to be understood in their entirety and their physiological benefits for human being. The European Union underlined this classification by including all three groups of fibers and opened with this legal assessment the door to apply intrinsic and extrinsic fibers in all kind of food applications.

More research would be needed to develop a deeper understanding using different cereal raw material and extraction methods to gain fibers with a higher fiber content and unique fiber characteristics. It is understandable that fibers from different cereal plants and tissues from defined periods of growth could deliver fiber specific structural compositions in higher concentration which would reveal unique health benefits in a consumer appealing way. In the development of the primary and secondary plant cell wall organization the plant enzymes will lead to higher organization of cellulose, are responsible for a more or less branched hemicellulose and additionally could include an interesting part of arabinoxylans.

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Session 3

Processing and Cereal Products, Part I

O.20 TEXTURE DESIGN OF CEREAL FOAMS BY 3D FOOD PRINTING

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From a physical perspective, bread is a complex edible cellular solid. Its textural properties are the sum of its intrinsic material functionalities of a solidified matrix, based on the complex structures formed and controlled during development and processing of the intermediate product dough. The production process baking is the physico-chemical transition of the cereal-based biopolymers and the transition of a viscoelastic closed-cell foam to a solid open-cell foam with specific textural and thus mechanical properties. This short gives a hint of the high complexity of the structure-function and process-material relations during the production of baked goods. Thus, we try to reduce the complexity by a radical redesign of the current processes by additive manufacturing approaches. This should enable especially in a scientific point of view complete new possibilities for the understanding of the current classical processes.

Additive manufacturing (3D food printing) is a process to join materials to create objects based on 3D model data. The mostly layer based process gets more and more important for scientific and application reasons in the cereal food sector. We connect the knowledge from traditional food science with our novel highly flexible process. 3D food printing is not just a new processing technology, it's also an analytical tool to find new insights for other processes. In the short run 3d printing enables tremendous insights in the relations between structures in foods and its sensory qualities. In the long run fundamental material science approaches are necessary for designing these structures, textures and qualities. As first steps, an inline quality assurance system was established to enable a texture and sensory design of cereal-based food foams. A hardness-driven model was developed to predict and control the texture of the printed edible products.

These studies enable future developments and new impulses for the texture design of edible starch-protein based products. Thus, 3d food printing will lead to an unbounded texture design of foods.

Keywords:
3D food printing, texture design, cereal-based foams, edible cellular solid

O.21 FERMENTATION DYNAMICS OF NON-CONVENTIONAL YEAST STRAINS IN SWEET DOUGH AND FERMENTED PASTRY

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Traditionally, a relatively homogenous group of S. cerevisiae yeasts is used in fermented bakery products. Non-conventional yeast strains (NCYs) could, however, offer opportunities to improve aroma and product quality. For this purpose, more insight is needed into the fermentation dynamics of NCYs in order to implement these yeast strains in the recipes of fermented bakery products. Therefore, this study aimed to investigate the fermentation dynamics of 23 NCYs in sweet dough with 14% added sucrose (% w/w dm flour) by determining the relation between sugar consumption and metabolite production, and the production of volatiles. The 23 NCYs were able to ferment in sweet dough, although at different fermentation rates, which resulted in diverse sugar and metabolite concentrations in the doughs. A strong positive correlation (R2 = 0.76) was observed between sugar consumption and CO2, ethanol, glycerol and organic acid production. In addition, several yeast strains produced more positive aroma compounds compared to conventional yeast, which is desired for the production of fermented bakery products. Next, four yeast strains were selected to investigate their potential in fermented pastry products. Fermented pastry products are distinguished from other bakery products by their alternating layers of dough and bakery fat. These layers are, together with CO2 and steam production by yeast and water evaporation, responsible for dough leavening. Most of the NCYs produced a lower amount of CO2. Hence, to obtain the required product volume, higher yeast concentrations or longer fermentation times were required. The use of higher yeast concentrations resulted in high concentrations of glutathione, which is released from yeast cells. Glutathione destroyed the layered structure, leading to a reduced product volume. This problem could be solved by washing the yeast with water, which significantly reduced the glutathione content. In conclusion, NCYs can be used in fermented pastry without affecting product volume and texture, if some optimisation steps are taken into account. The results in this work contribute to the exploration of the possibilities of NCYs in fermented bakery products, which is justified by the increasing demand for fermented bakery products with novel natural aromas.

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O.22 IMPORTANCE OF THE THERMOSET GLUTEN NETWORK FOR BREAD MACROSCOPIC PROPERTIES

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Wheat bread is an important part of a balanced diet. To master bread quality, it is necessary to fully understand the functionality of its ingredients in the bread making process. During baking, gluten proteins polymerize to form a thermoset gluten network by disulfide bond formation. Glutenin starts polymerizing at about 70 °C with gliadin incorporating in the protein network at temperatures from about 90 °C onwards. However, the relevance of these molecular scale changes for gluten microstructure and bread macroscopic properties are largely unknown. In this work, the thermo-active serine peptidase aqualysin 1 (Aq1) of Thermus aquaticus was applied in bread making. Aq1 is inhibited by wheat endogenous serine peptidase inhibitors during dough mixing and fermentation. As such, it will hydrolyze gluten proteins during baking only above 80 °C when the enzyme is no longer inhibited. Although the thermoset gluten network was drastically impacted by Aq1 use on molecular scale, no impact was observed on gluten microstructure (confocal laser scanning microscopy), bread loaf volume or crumb structure. Only rather small changes in crumb texture profile analysis parameters were noted. The discrepancy between the impact of Aq1 on molecular scale and micro- and macroscale is explained by a decreased protein mobility after starch gelatinization. That Aq1 hydrolyzes gluten proteins in an already set gluten network explains the negligible impact on gluten microstructure, bread loaf volume, crumb structure or texture. The latter also indicates that gliadin incorporation into the thermoset gluten network, which occurs in the same temperature range, has no significant role in bringing about these macroscopic bread properties. The crumb was perceived to be more crumbly when Aq1 was included in the recipe. Therefore, it is clear that gluten polymerization is important for crumb coherence.

Keywords:
Thermoset gluten network, Aqualysin 1, confocal laser scanning microscopy, gluten microstructure

O.23 LINKING WATER MOBILITY DURING DOUGH MIXING WITH GLUTEN NETWORK FORMATION USING NMR

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Flour hydration is one of the main factors that govern the rheological behavior of dough throughout the mixing process. Determining the distribution of water between flour components would allow better understanding and optimizing dough changes during processing. 1H time domain nuclear magnetic resonance (TD-NMR) has shown to be particularly well suited for this purpose (Bosmans & Delcour, 2016).

In this study, doughs from 4 wheat flours were kneaded in the Farinograph at different kneading times (3 - 9 - 12 min, corresponding to an under-, optimal- or over- mixing respectively) and hydration levels (50% -Farinograph optimal value -and 66% by weight flour). Water dynamics were assessed by low field NMR (MiniSpec, Bruker Biospin, 20 MHz). Carr-Purcell-Meiboom-Gill (CPMG) pulse-sequence was used to characterize the different water mobility domains.

On the CPMG sequence, we have observed 4 to 5 different water proton populations in dough (a, b, c+d and e; or a, b, c, d and e, respectively from the least mobile protons to the most mobile ones), and their variations with processing conditions (flour origin, kneading time and dough hydration). We have interpreted these results by dough Hydration States (HS) that were represented using a Water Sink-Source Graph (WSSG) based on the relaxation distribution parameters (T2 and proportion). This formalism led to 4 different HS between the 4 or 5 proton populations regardless of dough processing conditions and flour origin. These evolutions of HS can be attributed to physical/chemical changes of the gluten network during dough formation. As a prospect, the dough HS will be related, on the one hand, to these structural changes and, on the other hand, to the power curve (P(t)) of dough during mixing.

Reference:
This work was carried out within the framework of a Cifre agreement n°2020/0687 between the firm La Boulangère & Co and INRAE.
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Keywords:
Bread process, Wheat Flour, Hydration kinetics, Power curve, Farinograph, Formalism graph

O.24 YEAST (SACCHAROMYCES CEREVISIAE) FUNCTIONALITY DURING THE BAKING PHASE AND OVEN SPRING

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The role of baker's yeast (Saccharomyces cerevisiae) during the fermentation phase of breadmaking has been extensively studied and reported in the literature. However, the importance of yeast during the baking phase has not been sufficiently explored or underestimated. Evaporation of water and ethanol, together with the expansion of produced CO2 by the yeast during the fermentation phase were considered as the major contributors to the oven spring. In this study, the hypothesis that the yeast is still functional during baking phase and can thus contribute to bread volume is attempted to be validated. An Electrical Resistance Oven (ERO) was used to assure a gradientless temperature profile in bread and to exclude the impact of crust formation on volume expansion. In this framework, Yeast Performance Indicators (YPIs) were defined to assess objectively the performance of seventeen yeast strains during proofing and baking in ERO. Moreover, the yeast activity was also studied by evaluating yeast viability and yeast-derived metabolites during baking. The YPIs revealed that some bioethanol and winemaking strains performed similar activity to the breadmaking yeast strains during both proofing and baking. The Mean Proofing Speed, Oven Spring (OS%), OS Speed, Peak Height, and Time at PkH were identified as the most relevant YPIs. The strong correlation between the Mean Proofing Speed and the OS% provided support with the idea that yeast still displays significant leavening activity during the baking phase. The HPLC results indicate that the yeast-derived metabolites are continuously being produced at the beginning of baking and even at around 50–65°C. The flow cytometry assays in the dough samples revealed that yeast viability was moderately high within the baking phase. The comprehensive analysis of these results demonstrate that yeast is still functional during the baking phase and its activity should not be neglected.

Keywords:
Yeast, Saccharomyces cerevisiae, Breadmaking, Baking, Oven spring

O.25 PROTEIN DISTRIBUTION ANALYSIS OF THE WHEAT ENDOSPERM REVEALS POTENTIAL OF BRAN SELECTION FOR BREAD MAKING

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The endosperm of wheat consists of the aleurone layer and the starchy endosperm. The latter consists of three cell types, named from outside to inside: the sub-aleurone cells (originating from the aleurone cells after division and re-differentiation), the prismatic endosperm cells and central endosperm cells. The sub-aleurone cells are rich in protein and could therefore play an important role in the quantitative protein gradient within the starchy endosperm, which is increasing from the inner to outer starchy endosperm. It is unclear to this day what this quantitative gradient looks like, what the role of sub-aleurone cells is in this gradient and how it depends on wheat cultivar and level of nitrogen(N)-fertilisation. Besides a quantitative protein gradient, also a qualitative protein gradient is believed to be present within the starchy endosperm. The majority of the studies states that the relative gluten content is decreasing from the inner to the outer starchy endosperm. However, both studies investigating the quantitative and the qualitative protein gradient use dry fractionation as a tool and are therefore dealing with specificity issues (e.g. aleurone contamination).

In our study we investigated how the protein-rich sub-aleurone cells contribute to the quantitative protein gradient by studying three wheat cultivars, each cultivated at three levels of N-fertilisation. We selected one of these cultivars, grown at one certain level of N-fertilisation, to investigate the qualitative gradient.

Kernel embedding, microscopy and image analysis showed that the quantitative protein gradient could be described by an increasing biexponential curve, with protein contents up to 32% beneath the aleurone layer due to the presence of protein-rich sub-aleurone cells. At the same level of N-fertilisation, cultivars did not differ in protein content in the centre of the cheeks and only differed in the outer endosperm when N-fertilisation was applied. N-fertilisation resulted in relatively higher increases in protein content in the outer compared to the inner endosperm.

Cryosectioning, laser microdissection and nanoLC-MS/MS indicated that the proportion of gluten proteins is significantly higher in the sub-aleurone cells compared to the other starchy endosperm cells.

To conclude, sub-aleurone cells are the cells of the starchy endosperm with the highest protein content and relative gluten content. Furthermore, this study reveals the potential of bran selection for wholemeal bread making as (i) most sub-aleurone cells remain attached to the miller's bran and (ii) the protein content of the sub-aleurone cells is highly dependent on the wheat cultivar and level of N-fertilization. The right cultivar-N-fertilisation combination could therefore yield protein-rich, and, more specifically, gluten-rich miller's bran, which could be beneficial for wholemeal bread making. Calculations show that due to the presence of sub-aleurone cells, a white flour yield of 75% could mean that at least 18% of the starchy endosperm proteins remains attached to the bran and that the residual endosperm has a protein content of about 28%. These insights can be of great value to the milling and cereal-based manufacturing industry.

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Keywords:
Wheat, Protein distribution, Gluten proteins, Sub-aleurone cells, Miller's bran

O.26 CORRELATIONS BETWEEN HMF AND EASILY DETECTABLE BROWNING INDICES IN BREAD

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Bread is one of the cereal-based foods most consumed worldwide. Baking makes bread edible and appealing, in fact during the thermal process a variety of reactions take place, including protein denaturation, starch gelatinization, aroma and colour development. The reactions involved in browning are the Maillard reaction and caramelization. 5-hydroxymethylfurfural (HMF) is formed during bread baking as a Maillard reaction product (MRP) and is regarded as a potential health risk since it can be converted into the genotoxic compound 5-sulfoxymethylfurfural. The aim of this study was to evaluate HMF formation in bread as a function of heat treatment intensity and to investigate correlations between HMF and easily detectable browning indices. White breads were baked at 200 °C and 225 °C for different baking times for a total of 24 baking trials. The extent of browning was evaluated as colour indices, obtained by reflectance colorimeter (L*a*b* space) and by computer vision system (RGB space). MRP were quantified spectrophotometrically at 280, 360 and 420 nm and HMF was determined by HPLC. As expected, bread crust colour varied from light to darker according to baking time and temperature and the concentration of MRP increased almost linearly with time at both baking temperatures. HMF concentrations were highly influenced by the baking temperature and varied from 4 to 300 mg/kg dw, with a parabolic evolution trend. Best fitting regression models between HMF concentration and other browning indices were explored. HMF was linearly correlated with Browning Index (100 – L*; r=0.930), Intensity Mean ((R+G+B)/3; r=−0.940) and MRP (r=0.969 and r=0.898, determined at 280 and 360 nm, respectively). However, for HMF values higher than 100 mg/kg dw, better fittings were obtained with nonlinear models.

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Session 4

Grain Biodiversity and Food Security

O.27 BREADS FROM AFRICAN CLIMATE-RESILIENT CROPS FOR IMPROVING DIETS AND FOOD SECURITY

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In sub-Saharan Africa (SSA), rural communities traditionally prepare meals from locally grown crops like cassava, sorghum and pulses, which are resilient crops in view of climate change. However, rapid population growth and massive urbanization are favouring a rapid transition in diets and lifestyle. We performed a food system analysis ([1, 2]) of the bread food value chain in SSA which indicates the positive effects of replacing refined, mostly imported, wheat by Climate Resilient Crops (CRC). The food system analysis also provided systematic insight into the challenges and hurdles that need to be overcome to increase the availability, affordability and uptake of CRCs.

Based on this Food System Analysis, we propose that the development of attractive bread products based on CRCs can be part of the solution towards a sustainable shift. Since CRC flours lack the unique gluten functionality of wheat, they mostly provide liquid batters which cannot be easily handled and has limited ability to hold gases. Although CRCs lack the technological functionalities to produce aerated bread products, our hypothesis is that by combining different CRCs with different properties, bread products with attractive textural properties can be obtained. In this presentation we show several applications of CRC based bread type products like flat bread, and our first results, demonstrating that combinations of sorghum, cow pea and cassava flour allow us to make aerated pan breads.

Our results demonstrate that climate resilient crops can provide valuable ingredients for healthy and attractive bread products and offer commercial opportunities and new value chains and can create jobs and employment. This could help to improve the resilience of the SSA food system.

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Keywords:
Food system, climate, bread, cereals

O.28 EFFECT OF SORGHUM VARIETIES ON WESTERN STYLE BREADS

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Over the past few years, the wheat cereal industry has faced several challenges, such as crop failures and changes in protein quality, due to the ongoing effects of the climate change (Gagliardi et al., 2020). In order to secure the grain availability and keep up with future demand, it may be necessary to introduce climate smart cereals into the Western cereal industry and diet. In this context, sorghum has proven to be a promising smart grain crop for application in baking. Previous research showed that the effects of sorghum addition on wheat bread quality strongly depended on the sorghum variety (Rumler et al., 2022). Therefore, this work focused on determining the suitability of selected sorghum varieties for the application in the Western diet. Selected varieties were characterized according to their chemical composition (ash, protein, fat, starch, dietary fiber and phenolics). To evaluate the effect of sorghum on the rheological behavior of wheat dough, pasting, mixing and stretching behavior of doughs were evaluated. Standardized baking trials were carried out to estimate the technological (specific volume, crumb firmness, porosity and color) and sensory properties of wheat breads added with sorghum. Results showed that some sorghum varieties possessed higher functional properties and sensory acceptance in wheat breads than others. This work enabled a first pre-selection of promising sorghum varieties in terms of nutritional profile, processability and sensory acceptance for application in Western style breads.

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Keywords:
Sorghum, climate smart grain, rheology, baking, sorghum wheat blends

O.29 RESEARCH SUPPORTING THE HUMAN UTILISATION OF RYE AND OAT

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The importance of minor cereals such as oat and rye in human nutrition is growing especially due to their beneficial dietary fibre composition and the health claims related to them. Besides, oat can be also a part of gluten-free diet by selecting appropriate varieties and by ensuring strict gluten-free processing conditions. The aim of our work was to characterize oat and rye varieties regarding chemical composition and technological traits such as mixing, pasting, and baking properties, as well as to study the impact of processing on these properties.

Eight oat and five rye varieties cultivated by Galga Agrár Ltd. from 2018 to 2020 were investigated in this study. Heat treatment and storage experiment of oat samples were carried out in laboratorial and industrial conditions. Production of novel rye milling fractions was performed in an industrial mill at First Pest Mill and Bakery Ltd. The chemical composition, as well as peroxide and acid number were determined by standard methods (AOAC, ISO), and by separation technique methods (GC, HPLC). Rheological properties were determined by standard methods, while baking quality was investigated by self-developed tests. Oat varieties differed greatly especially in fat content and fibre composition, while the composition of rye varieties was less diverse. More prominent differences were found in case of both oat and rye varieties regarding technological properties, especially pasting and baking, which can be explained mainly by the differences in carbohydrate composition. A necessary step of oat processing to improve shelf life is heat treatment. According to the results, acid number stayed constantly low during storage, however, peroxide number values showed periodicity referring to formation of oxidative free radicals. Based on the results of industrial rye milling experiment, it was possible to manufacture such fractions that possess more advantageous fibre composition than conventional flours but behaving similarly.

Our work can highlight the untapped potential of oat and rye and might contribute to develop novel and healthier products.

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Keywords:
Chemical composition, technological properties, processing effect, oat varieties, rye varieties

O.30 PROCESSING OF QUINOA FOR GERM EXTRACTION AND ITS APPLICATION IN DEVELOPMENT OF GERM ENRICHED PASTA

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Quinoa, a pseudo-cereal, is popular for its nutritional value. A good amino acid balance and presence of unsaturated fatty acids make this grain beneficial for human health. The nutrient content of quinoa grain is reported to be unevenly distributed in the various seed components like perisperm, germ etc. Fractionation will facilitate separation of nutrient dense components for their effective utilization. Physical fractionation method has a number of benefits over conventional wet milling; the present study is aimed at dry fractionation of quinoa seed components using roller milling process to separate different botanical components of grains with higher recovery and purity. Quinoa grain was pre-processed by water conditioning and conditioned grain samples were roller milled in laboratory mill, which has resulted into the production of fractions viz., bran, perisperm and germ. The milled fractions obtained at different moisture conditioning were evaluated for their yield and physicochemical properties by using standard AACC and AOAC methods. Developed process resulted into germ extraction of 23% containing higher amount of protein (36.47%), fat (21.30%), ash (4.81%) and dietary fiber (14.13%). Quinoa germ obtained was stabilized by heat treatment before utilizing in development of pasta. Durum semolina and quinoa germ blends were prepared and evaluated for the physical, nutritional and rheological properties. Nutritive value of the blends was found to be increasing with increased amount of quinoa germ substitution in durum semolina. The L* (lightness) values of pasta recorded a decrease in trend with an increase in the level of quinoa germ in the durum semolina. These results showed that the pasta became dull in colour than the control pasta by the supplementation of quinoa germ. The rheological study showed a significant influence on the blends. The pasta was prepared by the laboratory extrusion method and evaluated for quality parameters. The cooking loss decreased and cooking time increased with increased addition of quinoa germ to pasta. The sensory evaluation showed that pasta with 20% substitution of quinoa germ had an acceptable score and above which the pasta became inferior in quality. The developed pasta showed an increase in protein, oil, dietary fiber and mineral content compared to control pasta.

Keywords:
Quinoa, germ, processing, pasta,quality

O.31 EVALUATION OF THE SHELF LIFE OF GLUTEN-FREE COUSCOUS FROM GERMINATED QUINOA

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Quinoa sprouts couscous is considered a "novel food", which has maximized nutritional and functional properties compared to traditional couscous. However, its shelf life has not been determined. The objective of this contribution was to determine the shelf life of a gluten-free couscous made from sprouted quinoa. Desaponified quinoa of the Tunkahuan variety from Ecuador was used. The grain was germinated for 24 h at 20 ºC. Particle agglomeration equipment was used to produce the couscous. The shelf life of the product was determined by accelerated testing. Product quality changes were evaluated during storage for 90 days in different types of packaging (cardboard, polyethylene polyester and metallized polypropylene) under different conditions (15, 25, 35 and 45 °C). The parameters evaluated were moisture content, water activity, free fatty acids, peroxide index and maximum compression force. Analysis of total aerobes, total coliforms, molds, and yeasts were performed, which showed that the product complies with the microbiological parameters established for the three types of packaging during storage. In addition, a significant increase in water activity and in the concentration of free fatty acids was found, whose deterioration kinetics presented a reaction order of one. Thus, the results suggest that the product can extend its shelf life at 20 °C up to 85 days and 136 days in cardboard and polyester polyethylene packaging, respectively.

Keywords:
Quinoa, germination, couscous, shelf life, accelerated testing

O.32 BAKING QUALITY OF ORGANIC HETEROGENEOUS MATERIAL AND VARIETY MIXTURES: MUCH MORE THAN FLOUR BLENDS

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Despite taking up the highest share of utilized agricultural area in the EU (61%), arable crops are struggling the most to transition towards sustainable practices: while respectively 9.6 and 12% of permanent crops and permanent grassland area was organic, the share of organic arable land was only 5.8% in the EU-28 in 2018. Cereals – which are the main arable crops in Europe – are an eloquent example: in 2019, only 4% of the area cropped with cereals was organic in the EU. If the Farm to Fork Strategy's objective of 25% of organic agricultural land by 2030 is to be achieved, the issue of organic transition in cereals should be of particular attention.

In the case of bread wheat, a known agronomic lock-in is the lack of cultivars adapted to organic practices (1,2). Rigid DHS and VCU criteria which were designed for conventional breeding have long been one of the reasons for the gap in organic breeding. However, EU regulations have been adapted as of this year, with two major novelties: Organic Heterogeneous Material (OHM), which "is characterised by its high level of [intraspecific] phenotypic and genetic diversity, and its dynamic nature to evolve and adapt to certain growing conditions" (3), and a temporary experiment for Organic Varieties.

Aside from the evolution capacity inherent to genetic diversity, a main interest of OHM is the facilitation effects that can result from crop intraspecific functional diversity (4). As such, OHM brings whole new challenges to breeders and researchers: to uncover the full potential of OHM, they need to gain a better understanding of the effects of diversity, in order to identify (un)favorable trait associations. These questions also apply to variety mixtures, which are gaining attention as well. In France, variety mixtures were estimated to represent 17% of wheat stands in 2021, with the vast majority of them consisting of high baking quality cultivars (5).

Besides agronomic considerations, diversity effects may also affect baking quality characteristics of OHM and mixtures. This warrants specific attention. Indeed, the baking quality of a mixture cannot simply be expected to correspond to that of a flour blend of the same constituting varieties: facilitation and/or competition between genotypes will be expected to affect the end-result. To address these questions, we have conducted agronomic trials in Gembloux, Belgium, evaluating mixtures of 2, 4 and 8 wheat varieties (both modern and heritage cultivars), as well as their constituting varieties grown in pure stands. We carried out a number of agronomic observations– including lodging resistance as well as relative yield and yield components of the different varieties within the mixtures –, along with baking quality indices such as protein content, test weight, Hagberg falling number and Zélény sedimentation test.

In this presentation, we present preliminary results of these trials. To evaluate mixture performance, we compare baking quality performances of the mixtures to those of flour blends of the same varieties. We then interpret these results in the light of our agronomic observations, in order to suggest hypotheses as to the possible mechanisms underlying the observed mixture effects.

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Keywords:
Bread wheat, variety mixtures, organic heterogeneous material, baking quality

O.33 INFLUENCE OF AGRONOMIC PRACTICES ON ANTIOXIDANT COMPOUNDS OF PIGMENTED WHEAT AND TRITORDEUM CULTIVARS

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Cereals are staple foods worldwide and have long shelf life, so they could contribute substantially to the daily intake of antioxidant compounds and the prevention of aging processes associated with oxidative stress. Among cereals, bread wheat is one of the major cereal crops all over the world and constitutes a key source of micro- and macronutrients for human nutrition. Furthermore, researchers and breeders have focused their attention on wheat as a reservoir of protective phytochemicals that have shown several biological activities. Novel pigmented genotypes have been recently developed for their content in antioxidant pigments and represent valuable raw materials for the production of baked goods with added health benefits.

It is already known that agronomic practices, such as nitrogen (N) fertilization, can affect both physical and nutritional parameters of cereal grains (grain yield, protein content). Such practices may also influence the phytochemical content of kernels and flours. The aim of the present study was to investigate the effect of N on the content of bioactive compounds and the antioxidant capacity of innovative purple, blue, black, yellow genotypes, having one common-coloured wheat cultivar as control. One variety of the new cereal species tritordeum, characterized by yellow-coloured grains, was included in the scope of the study. The N effect was investigated in terms of N fertilization and soil N content, growing the genotypes at different fertilization rates (0, 80 and 160 kg of N/ha) in three experiments characterized by low, medium, and high soil N content, carried out in northern Italy. As the successful application of these novel genotypes will depend on their agronomic performances compared to commercially used varieties, also grain yield and physical kernel parameters were taken into consideration.

Grain yield of the novel genotypes was significantly lower than that of the control, with the black type differing slightly and the yellow-grained varieties differing the most. The genotype factor showed a significant effect on all the analysed agronomic and chemical parameters, and soil N content had a greater impact than N fertilization. Black-grained cultivars stood out for having the highest content of anthocyanins and phenolic acids, both soluble and cell-wall bound, and the highest value of antioxidant capacity measured by FRAP assay. FRAP was found to be positively correlated with the mentioned bioactive compounds, while the highest antioxidant capacity measured by ABTS assay was observed in tritordeum grains and was positively correlated with total carotenoid content. Samples from the site with low soil N content were characterized by a high content of anthocyanins and cell-wall bound phenolic acids (CWBPAs), whereas samples from medium and high soil N content differed for a higher content of soluble phenolic acids and greater ABTS. N fertilization significantly affected the grain yield, but had limited effects, although still significant, on anthocyanins and CWBPAs.

Among the analysed genotypes, some of them seems to be promising for the development of an innovative supply chain and the production of health-valued foods, having the highest performance when considering their antioxidant properties, quality and yield capacity.

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Keywords:
Wheat, tritordeum, pigmented grains, bioactive compounds, antioxidant capacity

Session 5

Processing and Cereal Products, Part II

O.34 PLANT-BASED MEAT ALTERNATIVES AND ULTRASONICS AS AN ONLINE TOOL TO CONTROL THEIR PHYSICAL QUALITY

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Plant-based meat alternatives (e.g., vegan, vegetarian burger patties, sausages) are progressively gaining global interest as healthy and sustainable sources of proteins as substitutes of animal meat. However, obtaining the most appealing meat-like structure and texture from plant proteins, i.e., their texturization, is challenging. Currently, the most common way of producing texturized plant-based meat alternatives is extrusion cooking. The characteristic textural features of such foods is a function of ingredient properties, extrusion process conditions such as barrel temperature and screw speed, and the alignment of proteins in the extruder die. Accordingly, development of desired textures in plant-based meat alternatives is a complex process that needs to be fully understood and monitored for optimized product properties. To tackle this challenge, extrudates made from a blend of soy and wheat proteins were extruded at different moisture content conditions (50-70%). The ultrasonic properties (phase velocity and attenuation) of the extrudates have been assessed using an ultrasonic air-coupled system (200 kHz – 600 kHz) placed at the die exit, during production or later in the lab after production. Texture measurements were also performed on the same products with a texture profile analyzer, to acquire information on the level of texturization, which is a good signature of the formation of meat-muscle-like fibers in an extrudate. The relationship between extrudate texture and ultrasonic properties showed a high correlation (R2=0.98) between longitudinal cutting force and ultrasonic velocity. Low-intensity ultrasound has shown great potential to be utilized as a non-destructive tool to monitor the quality of plant-based meat alternatives in-real-time during processing.

O.35 HIGH MOISTURE EXTRUSION OF PULSES FOR THE PRODUCTION OF MEAT ANALOGUES

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As animal-based foods, such as meat, have a large impact on the environment, meat analogous products, based on vegetable proteins, are now in the spotlight. The market for these products is in rapid growth, offering a great opportunity for the food industry. Meat analogous products can mimic the meat functionality, i.e. have similar product features and sensory attributes, thanks to the fibrous nature of those products. The purpose of meat analogous is to meet the needs of consumers who are aware of sustainability and nutritional issue. For this reason, pulses could play a key role thanks to both nutritional and health-promoting features, together with their low environmental impact.

This work is aimed at understanding the aptitude of pulse flours (chickpea, red lentil, fava bean, and yellow pea) to be transformed into meat analogous. Specifically, the fractions rich in proteins obtained by air fractionation were used.

Initially, flours fractions were characterized to understand the rheological behavior; specifically, the pasting properties (ViscoQuick, Brabender®) were studied to understand the starch and protein behaviors on heating and cooling cycles under controlled conditions. Functional properties, such as the ability to absorb and retain water and oil and the emulsifying and foaming properties, were assessed to understand the interactions of these raw materials with water and oil. Finally, mixing behavior (Farinograph, Brabender®) was studied to investigate dough resistance to shear stress.

Then, pulse fractions were subjected to high moisture extrusion process (~50% hydration and temperature up to 100°C) in a TwinLab-F 20/40 twin-screw extruder (Brabender®). Soy protein concentrate was used as a control since it is up-to-now the most widely used raw material to produce meat analogous.

Each pulse fraction showed peculiar functional and rheological properties, which allowed to predict the behavior of the material during the extrusion. For example, samples showing the highest torque stresses at the farinograph test led to the formation of a product with better characteristics. Differences in functional and rheological properties resulted in products with different features. Specifically, the products obtained from the extrusion of red lentil tended to expand at the end of the process creating, consequently, a heterogeneous structure characterized by the presence of air bubbles. Chickpea led to a product characterized by a different appearance compared to the conventional meat analogous (i.e based on soy proteins), specifically, it was not possible to distinguish the typical fibers of the reference product. On the contrary, products from fava bean and yellow pea presented similar characteristics to the reference. In conclusion, fava bean and yellow pea could successfully be used to produce meat analogous in order to offer consumers sustainable products with high protein content.

Keywords:
Pulses, high moisture extrusion, meat analogues

O.36 APPLICATION OF HIGH-PRESSURE AND ULTRASOUND TECHNOLOGIES FOR LEGUME PROTEINS AS WALL MATERIAL IN MICROENCAPSULATION

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Plant proteins, especially legume proteins, are among the most versatile, nutritious, and sustainable protein sources compared to animal-derived counterparts. Moreover, legume proteins have recently attracted interest of the scientific community owing to their wall-forming, gelling, and emulsifying properties in microencapsulation delivery systems. However, many industries have limited the use of legume proteins due to their poor solubility, lower functionality, presence of saponins and phenols leading to beany favor, and susceptibility to environmental stress. Modification of legume protein functional properties through emerging high-pressure processing and ultrasound technologies have therefore attracted considerable research interests to prepare legume proteins with desirable functional properties as wall material. Thus, we highlighted the application of emerging technologies to modify legume protein functional properties for the improvement in encapsulation properties. The application of legume protein-based microcapsules in the design of novel foods and their bioavailability is thoroughly discussed with emphasis on the current scientific knowledge and future perspective. The growing interest on legume proteins was due to consumer shift towards healthy diet choices that also have a better ecological footprint. The legume protein-based market has gained momentum among the consumer market with USD 267.53 million over 2019 to 2023, which is ultimately due to growing preference for sustainable and healthier foods. Application of non-thermal technologies, such as high-pressure processing and ultrasound technologies to legume proteins significantly improved their structure, functionality, and other encapsulation properties to better encapsulate the bioactive core materials. The designed novel foods using microencapsulated bioactive compounds with legume proteins showed the increased bioavailability of active components along with controlled release, improved nutritional values, sensory attributes, and other health-promoting effects.

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Keywords:
Vegetable proteins, non-thermal technologies, legume protein functional properties, microencapsulation, design of clean-labeled novel foods

O.37 EFFECT OF SELECTED PHENOLIC ACIDS ON THE BEHAVIOUR OF MODEL DOUGH AND GLUTEN STRUCTURE

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Gluten is a continuous and viscoelastic network that forms during dough mixing process and is responsible for dough as well as bread quality. The appropriate structure of the gluten network may be disturbed by supplementation of the wheat dough with phenolic compounds. As the result of the supplementation, changes in the behaviour of the bread dough, gluten structure, and bread quality including chemical and sensory parameters can be observed. The present studies were aimed at determination of changes in behaviour of model dough as well as secondary and tertiary structure of gluten network as result of supplementation the model dough with eight phenolic acids using farinograph and spectroscopic methods, respectively. The phenolic acids can be included to the hydroxybenzoic (4-hydroxybenzoic, protocatechuic, vanilic and syringic acid) and hydroxycinnamic acids (coumaric, caffeic, ferulic and sinnapic acid). Additionally, content of the phenolic acids in gluten samples after process of washing out was determined using UV-VIS spectroscopy. Phenolic acids were added to the model dough in three concentrations (0.05%, 0.1% and 0.2%).

Analysis of farinographic results showed that addition of phenolic acids led to the 'dough breakdown'. The appearance time of dough breakdown depend on the structure of phenolic acids. It is shorter for the hydroxycinnamic acids comparing to hydroxybenzoic acids. Spectroscopic analysis indicated that all phenolic acids caused similar changes in the structure of gluten structure i.e. formation of aggregated structures from α-helices, β-turns and H-bonded β-turns. Moreover, hydroxybenzoic acids induced formation of pseudo-β-sheets (aggregated β-structure characteristic for amyloids [1]). These results may suggest that hydroxybenzoic acids interacted less with gluten proteins in comparison with hydroxycinnamic acids. Further analysis showed that tryptophan is more buried within the protein complex (hydrophobic environment) in the presence of an acid with methoxy group at the aromatic ring. The mechanism of interactions between gluten proteins and phenolic acids depends on the type of functional group at the aromatic ring of phenolic acid, its molecular size and concentration.

Acknowledgments:
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Keywords:
Gluten, secondary structure, tertiary structure, phenolic acids, farinograms

O.38 DRY HEAT TREATED FLOUR, CONCEPT AND APPLICATION IN A SPONGE CAKE

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The Dry Heat Treatment process (DHT) applied to flour or starch aims at producing a functional ingredient; according to the ongoing EU regulation. Such ingredient can be labelled as “starch” or “flour” which complies with the “clean label” status. The interest of DHT flour is to mitigate collapsing issues in the case of high ratio cakes (mass of sugar above or equal to the mass of flour) or to enhance the texture for bread. The DHT process is a simple process and is based on a time and temperature combination treatment; the temperature rises meanwhile the starch/flour loses water by desorption. The known effect of DHT process relies on the denaturation of proteins located at the starch granule surface and the starch characteristics. However, the link between the DHT parameters and the flour’s functionalities is still scarcely documented in the literature. This study considered a set of DHT process applied to a wheat flour and performed at different temperature/time combinations ranging from 108 to 150 °C and from 10 to 40 min, respectively. The results showed that the batters made with DHT flours had higher viscosities than the control batter, from 1.759±0.094 Pa*s, to 2.705±0.121Pa*s and 1.397±0.078 Pa*s, respectively. Furthermore, the sponge cakes made with standard flour (control) and flours treated at 108 ºC-25 min had similar specific volumes of 2.69 ± 0.20 cm3/g and 2.58 ± 0.10 cm3/g, respectively. However, the cake structure collapsed for the cake made of the standard flour, as it didn’t for the cake made of the heat treated flour. The enhancement of starch’s gelatinization during baking is suggested to be the first effect to take place during the DHT process leading to a higher viscosity which may eventually alter the cake specific volume. As the DHT severity increases, the proteins located at the starch granule surface tend to expose their hydrophobic core, resulting in a surface active functionality. This new property is thought to become then the dominant mechanism improving the batter stability. The gas cells would be stabilized thanks to a Pickering effect of the newly hydrophobic starch granules. A partial replacement of DHT flour was preferred to a full replacement and has shown enhanced functionalities that are suitable for a clean label high ratio sponge cake.

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Keywords:
Dry heat treatment., starch functionalities, pickering effect, sponge cake, clean label

Session 6

Grain Quality, Safety & Analytical Tools

O.39 ANALYTICAL TOOLBOX TO ASSESS THE SAFETY OF GLUTEN-FREE PRODUCTS

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Wheat is one of the pillars for nutrition security worldwide, but the prevalence of wheat-related disorders is increasing. Taken together, celiac disease (CD), non-celiac wheat sensitivity (NCWS) and wheat allergy may affect up to 5% of the population. The triggers are gluten proteins in case of CD and both gluten and other proteins in case of NCWS and wheat allergy. The only effective treatment for CD is a gluten-free diet that involves strict avoidance of wheat, rye and barley products. Improved analytical methods are urgently required to protect sensitive individuals and better understand mechanisms of immune activation. Therefore, the aim was to advance the detection of immunoreactive cereal proteins using enzyme-linked immunosorbent assays (ELISA) and liquid chromatography tandem mass spectrometry (LC-MS/MS).

First, improved reference materials for gluten from wheat, rye and barley were developed for analytical method development and validation. Having studied the recognition profiles of the antibodies currently used in gluten ELISA testkits, novel antibody target sequences were identified. A new commercially available testkit with four antibodies now enables the comprehensive detection of gluten. Furthermore, targeted LC-MS/MS methods were developed for selected CD-active peptides. Analyses of the 60 most common German wheat varieties from 1890 to 2010 grown together in three consecutive years showed that the content of CD-active peptides was similar in old and modern varieties. The environment had a larger effect on the content of CD-active peptides than the genetic background of the varieties. These findings successfully ruled out wheat breeding as a cause for the increasing prevalence of wheat-related disorders. Current studies focus on characterizing partially hydrolyzed gluten in a variety of fermented or otherwise treated foods. The quantitation of residual CD-active peptides is especially challenging in these foods and further advances in gluten analytical method development are necessary to enhance food safety for CD patients.

Keywords:
Gluten-free, celiac disease, wheat allergy, LC-MS/MS, ELISA

O.40 HIGH-RESOLUTION SOLID-STATE NMR FOR UNRAVELING THE STRUCTURE OF WATER-UNEXTRACTABLE ARABINOXYLAN IN WHEAT FLOUR

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The predominant dietary fiber in wheat is arabinoxylan (AX). It consists of a linear backbone of β-(1,4)-linked ß-D-xylopyranosyl (Xyl) residues that can be unsubstituted, mono-substituted or di-substituted (uXyl, mXyl, dXyl) with α-L-arabinofuranosyl (Ara) residues, some of which carry a phenolic acid (in essence ferulic acid) residue (Izydorczyk and Biliaderis, 1995). AX molecules differ in molecular weight and degree of arabinose and ferulic acid substitution (Gebruers *et al.*, 2008). Insight in AX structural heterogeneity is essential, as AX structural features determine its solubility, extractability, viscosity, water binding capacity and therefore also its overall functionality during product making, but potentially also its health effects (Damen *et al.*, 2011). Part of the wheat flour AX (20-30%) is water-extractable (WE-AX), but the major part (70-80%) is water-unextractable (WU-AX). The unextractable nature of WU-AX makes its structural characterization challenging. WU-AX has often been solubilized by alkali or enzymatic modifications (Gruppen *et al.*, 1991) which disrupt the native WU-AX structure. Here, we characterized wheat flour WU-AX by means of high-resolution solid-state Nuclear Magnetic Resonance (NMR) technologies, without disrupting its native structure. WU-AX was isolated from wheat flour as unextractable cell wall material (UCWM) with an AX content of 40.9% ± 1.5% of dry matter (DM) and an arabinose-to-xylose ratio of 0.62 ± 0.04. Apart from AX, the UCWM still contained significant levels of polymeric glucose (21.6% ± 1.45% of DM, likely in the form of cellulose), and protein (12.6% ± 1.0% of DM). Solid-state ^{13}C High-Power Decoupling with Magic Angle Spinning (HPDEC MAS) NMR analysis of hydrated UCWM sample yielded a spectrum with sufficiently high resolution to perform peak identification. Based on earlier reports on liquid-state ^{13}C NMR on WE-AX (Hoffmann *et al.*, 1992), spectral resonances of C-1 from Ara and Xyl residues of WU-AX could here be identified in solid-state. The resonance at d 108.4 ppm represents the C-1 of an Ara residue linked to *O*-3 of a mXyl residue. Resonances at d 108.8 ppm and 109.5 ppm originate from the C-1 atoms of two neighboring Ara residues linked to *O*-3 and *O*-2 of a single dXyl residue, respectively. The resonance at d 102.5 ppm is that of both C-1 of mXyl and C-1 of an isolated uXyl residue, whereas those at d 100.7 ppm and d 102.0 ppm represent the C-1 of dXyl and C-1 of a uXyl residue with neighboring mXyl or dXyl, respectively. To the best of our knowledge, this study is the first to successfully present a solid-state NMR spectrum of wheat WU-AX with sufficiently high resolution and without prior solubilization by e.g. alkali or enzymatic treatment. In future work, solid-state NMR will be applied to further elucidate the WU-AX structural heterogeneity by analyzing relaxation properties, allowing the identification of different WU-AX structures present in wheat flour.

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Keywords:
Arabinoxylan, dietary fiber, solid-state NMR, wheat flour, 13C NMR

O.41 THE NEXT CHAPTER OF THE REFERENCE MATERIAL JOURNEY- RYE AND BARLEY IN GLUTEN QUANTIFICATION

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Celiac disease (CD) is an autoimmune enteropathy with a global prevalence of about 1% that is triggered by the gluten proteins of wheat and other cereals, such as rye and barley. With no available cure, CD patients must adhere to a lifelong gluten-free diet to be in remission. Current European legislation defines a threshold of 20 mg/kg gluten for the labelling of gluten-free products. Monitoring of compliance relies on suitable analytical methodologies of which the immunoanalytical ELISA is the routine method of choice. While ELISAs are specific, sensitive, quite simple ways of gluten quantitation, they have a few inherent problems that pose reliability issues. In one hand, there are no reference methods and commercial assays very often provide different results for the same sample due to differences in the applied antibodies, extraction methods and calibrating materials. On the other hand, gluten is a remarkably complex protein that is prone to genetic and environmental variability that also affects analytical data. A reference material would be very helpful to resolve harmonization issues of gluten analysis but its development is hindered by the aforementioned variability of gluten. There have been efforts to identify a suitable reference material, like the PWG gliadin as a notable example. Our group also developed a wheat reference material consisting of five wheat varieties selected by the analysis of a large pool of international samples. However, gluten ELISAs also appear to be different in terms of their affinity towards rye and barley gluten proteins, which makes it necessary to extend reference material development to these cereals as well. The goal of our current work is to assess rye and barley varieties from multiple countries in order to identify the ones that can be considered as candidates for reference material development. The outcome is expected to be new reference materials for rye and barley and their combination with wheat that has the potential to cover all major CD triggering cereals.

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Keywords:

Celiac disease, reference material, gluten ELISA, rye, barley

O.42 COLLABORATIVE STUDY USING AN UNPRECEDENTED WIDE RANGE OF MATRICES FOR GLUTEN ANALYSIS

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The RIDASCREEN® Gliadin R7001 ELISA was endorsed in 2012 as AOAC First Action *Official Method*^{SM} 2012.01 and in 2016 as ICC Standard Method No. 182 for analysis of gliadin as a measure of gluten in foods. However, for Final Action *Official Method*^{SM} endorsement, the method's scope was revised by AOAC to "Gliadin as a Measure of Gluten in Rice and Corn Based Foods", since these were the matrices tested in two collaborative studies. This reduction of the scope led to irritations in the analytical community, as laboratories were unsure which matrices could be analyzed or would have to be additionally validated.

In order to demonstrate the indisputable ability of this ELISA to analyze all kinds of matrices, the method provider R-Biopharm decided to perform another international collaborative study with a very wide range of different foods. In total, 19 incurred and mostly processed matrices were prepared at Hochschule Geisenheim University. Each of the participating 14 laboratories received two blind coded replicates per matrix and concentration level, overall 64 samples. Moreover, additional concentration levels of the 19 different matrices prepared by Geisenheim were mixed and analyzed by R-Biopharm (overall 46 contaminated and 13 blank levels).

The results of the collaborative study showed recoveries ranging from 80 to 130 % with the exception of two matrices showing recoveries at around 60 %. Relative reproducibility standard deviations for contaminated samples ranged from 9.8 to 27.7 % with the exception of multivitamin juice (38.7 %). The collaborative study results confirmed that the method is accurate and suitable to measure gliadin in important gluten-free food matrices.

Keywords:
Gluten measurement

O.43 MYCOTOXINS REDUCTION STRATEGIES TO REINTRODUCE GRAIN SIDE PRODUCT STREAMS INTO THE FOOD VALUE CHAIN

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Wheat is considered a key staple food worldwide but is often contaminated with molds that can produce harmful mycotoxins. Food safety has become a major challenge as an estimated 25 % of all global crops are affected by molds [1]. According to literature, between 8 % to 88 % of wheat, wheat flour, and wheat products are contaminated with mycotoxins, mostly with *Fusarium* mycotoxins like deoxynivalenol (DON), zearalenone (ZEA), and the emerging mycotoxin enniatin B (ENB) [2,3]. Measures to reduce mycotoxins are urgently needed because discarding contaminated grains results in significant food and economic loss, and the health consequences of consumption can be severe [4].

In this project, an interdisciplinary team of researchers from the Zurich University of Applied Sciences (ZHAW) is developing and testing strategies to reduce mycotoxins. The goals are:

o To develop and test an accurate analytical method for determining the content of mycotoxins in wheat,

o to test ways of enzymatic and microbiological degradation / conversion of mycotoxins into non-toxic molecules and to test their effectiveness,

o to develop a pretreatment of whole wheat grains that allows the active substances to be applied, thus minimizing the need to adjust the usual wheat standing and milling process, and

o to test and analyze the effect of pretreatment and treatment on whole wheat grains.

The untargeted HPLC-MS/MS analysis developed had the advantage of allowing the quantification of ZEA, DON and ENB in the samples up to levels 80 times below the legal limits, as well as enabling the identification of degradation products in the samples treated enzymatically and microbiologically, in the same run.

The biotechnological screening of microbial strains with QPS status from the own strain collection of the ZHAW showed promising results. Out of 213 strains screened, 51 strains showed great potential to reduce ZEA. The mode of action of the microorganisms was also investigated, showing that living cells had the greatest effect on ZEA reduction. No suitable strains could be identified for the reduction of DON.

In parallel, genes of ZEA and Zearalenol (ZOL) degrading enzymes were subcloned and the proteins produced in *E. coli*. An almost complete degradation of ZEA to the significantly less estrogenic components 'hydrolyzed ZEA' and 'decarboxylated hydrolyzed ZEA' could already be achieved within an exposure time of 30 min treatment time, a complete degradation within 24 h.

Different pretreatment methods of whole wheat grains from the application of electromagnetic waves, mechanical waves, mechanical stress, heat treatment as well as water evaporation under vacuum were tested. The effect of the treatments on the microstructure of the grains was tested using fluorescent pigments and imaging techniques. The treatments using cold-needle perforation and pulsed electric fields proved to be particularly promising.

In an application trial, the pretreatment and treatment processes will be further optimized and combined, and the effectiveness of the approaches on contaminated wheat grains will be determined using the novel analytical methods. Furthermore, the effect of the treatments on the milling properties of wheat will be tested.

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Keywords:
Mycotoxins, wheat, food safety, food waste, interdisciplinary approach

O.44 CHEMOMETRIC MODELS BASED ON 2D-FLUORESCENCE SPECTROSCOPY FOR RICE SOURDOUGH FERMENTATIONS

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At present, pH and total titratable acid (TTA) are the main monitoring values for sourdough fermentations. In addition, the concentrations of present sugars, acids, glycerine and ethanol are determined using HPLC. Samples are taken at defined intervals during the ongoing fermentation. For pH and TTA no online measurement systems are available. Online monitoring is, with respect to the ongoing digitalization of food processes, of increasing relevance. Due to biogenic fluorophores 2D-fluorescence spectroscopy makes it possible to monitor the fermentation process of sourdoughs. Fluorophores are influenced by pH, viscosity and temperature, subsequently their spectra show differences too. Using chemometric models it is possible to predicted the courses of further fermentations. The aim of the study was to predict the course of the pH and TTA during sourdough fermentations at different temperatures using fluorescence spectra. The authors will demonstrate that fluorescence spectroscopy fulfil the needs for the online-monitoring of sourdough fermentations.

Twelve sourdough fermentations with three different temperatures that were 26 °C, 28°C and 30 °C were performed for the model development. During the fermentation process fluorescence spectra were recorded every 90 s. In addition, at defined time intervals samples were taken to measure pH, TTA and for HPLC analysis of maltose, glucose, fructose, lactic acid, glycerine, acedic acid and ethanol. The spectra were evaluated either as raw spectra or pre-processed with Standard Normal Variate Transformation (SNV) or a High-Pass-Filter (HP). Using the Regression Learner (Matlab 2021) three regression models, linear, support vector machines, gaussian process regression were trained with or without a previous performed prinicipal component analysis (PCA).

The quality of the models for the courses of pH, TTA, maltose, glucose, fructose, lactic acid, glycerine, acedic acid and ethanol were rated by the R^2, RMSE and percental error ERP (RMSE related to the measurement range) of a five-fold cross validation implemented in Matlab. A 13^{th} fermentation at 29 °C was performed to validate the models.

Best results were obtained for the courses of the pH and TTA. For the linear models of the TTA the same calibration and validation ERP of 7.1 % could be achieved. Figure 1 presents some validation results for the predicted courses of pH, TTA and ethanol during the validation fermentation. The best models were the GPR models with R^2 of 1 and an ERP of 0.03 % for the validation without pre-processing even for ethanol whereas the other models resulted in ERPs around 30 %. The PCA lead to better results for the SVM models, for the others the results were worse. Advantages and disadvantages of the methods will be explained within this contribution.

Keywords:
Sourdough, monitoring, quality assurance, fluorescence spectroscopy, fast method

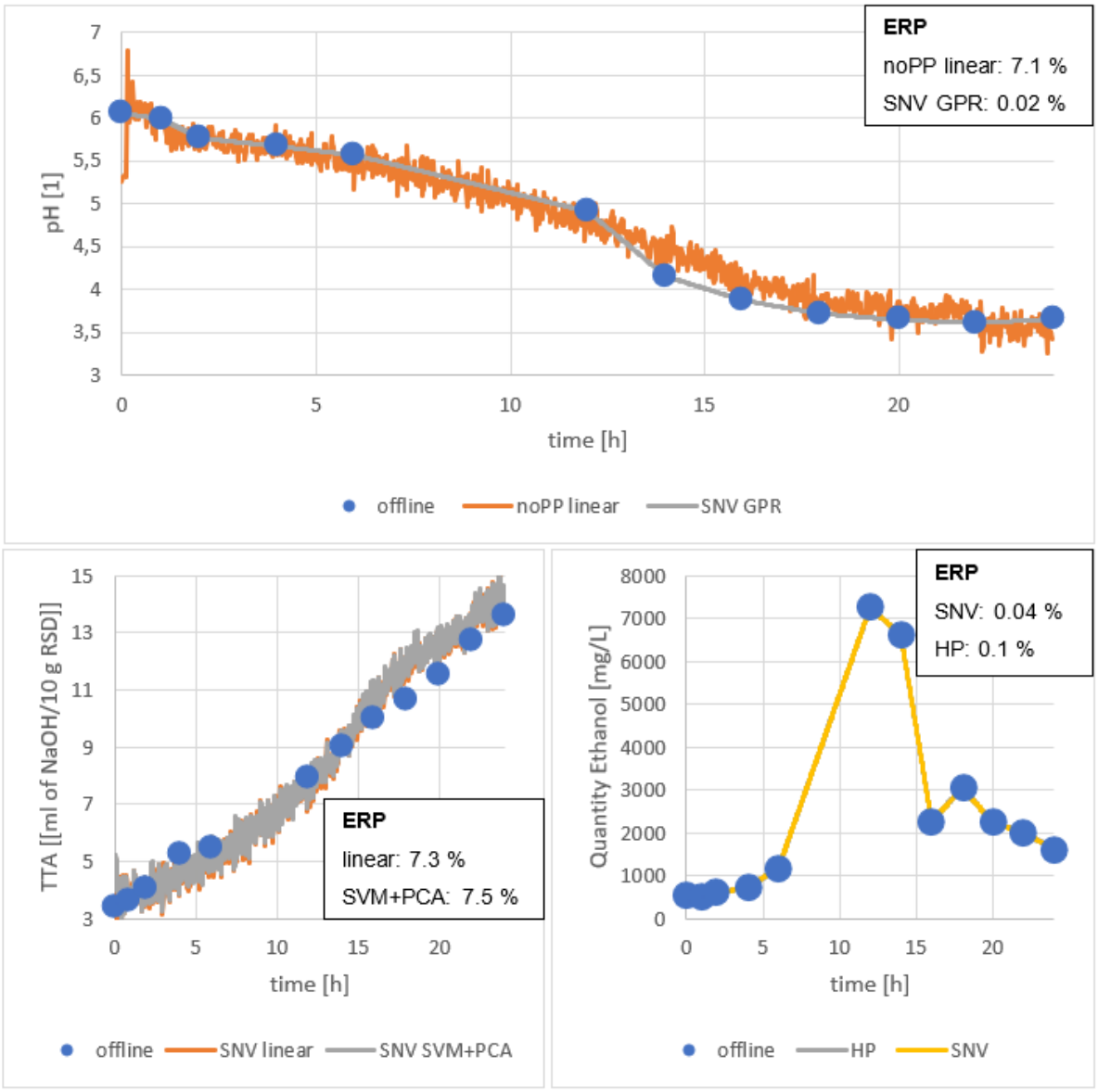

Figure 1: Validation results for the models of pH (top) linear without pre-processing and SNV GPR, TTA (bottom left) linear and SVM with previous PCA pre-processed with SNV and Ethanol (bottom right) GPR with pre-processed with SNV and HP. ERPs are given in the graphs.

O.45 PULSES PASTA: INNOVATION FROM THE PAST

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Pasta is an increasingly popular food worldwide and different formulations have been developed to improve its nutritional profile. Among other ingredients, pulses could meet the growing consumer interest in healthy and sustainable diets. Moreover, the absence of gluten makes them suitable for gluten-free diets.

This study aims at understanding the relationships between raw materials and processing conditions and their effect on starch structure and pasta quality.

In the first part of the work, the cooking behavior of commercial pulse pasta was investigated in relation to starch and protein features to provide an insight on how their molecular organization may affect cooking behavior. After that, the role of processing was investigated.

Commercial chickpea and red lentil pasta from two Italian producers (indicated with the letters A and B were considered). All pasta showed a fair cooking behavior, with high water absorption (> 100%), low cooking loss (< 10%) and high consistency (> 400 N). Only one sample of chickpea pasta showed cooking loss values above 11% and a consistency below 300 N. Regardless of the manufacturer, chickpea pasta generally had higher water absorption and cooking loss values than red lentil pasta, and a lower consistency. These differences could be due to the different structure and organization of proteins and starch between the two types of legumes. Regardless of the raw material considered, samples from manufacturer A showed greater cooking loss and less firmness than pasta from manufacturer B, both at the optimal cooking time (7 min) and overcooking (9 min). These differences - which appear more evident in chickpea samples than in red lentil ones - could be attributable to the production process since, as discussed above, their chemical composition reported on the label is similar.

Thus the second part of the work focused on the role of processing. Unlike what has been observed for gluten-free pasta from rice and corn, it was possible to produce dry pasta in a continuous press without subjecting pulses to pre-gelatinization treatment. The latter, in fact, does not seem to influence the cooking behavior of the pasta. Pasta produced by conventional extrusion (with or without pre-gelatinization of the raw material) shows low cooking losses (< 6%) and an acceptable consistency (on average 650 N). The main differences concern the surface appearance of the product: in fact, the product produced by conventional extrusion of native flour (not pre-gelatinized) shows a greater surface heterogeneity than the others, with the presence of white dots suggesting uneven hydration during the kneading phase. The defect is greatly attenuated in case the flour is pre-treated before kneading.

In conclusion, pulse pasta currently available on the market has a good cooking behavior, although with some differences probably due to a different production process. Experimental trials suggest that, although it is possible to produce pasta by conventional extrusion of pulse as it is (not pregelatinized), surely pregelatinization improves the hydration phase and therefore the aspect of the finished product.

Keywords:
Legumes, pasta, processing, extrusion

O.46 INCREASING RESISTANT STARCH CONTENT OF TRADITIONAL TURKISH PASTA (ERISTE) BY USING HIGH AMYLOSE DURUM WHEAT

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Starch is a glucose polymer consisting of primarily α-1,4 linked linear amylose, and highly α-1,6 branched amylopectin. The amylose/amylopectin ratio differs among starches and the typical levels are 25–28%/72–75%. There are also some mutant cereal genotypes containing more amylose or amylopectin than typical levels (i.e., wheat containing more than 35% amylose is categorized as high amylose; maize has high amylose varieties containing 55% and 70% amylose).

Starches are divided into three types based on their digestion rate; rapidly digestible starch (RDS), slowly digestible starch (SDS), and resistant starch (RS). RDS is digested in the small intestine and has a high glycaemic index (GI), whereas SDS is digested at a slower rate and has a lower GI. In contrast, RS is not digested in the small intestine, but fermented in the large intestine. RS is defined as "the sum of starch and starch degradation products that are not absorbed in the small intestine of healthy individuals". RS is generally categorized into five types and RS3 is "retrograded" starch. RS3 has higher thermal stability which allows it to be stable in normal cooking operations. If the starch gels are cooled, amylose and long branch chains of amylopectin form double helices which do not fit into the binding site of amylase, thus cannot be digested. Many factors may influence the formation of RS3, such as amylose content and amylopectin chain length, autoclaving temperature, storage period and temperature, etc. It is beneficial to use a starch high in amylose to form RS3.

The purpose of this work was to increase RS3 content of traditional Turkish pasta (Eriste) by applying were used a) with normal amylose content (Svevo) and b) high amylose content (HA-Svevo). In latter one, the gene *SBEIIa* was knocked-down by a non-transgenic technology resulting in an amylose content of 55% (on total starch).

Flour samples were mixed with water, briefly heated at 100°C and then autoclaved for 30 min at 121°C. Autoclaved samples were kept at 4°C and 100°C for various time periods. After these heating cooling cycles, the dough was passed through a noodle machine to produce a dough sheet with a thickness of 2 mm. The sheet was cut using tagliatelle setting to obtain Eriste samples (3 x 0.5 cm). Eriste samples were analysed in terms of cooking properties (cooking time, cooking loss and total organic matter) and textural properties. Nutritional properties such as RS content and GI of the samples were also determined. Eriste sample produced using HA-Svevo had higher RS content and lower GI compared to the one produced using Svevo. The results indicated that high-amylose durum wheat seems to have potential health benefits while maintaining acceptable technological properties and this study is expected to open interesting possibilities for the production of new healthy Mediterranean foods.

Acknowledgements:
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Keywords:
Resistant starch, high amylose starch, glycaemic index, pasta quality

POSTER PRESENTATIONS

Abstracts are listed according to the topics
in the order of their submission

POSTERS – TOPIC:

Crop Production and Agricultural Challenges

P1.1 MORE THAN A CENTURY OF SPELT SELECTION AND BREEDING: ENHANCEMENT OF AGRONOMICAL AND TECHNOLOGICAL PROPERTIES

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Spelt selection and breeding took place concurrently to soft wheat in different part of the world. European countries where spelt is most cultivated are also the ones that were most involved in historical spelt selection and breeding. Spelt improvement started in the early 1900's with the selection of plants within local landraces. This resulted in the selection of varieties such as Oberkulmer Rotkorn in Switzerland, Steiners Roter Tiroler in Austria, Lignée 24 in Belgium and Baulander Spelz in Germany. Crosses were then made between spelt varieties to combine specific characters such as for Ostro (Oberkulmer Rotkorn x Steiner Roter Tiroler). Crosses between spelt and wheat can occurred either naturally or artificially, although this technique was massively used in breeding programs to improve spelt agronomical and technological aptitudes. The first hybrid varieties were released in the early 1960's (e.g. Ardenne in 1965). Varieties like Ardenne, Lueg and Hubel were obtained from a single cross between a wheat and a spelt parent, whereas varieties like Rouquin, Albin and Franckenkorn originate from more elaborate crossings and back-crossings strategies. Most modern spelt varieties, such as Cosmos, Sérinité, Badenkrone or Zollernspeltz now possess some of the wheat genome.

Breeding has, over the years, drastically enhanced the characteristics of spelt varieties. Most breeding programs focused on increasing the yield (also increasing grain size) as well as the resistance to lodging (also reducing plant height). Resistance to disease did not change very much except for a loss in powdery mildew resistance. When it comes to technological advances, all modern varieties show a reduced content in protein (also reduction in gluten quantity). Most of the modern varieties also have less α-amylase activity and better starch properties. The quality of gluten was drastically improved but to varying degree between varieties. Some selection program seems to have favored protein qualities (such as for Sérénité, Ressac or ZOR) whereas other have accentuated starch qualities (such as for Alkor or Samir).

Keywords:
Spelt, breeding, ancient, novel, quality

P1.2 AGRONOMICAL AND TECHNOLOGICAL PROPERTIES OF A EUROPEAN PANEL OF SPELT VARIETIES

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In Belgium, spelt (Triticum aestivum ssp. spelta) is a cereal historically grown in the south of the country. This cereal is known for its characteristics of resistance to biotic and abiotic stresses. These characteristics allow the cultivation of spelled in regions where the soil is poorer and the climate colder (eg Ardenne) but also to be a good candidate for low-input farming systems as well as in organic farming.

Spelt has interesting nutritional qualities but its technological characteristics are generally poorer than those of wheat. The plant improvement carried out by breeders together with the knowledge and mastery of raw spelt materials are essential to the development of this crop. Currently, spelt cultivation in Belgium is dominated by the Cosmos variety (Fig. 1), mainly for fodder or food (mixed with wheat.).

The Wallep project brings together different players in the cereals sector, from production to commercial development, in order to promote the cultivation of spelt and develop a Walloon sector for this crop.

Keywords:
Spelt, quality, technological, product

P1.3 TECHNIQUES FOR EXTRACTION AND ISOLATION OF BIOACTIVE FRACTIONS FROM CEREAL BY-PRODUCTS

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The cereal processing chain generates a huge amount of agricultural waste. It is estimated that around 12.9% of all food waste produced worldwide is from cereal processing. Plant sources must be processed efficiently, and environmentally friendly to obtain high-value bioactive compounds. The most crucial stage in isolating various types of bioactive molecules from cereals is the extraction process. Bioactive compounds have been extracted from cereal waste using both traditional and innovative extraction protocols. This review aims to comprehensively analyze both the conventional and novel extraction methods of cereal by-products. Conventional extraction technologies, such as organic solvent-based extraction, Soxhlet extraction, maceration, and hydrodistillation have been practiced for a long time, mainly in the food area, to extract nutritionally essential and non-essential components. However, conventional extraction procedures need expensive and high purity solvents, have a low extraction yield, and consume a large amount of solvents, also they are time-consuming and result in low extract purity caused by the presence of organic solvent residues in the extract which can represent environmental risk and toxicological effects. Because of all the limitations of conventional extraction methods, intensive efforts have been made for the development of more efficient, sustainable, and ecologically friendly extraction technologies, such as enzyme-assisted extraction, microwave-assisted extraction, ultrasound-assisted extraction, membrane technology, subcritical and supercritical extraction, pressurized liquid extraction, steam explosion, pulsed electric field, and high voltage electrical discharge. Valuable bioactive compounds derived from natural sources are essential in the food, pharmaceutical, and cosmetics industries, and the appropriate techniques for extracting and isolating the targeted compounds from agro-food by-products require comprehensive research.

Keywords:
Cereal by-products, bioactive compounds, novel extraction techniques, conventional extraction, circular bioeconomy

P1.4 DETECTION OF INSECT PEST INFESTATION STRESS IN WINTER WHEAT USING PROXIMAL SPECTROSCOPIC MEASUREMENTS

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Climate change and extreme weather events have significant impacts on winter wheat (*Triticum aestivum* L.) production and its arthropod pests. Under these new climatic conditions, pest infestations are expected to be severe. Insects tend to reduce the photosynthetic activity of wheat plants and negatively affect their growth and development, ultimately leading to even greater yield losses. Inaccurate decision making in an integrated pest management program can result in ineffective control in infested areas. To achieve more effective control of pest populations, it is important to assess infestations in a timely manner to reduce the negative impact on crops. Great efforts have been made to prevent and manage these negative impacts, including remote sensing of damage symptoms. Proximal remote sensing provides a fast, accurate, non-invasive, and simple method for monitoring and assessing pest damage to various crops. The efficiency of pest monitoring in the field could be improved by knowing the solar radiation reflected from the leaves and canopies of winter wheat. Canopy and leaf reflectance is measured using a spectroradiometer in the wavelength range of 350-2500 nm on experimental crops of five winter wheat cultivars at crucial phenophases. This summary represents an ongoing research effort aimed at detecting stress caused by insect pests and evaluating stress levels in different winter wheat cultivars. Chemometric analysis of spectral response patterns is used to isolate sensitive wavelengths that indicate early signs of infestation. Results of similar studies showed that spectral reflectance of leaves in the visible (VIS, 350-700 nm) and near infrared (NIR, 700-1300 nm) range decreased with increasing aphid infestation and that there were significant differences in blue, green, red, NIR, and shortwave infrared (SWIR) between different severity levels of aphid infestation. The spectroradiometric method can also be used to test the commonly used spectral vegetation indices (e.g. NDVI, RVI, etc.) as indicators of stress in winter wheat cultivars. The results obtained made it possible to distinguish the different levels of infestation and to distinguish healthy wheat plants from insect-infested plants based on their reflectance.

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Keywords:
Remote sensing, spectroradiometer, winter wheat, insect pest, reflectance data

P1.5 USING ARTIFICIAL INTELLIGENCE TO PREDICT CROP ROTATION FOR SUSTAINABLE AGRICULTURE

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In a context of growing food demand and scarcity of natural resources, the development of more sustainable agriculture is imperative. Sustainable agriculture is meant to limit the environmental impact of agricultural activities on soil, water, and carbon footprint while maintaining crop yields and economic benefits for producers. Crop rotation is a valuable tool in sustainable agriculture, but this technique must be appropriately coupled with sustainable fertilization plans to optimize crops. To do so, it is necessary to forecast the crop rotations considered in the medium term and to be able to evaluate each scenario according to the economic and environmental criteria considered by the producer. Since each crop has specific needs, knowledge of the future sequence of crops in a field will help determine the actual fertilizer needs of the field. This knowledge will reduce the amount of fertilizer and herbicides used, which will limit the negative impact of farming activities on soil and water and increase the profitability of the farm for the producer. The results will then be used in crop models to build a decision support system for greater sustainability in agricultural production. The proposed methodology uses recurrent neural networks (RNN), more precisely LSTMs, in a Seq2Seq architecture to predict the most probable scenarios of crop rotations to be exploited in a field in the next x years according to the cropping habits, the economic and meteorological context. The methodology was applied to the problem of crop rotation prediction for field crop farms in Quebec, Canada, leading more than 81% of successful predictions for the next three crops grown in a field with knowledge of the last six crops grown in the same field as well as economic and meteorological data. These scenarios could then be used in crop models such as APSIM to simulate the impact of each scenario in different contexts. this decision support system will help producers understand the effects of their strategies on the environment and the profitability of the exploitation.

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Keywords:
Sustainable agriculture, artificial intelligence, recurrent neural network, Seq2Seq

P1.6 CONTENT OF ARABINOXYLAN IN BARLEY AND WHEAT GRAINS DEPENDING ON N RATE USED AND YEAR

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Cereal yields in agricultural sector can be very variable depending largely on weather conditions. This means that also crop producers' incomes are vulnerable. Although it is impossible to predict crop yields for every year it is possible to ensure a more stable income via added value. This could be achieved by finding opportunities to sell more valuable components of cereals instead of grains themselves. Cereal grains are rich in dietary fibres that are known to have immense effect on the properties of food and human health. Extraction of those valuable substances from grains could offer more opportunities for agricultural sector economic development. One of the most important dietary fibre components in cereal grains is arabinoxylan (AX), which can be extracted from the grains of wheat and barley. Its concentration in cereal grains depends on genetic, environmental and agronomic factors.

The goal of our study was to investigate the effect of plant nitrogen supply and source on AX accumulation in the grain and to observe the effect of growing conditions on grains AX content. More specifically, the objective was to compare the effect of organic (cattle manure, off-season cover crop) and mineral N (NH_4NO_3; 0, 50, 100° 150 kg N ha^{-1}) fertilizers on AX content in barley and wheat wholegrain flours and to observe the impact of different weather conditions on AX content in the grains. The grain samples were collected from the long-term field crop rotation experiment located at the Estonian University of Life Sciences in Tartu County (58°22′ N, 26°40′ E) in 2019-2021. The amount of AX in the barley (N=84) and wheat samples (N=83) was determined by using D-xylose assay with enzymatic kit from Megazyme (Megazyme International Ireland, Ltd) in triplicate.

The results revealed that barley and wheat AX content was stable and did not depend on N fertilization. The average content of AX in compared cereal grains was similar 4,5 and 4,9 g 100 g^{-1} in barley and wheat respectively, showing that both grains can be considered as a good source of AX. Barley and wheat grains AX content was affected by the growing year. For barley it was significantly lower in 2020 (3,3 g 100 g^{-1}) compared to 2019 (5,5 g 100 g^{-1}) and 2021(4,7 g 100 g^{-1}) and for wheat it was the lowest also in 2020 (3,4 g 100g^{-1}) compared to 2019 and 2021 (5,1 and 6,1 g 100 g^{-1}). Lower AX content in 2020 could be associated with lower amount of precipitation at the stages of grain development and ripening. Our results are supporting the idea that AX from wheat and barley grains can be a valuable resource for cereal valorization and though it is not affected by N fertilization its content in grains could vary depending on weather conditions.

Keywords:
Arabinoxylan, nitrogen, fertilization, weather conditions

P1.7 STRATEGIC USE OF HERBICIDES AND CULTIVATION TECHNIQUES AGAINST RESISTANT BLACK GRASS (ALOPECERUS MYOSUROIDES) IN WINTER GRAINS

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Heavy clay soils in the region Westhoek (Flanders, Belgium) create optimal circumstances for the cultivation of winter cereals. However due to frequently wheat cultivation and intensively use of herbicides with the same mode of action (MOA), the region is confronted with resistant varieties of black grass (Alopecerus myosuroides). This has a negative impact on quality and yield of the grains. To avoid the (further) development of resistant varieties of black grass an integrated weed management is necessary, including the use of herbicides with different MOAs. Hence for a good management of (multiple) resistant black grass varieties, it is of importance to obtain knowledge about the correct timing, dose and application of different types of herbicides. Next to chemical application, enhanced use of mechanical management and alternative cultivation techniques have to be integrated. Several field trials were set up in order to show on the one hand the influence of different active ingredients and timing of application and on the other the effect of cultivation techniques on black grass population density. For the chemical trial we focussed on pre- and post-emergence treatment in autumn. The choice of the herbicide combinations was based on advice from several phytopharmaceutical companies. First results of this trial show the importance of chemical treatment in an early development stage of the black grass and insinuate the presence of different black grass populations. In the cultivation technique trial we included the effect of row distance, seed density and date of sowing. The preliminary results indicate the importance of alternative cultivation techniques in combination with a phytopharmaceutical approach.

Keywords:

Herbologyintegrated weed managementherbicide resistanceblack grassAlopecurus myosuroides

POSTERS – TOPIC:

Grain Nutrition and Health

P2.1 RELEVANCE OF B-GLUCAN MOLECULAR PROPERTIES ON ITS SUITABILITY AS HEALTH PROMOTING BREAD INGREDIENT

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One type of dietary fibre with great popularity is β-glucan from cereals, with highest contents found in barley and oats. These are a heterogeneous group of non-starch polysaccharides, consisting of glucose units classified by their intramolecular linkages of β-(1-3) and β-(1,4) glycosidic bonds.

Numerous studies have already shown, that β-glucans contribute to lowering LDL cholesterol levels by binding of free bile acids in the intestine. Thus, β-glucans can help reduce the risk of coronary heart disease. In the evaluation of β-glucans the EFSA (European Food Safety Authority) has concluded that foods allowing the regular daily intake of at least 3 g β-glucan from oats or barley contribute to reduced blood cholesterol levels. Other structural properties, such as molar mass, molar ratio or solubility of the β-glucan, are not considered for the health claim.

Studies on the continuous tracking of β-glucan from the raw material through food processing to the digestive tract are still missing. To contribute to filling this knowledge gap, two barley β-glucans with divergent molar masses (170 kDa and 960 kDa) were used for enrichment of wheat bread. With increasing β-glucan content, the bread volume decreased and the crumb hardness increased, regardless of the molecular properties of the two β-glucans. Determination of the β-glucan content in the breads did not reveal significant differences between the two β-glucans used. However, 30 - 40% of the added β-glucan was degraded by enzymatic hydrolysis during bread production. Qualitative observation of the β-glucans contained in the bread revealed a significant molar mass reduction of more than 50% for the originally 170 kDa β-glucan to 80 kDa (weight average). In contrast, the molar mass of the 960 kDa β-glucan decreased by only 7.3 % to a weight average of 890 kDa. Subsequently, the wheat breads were subjected to an *in vitro* digestion model, where the differences between the two β-glucans were magnified. Only less than 10% of the originally 170 kDa β-glucan could be recovered after digestion and the molar mass was decreased to approximately 10 kDa. As a result, the viscosity of the chyme and the binding of the bile acids were comparable to standard wheat bread without β-glucan. In contrast, about 40% of the higher molecular weight β-glucan used could be recovered in the supernatant after digestion with a molecular weight of 680 kDa. This chyme showed increased viscosity and improved binding of free bile acids compared to wheat bread without added β-glucan.

These results show that in addition to the amount of β-glucan, the structural properties should also be considered in order to achieve ideal health promoting effects. It could be confirmed, that there is a reduction in β-glucan content and molar mass from raw material to food through the manufacturing process. The impact of bread making on the health promoting properties is dependent on the structural properties. Hence, these results provide a valuable contribution on the selection of appropriate β-glucan containing raw materials towards the production of foods with maximum health promoting properties.

Keywords:
Barley, beta.glucan, molar mass, bread making, functional food

P2.2 INTEGRATION OF T. TURGIDUM TO INDUSTRIAL BREAD PRODUCTION FOR REGIONAL ECONOMIC DEVELOPMENT IN TURKEY

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The global interest in wheat due to its high nutritional content and easy access has carried it to second place in the most consumed cereal products with 770 million tons of consumption in 2020-21. Turkey is a homeland of wheat which originated in the Fertile Crescent roughly 12,000 years ago however, ancient grain varieties have been neglected due to the efforts to increase the yield of modern wheat. Modern wheat species are uncompetitive in harsh conditions whereas ancient wheat species have been cultivated easily. Nowadays, crop productivity has been damaged by climate change, biotic and abiotic stress. Although the low grain yield of ancient crops, better adaptation to poor conditions and improved lodging resistance allow them to yield greater and more stable. Innovations in production technology have provided to increase the interest of the food industry in ancient wheat. Furthermore, improved food awareness, changing trends in consumers, and positive health effects of ancient grains accelerated the tendency to the ancient wheat from modern wheat. *Triticum turgidum* subspecies durum wheat is tetraploid wheat with 14 pairs of chromosomes (2n=2x=28; AABB genomes). It is grown from a wild *Triticum dicoccoides* variety in the Middle East. The aim of this project was to characterize *Triticum turgidum* ssp. *dicoccum* (Kavılca/Kablıca) which was grown in Kars, Turkey and integrate it to bread production to contribute to regional economic development. For this purpose, fatty acid, amino acid, mineral, and phenolic profiles of grain and flour of *T. turgidum* and *T. aestivum* were identified. In addition, bread made of 100% *T. turgidum*, 100% *T. aestivum*, and a mix of *T. turgidum* and *T. aestivum* were evaluated in terms of phenolic profile. Total phenolic content (TPC), total antioxidant capacity (TAC), antidiabetic activity (α-amylase inhibition), Angiotensin-converting enzyme (ACE) inhibition and a triangle sensory analysis was conducted. Briefly, 100% *T. turgidum* was the leader in TPC and TAC among bread samples and had better inhibition of α-amylase and ACE.

Keywords:
T. turgidum, ACE inhibition, antidiabetic, Kavılca, T. aestivum

P2.3 A PARTICIPATORY RESEARCH ON NCGS: ARE BREAD AND PASTA PRODUCED BY FARMERS AND MANUFACTURERS DIFFERENT?

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The number of people suffering from non-celiac gluten sensitivity (NCGS) has increased during the last forty years. About 10% of French people claim to have disorders when eating wheat products and tend to avoid them. However, some people suffering from NCGS may eat some wheat products made by peasant-millers, peasant-bakers or peasant-pasta makers. An analysis of farmers' practices pointed out similarities, such as the use of "ancient" or local varieties, grown in organic conditions, stone milled and transformed with sourdough for bread and in mild conditions for pasta. Involving researchers from several disciplines (sociology, agronomy, technology, biochemistry), and a large diversity of actors (farmers, consumers, doctors, sick people, etc.), a participatory project was implemented to understand which differences between farmers' and manufacturer's practices could be linked to NCGS. Almost 500 consumers filled a survey on their cereal products consumption and among them, 38 clearly sensitive were deeply interviewed. On a sociological point of view, people suffering from NCGS are mainly young women, at least 3 years are necessary to make a diagnosis after the first appearance of symptoms and 26 persons on 38 can re-eat cereal products issued from farms and short chains. To go further, bread and pasta were prepared according to different processing ways. The biochemical comparison between farmers' breads and industrial type products shows that the first ones, when they are made with flours issued from stone milling, leavened with sourdough, after a long fermentation and baked in a wood oven have more easily extractable proteins in a buffer containing detergent (SDS) and more digestible proteins. Similar trends were found for pasta made with stone milled flours and dried at ambient temperature.

Keywords:
Bread, pasta, NCGS, process, participatory research

P2.4 ENHANCEMENT OF BIOACTIVE COMPONENTS AND BCAA IN SNACKS BY ADDITION WHEAT BRAN FERMENTED WITH LAB

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The main objective of this study was to enhance the nutritional and functional properties including branched chain amino acids (BCAAs) in snacks by adding different levels of fermented wheat bran (WB). Brown rice snacks were prepared with different additional levels (0, 2.5, 5, 10, 15%) of WB fermented with L. *acidophilus* and their physicochemical and textural characteristics, total phenolic (TPC) and flavonoid contents (TFC), 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity, and Trolox equivalent antioxidant capacity (TEAC) as well as amino acids composition were determined. Dietary fiber content increased with the amount of fermented WB ranging from 5.79 to 11.28 g/100 g. The level of hardness in snacks samples increased with the incorporation of fermented WB, ranging from 60,345 to 84,310 N/m^2. The maximum hardness was observed in the formulation with the highest amount of fermented WB. The TPC increased steadily with increasing amounts of fermented WB added in the snacks showing the highest value of 1.39 mg GAE/g in snack with 15%WB. Similarly, a significant increase was observed for TFC with snacks formulated with fermented WB, ranging from 0.32 to 0.46 mg CE/g. The antioxidant capacities (DPPH and TEAC) increased with the incorporation of fermented WB, ranging from 5.44–6.31 µM TE/g for DPPH and 3.42–6.58 mM TE/g for TEAC, respectively. Snack with 15% WB exhibited the highest amount of BCAAs, isoleucine (0.53 mg/100 g), leucine (0.67 mg/100 g), and valine (1.37 mg/100 g). These results confirmed that the snack formulation with the addition of fermented WB can improve nutraceutical and textural properties without producing any detrimental effects. Therefore, this study distinctly stated the possible use of fermented wheat bran in BCAAs enriched-snack formulation.

Keywords:
Branched chain amino acids, wheat bran, fermentation, bioactive component, dietary fiber

P2.5 EXPLORING OF THE UNDEFINED GENETIC, COMPOSITIONAL AND PROCESSING POTENTIALS OF SPELT IN DIFFERENT ENVIRONMENTS

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One of the main aim of cereal breeders is to produce wheat varieties with excellent traditional breadmaking quality. However, there is a demand for cereals more resistant to environmental stresses, so the potential of less use of chemical fertilizers, and the production and consumption of healthier food containing less chemicals and more natural bioactive components. Spelt (Triticum spelta L.) is one of the promising solutions to this demand. However, the increased health related benefits and the variability of the technologically important properties of spelt have not been supported scientifically yet. Several studies tried to summarise the differences in common wheat and spelt nutritional and technological values, but due to different sample numbers and methods or fractions to be used this question still remained open.

The main objective of our project is to explore the variation in the agronomical, compositional, nutritional and processing properties of spelt and the genetic background behind it, and their differences from common wheat with special emphasis on the carbohydrate and protein components.

In order to achieve these objectives, differences in spelt varieties and spelt x wheat lines were examined. In the initial phase of our research, the macronutrient content (moisture by drying; protein by Dumas; ash by incineration; dietary fibre by enzymatic method), protein (by liquid chromatography) and carbohydrate composition (arabinoxylan by gas chromatography; beta-glucan and fructan by enzymatic method; low molecular weight carbohydrates by liquid chromatography) and the rheological behaviour of the spelt samples (falling number, rapid visco analyzer, Mixolab) were investigated on 20 samples (4 varieties and 16 breeding lines).

Based on the results, we established that there was no substantive difference between the spelt varieties in any of the studied parameters, and these traits were also similar to common wheat. However, greater variability was identified in the ß-glucan content of the spelt breeding lines than in the spelt varieties. No particular differences were observed in mixing properties, either between samples or compared to common wheat. However, the viscous properties varied among the samples, but the profile was very similar for spelt and for common wheat. These properties could be also influenced by the different fibre constituents (e.g. arabinoxylans) as well as the properties of starch. The great variation found for the spelt breeding lines provide a good basis for an efficient selection during breeding.

This work was supported by the OTKA 135211 project: Exploring of the undefined genetic, compositional and processing potentials of spelt in different environments. The research is the part of the BME-EGA-02 - TKP2021 project supported by the Ministry for Innovation and Technology of Hungary from the National Research, Development and Innovation Fund.

Keywords:
Spelt, genetic variability, common wheat, carbohydrate composition, reological properties

P2.6 EFFECT OF ADDING LOCAL LEGUME FLOURS ON THE TEXTURE AND PHYSICAL CHARACTERISTICS OF GLUTEN-FREE BISCUIT

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People affected by celiac disease and other gluten-related disorders must follow a strict gluten-free (GF) diet. Recent attention has been focused on novel applications of legumes flours as sustainable, nutritious and inexpensive food ingredients in GF food formulations. This study aimed to develop an innovative GF biscuit by adding local, cheap and readily available legume flours: fava bean, lentil and chickpea to rice and maize flours. Formulation methodology was based on experimental mixture design where the used components were fava bean, lentil, chickpea, rice flours, and maize (starch and four). For determination of optimum points, eight responses were evaluated: hardness, color parameters (L*, a*, b*, C*, h), spread ratio and backing loss. Optimum formulas were validated by a consumer acceptance test. Mathematical analysis showed that legumes flours had a positive significant effect on the biscuit hardness. Besides, pulses had a significant positive effect on the spread ratio and backing loss except of chickpea flour which had an antagonist effect on the backing loss. Regression analyses indicated that the quadratic, cubic as well as special cubic non linear terms were significant ($p<0.05$) in many of the models derived. Optimum mixture obtained according to hardness, color parameters, spread ratio and backing loss contained 17.09% fava bean, 12.54% lentil and 12.72% chickpea with desirability equals to 0.69. The GF legume-based biscuit obtained was characterized by a good sensory acceptability, similarly to controls. In conclusion, these findings report the use of legumes as sustainable and inexpensive alternative ingredients for formulations of GF biscuits meeting functional and sensory standards.

Keywords:
Legumes flours, sustainability, acceptability, biscuit quality, gluten-free

P2.7 IMPACT OF PROCESSING STEPS ON PHYSICOCHEMICAL, NUTRACEUTICAL CHARACTERISTICS OF GERMINATED WHEAT IN BEVERAGE PREPARATION

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This study investigated the physicochemical, nutraceutical, and structural characteristics, amino acids, and volatile profiles of germinated wheat in the different processing steps of beverage preparation. Raw wheat (RW), germinated wheat (GW), steamed germinated wheat (SGW), and roasted steamed germinated wheat (RSGW) were prepared and compared their characteristics. The highest values of moisture, ash, and crude protein contents were observed in the GW sample showing 11.63, 1.83, and 16.12 g/100g, respectively, while displaying the highest fat content (1.93 g/100 g) in RW. In addition, as the processing step progressed, samples showed higher values of the brown index and lower values of lightness due to the Maillard reaction. RSGW presented the greatest GABA (2.45 mg/g), total flavonoid content (0.72 mg CE/g), as well as the strongest antioxidant activities including DPPH (4.66 μM TE/g), and TEAC (10.20 mM TE/g). According to Fourier Transform Infrared (FTIR) spectra, the transmittance (T%) of the peaks decreased in order of RW, GW, RSGW, and SGW, due to the enhancement of flavor-related compounds during processing. Profiling of amino acids stated that steaming process reduced the composition of amino acids due to the protein denaturation by high temperature. Twenty-two volatiles including 6 alcohols, 2 aldehydes, 4 acids, 1 furan, 1 hydrocarbon, 3 ketones, 1 pyrrole, and 4 sulfur-containing compounds, were identified by the electronic nose (E-nose). The roasting process revealed the enhancement of most volatile compounds, especially for 1-propanol, n-butanol, furfural, ethyl pentanoate, propan-2-one, 3-nonen-2-one, 2-propionylpyrrole which were significantly higher in RSGW. The principal component analysis (PCA) score plot described the abundance of most bioactive components and volatile compounds in RSGW and GABA and amino acids in GW and SGW samples. Conclusively, these results revealed that roasting and germination of wheat could improve the nutraceutical and functional characteristics of wheat and the application of these methods in beverage preparation could enhance the flavor and amino acid profile as well as bioactive components.

P2.8 COMPARATIVE STUDY ON FAVA BEAN FLOUR ON WHEAT BREAD

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According to the country nutrition profile of the Global Nutrition Report, the German population consumes too much red meat and milk and too little fruit, vegetables, pulses, nuts and whole grain products. The very low consumption of pulses is particularly striking, with an average intake of only 5.3 g/day. A possible opportunity to increase the consumption of legumes is the incorporation of legumes in widely used and popular food products like pasta or bread.

The aim of this work was therefore to analyse the physical properties of a whole wheat bread enriched with fava bean flour. For this purpose, 10 %, 15 %, 20 % and 25 % of the whole wheat flour was replaced by fava bean flour (FBF). The physical and baking properties of the composite flours were then investigated.

Farinograph measurements showed that water absorption and dough stability time decreased while dough development time increased with increasing concentrations of fava bean flour. During fermentation in the Rheofermentometer the doughs exhibited a presumably linear decrease in maximum dough height and decreasing required time for maximum development with increasing concentrations of fava bean flour. Only the substitution of 20 % significantly increased the total CO_2 volume produced and the volume of CO_2 loss. Lower or higher substitutions showed no significant change on the total CO_2 volume produced and the volume of CO_2 loss. In the samples the porosity and the retention volume was not affected by the replacement of whole wheat flour with fava bean flour. The stickiness and cohesiveness of the doughs increased significantly with increasing concentrations of fava bean flour.

The breads made from the composite flours showed no significant differences in terms of their baking loss. The bread crumbs are presented in Figure 1. Compared to the reference bread made from 100 % whole wheat flour, the specific volume of the formulations with 10 %, 15 % and 20 % fava bean flour was slightly but not significantly increased. The specific volume of the recipe with 25 % fava bean flour was significantly lower than that of the recipes with 10 % and 15 % fava bean flour. The colour saturation of the crust increased with increasing concentration of fava bean flour. A significant increase in crumb hardness and in crumb adhesiveness were observed with increasing concentrations of fava bean flour. The crumb springiness of the breads was also affected by the substitution of wheat flour, but no clear trend was evident. The breads with 20 % and 25 % fava bean flour showed significantly lower crumb moisture content than the whole wheat bread.

To overcome the quality deficits with high substitution rates, the combination of hydrated fava bean flakes with flour as substitution of whole wheat flour in combination with higher amounts of water during the dough preparation is currently evaluated. Nutritional analysis of the resulting breads are performed currently too. The promising results will be presented at the conference.

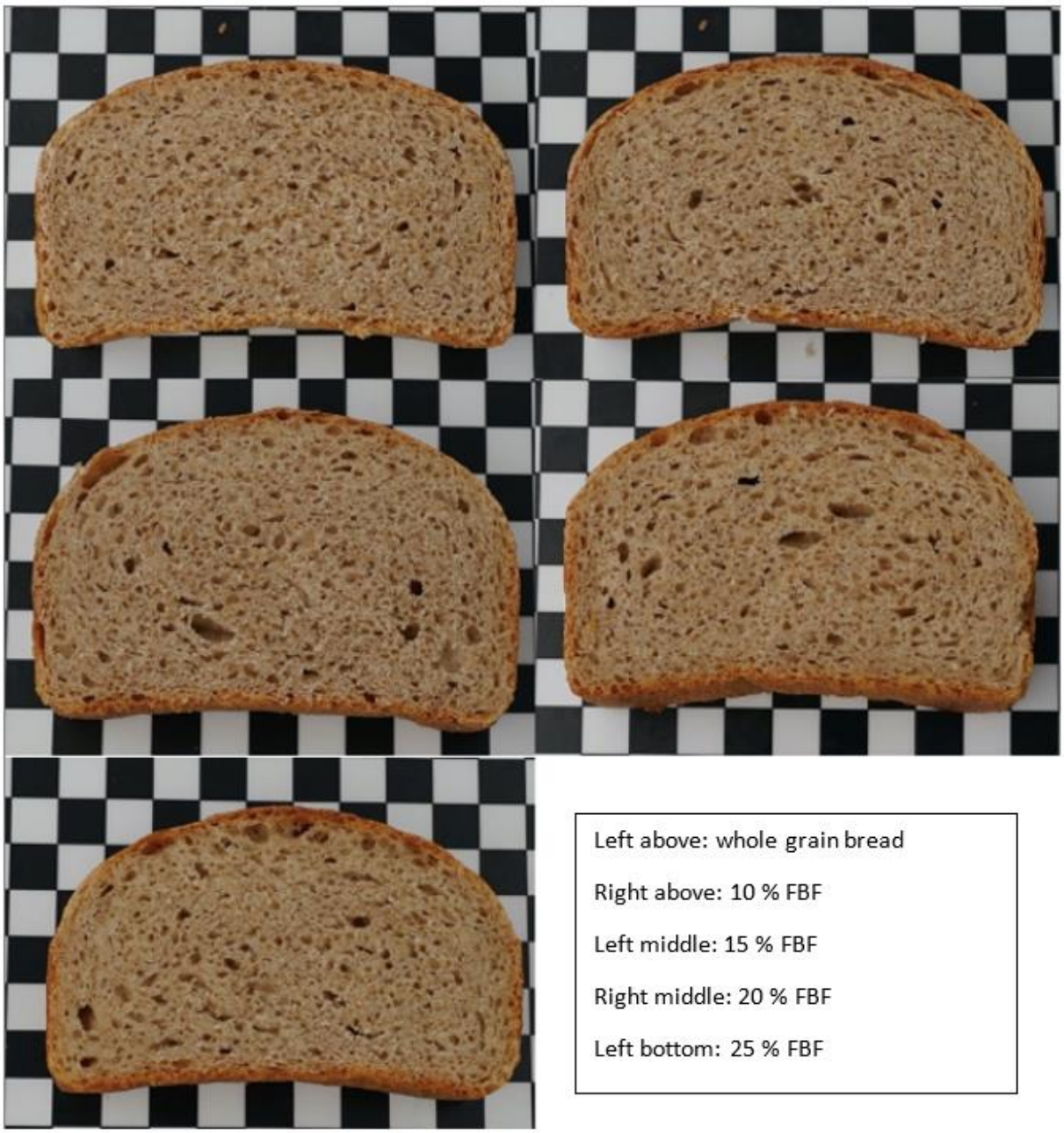

Figure 1: Bread crumbs of the produced breads with whole grain flour and substitution of 10 %, 15 %, 20 % and 25 % whole grain flour with fava bean flour (FBF).

Keywords:
Whole grain, legumes, protein, optimization

P2.9 WHEAT GRAIN PHENOTYPIC TRAITS TO CHARACTERIZE BREAD PROTEINS IN VITRO DIGESTION

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Grain proteins of wheat (*Triticum aestivum*) are composed of functional proteins and storage proteins, gliadins and glutenins. Gliadins and glutenins form the gluten polymeric network conferring dough rheological properties. Therefore, their content and composition strongly influence the aptitude for processing of wheat cultivar. Wheat is a staple food for human and mainly consumed as bread, after milling grains into flour. However, wheat grain proteins are partially resistant to gastrointestinal enzymes and are associated to several health issues related to gluten. In this context, our study aims at identifying phenotypic traits linked to proteolysis during bread *in-vitro* digestion. Grains from 17 cultivars grown at two locations were phenotyped. Grain hardness, thousand-kernel-weight and grain nitrogen content were measured. Protein composition was determined by Reverse-Phase High Performance Liquid Chromatography (RP-HPLC). Flour polymers were characterised by Asymmetric Flow Field Flow Fractionation (AF4). Dough and gluten technological properties were evaluated by a Chopin alveograph and a Glutomatic system, respectively. For each cultivar, breads were baked according to a standardized yeast-leavened method and digested *in vitro* with a dynamic gastrointestinal system TIM-1. After two hours of digestion, a nitrogen balance was performed on samples from the stomach compartment, the mall intestine, the post-jejunum and post-ileum dialysates and the ileal effluents (undigested fraction evacuated towards the colon) allowing to evaluate the quantity of nitrogen in the digested, ongoing digestion and non-digested fractions. After construction of a synthetic variable reflecting proteolysis at two hours of digestion, multivariate analyses were conducted. Proteolysis appeared to be related to some phenotypic variables.

Keywords:
Triticum aestivum L., bread, protein hydrolysis, in-vitro digestion, gluten polymers

P2.10 NUTRITIONAL PARAMETERS OF A FUNCTIONAL WHEAT-LENTIL BREAD TAILORED FOR THE AGING POPULATION

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A functional bread tailored to meet the nutritional needs of the aging population was produced by partially replacing soft wheat flour with red lentil flour (24%). Older adults are at risk of not meeting the recommended dietary allowance (RDA) or adequate intake (AI) values for calcium, vitamins, minerals, fibre and protein, a fact contributing to age-associated disorders including dysregulation of the immune system. Lentils are gaining interest as ingredients for functional and healthy foods due to their favourable nutritional composition, low antinutrient content and mild taste. A blend of 74% soft wheat flour and 24% red lentil flour was baked with water, salt, baker's yeast and a minimal amount of sucrose through a straight dough process. The nutritional profile of the bread was evaluated by analysing proteins, amino acids, lipids, ash, soluble and insoluble dietary fibre, resistant starch, free and hydrolysable bound polyphenols, lignans and the antioxidant capacity (by the FRAP assay). Compared to wheat bread, the functional bread had a 30% higher protein content (8.3%, as is) accompanied by a more balanced amino acid composition, almost double the amount of minerals (0.63%, as is) and dietary fibre (4.6%, as is), a double polyphenol content (939.1 mg GAE/100g on dry matter, d.m.), a higher amount and variety of lignans, and more than double the antioxidant capacity (71.6 µmoL/g d.m.). The effect of the functional bread consumption on the immune response was evaluated in vivo in a murine model of elderly mice, which were fed for 60 days a balanced diet containing, alternatively, the wheat-lentil bread or a control wheat bread or a standard diet. Serum cytokines and intestinal intraepithelial lymphocyte immunophenotype of mice were used as markers of systemic and intestinal inflammatory status, respectively. Immunophenotypic differences in intraepithelial lymphocytes were observed between the two groups of mice fed with the two types of bread, suggesting a positive effect of the functional bread on the intestinal immune response. Both diets containing bread induced a reduction in serum IL-10 with respect to the standard diet.

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Starr K.N.P., Mc Donald S.R., Bales C.W. Nutritional vulnerability in older adults: a continuum of concerns. Curr.Nutr.Rep., 2015, 4, 176-184.

Keywords:
Functional bread, lentil bread, aged mice, immune function, intraepithelial lymphocytes

POSTERS – TOPIC:

Processing and Cereal Products

P3.1 USING BROWN RICE AS A MEDIUM FOR HERICIUM ERINACEUS SOLID-STATE FERMENTATION

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Hericium erinaceus is a popular medicinal and edible mushroom. The objective of this study was to analyze GABA and erinacine A in *Hericium erinaceus* solid-state fermented mycelial products using germinated brown rice or brown rice as the medium. The results were showed that the GABA content reached to 169.8 mg/100g, when brown rice was soaked 6 hours and set 36 hours for continuous germination. The 3 kg germinated brown rice took only 17 minutes by 3 kW microwave drying to reach 13% moisture content; however, cold air drying took 4 hours. *Hericium erinaceus* solid-state 3-week fermented brown rice product had GABA 496.06 mg/100g and erinacine A 14.9 mg/100g. As a result, brown rice served as an excellent medium for *Hericium erinaceus* solid-state fermentation in order to improve the functional compounds.

Keywords:
Brown rice, GABA, Hericium erinaceus, fermentation, germination

P3.2 EFFECTS OF BUCKWHEAT SOURDOUGH ON THE BREAD-MAKING PERFORMANCES AND NUTRITION PROPERTIES OF BREAD

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In this study, the bread-making performances and nutritional qualities of buckwheat sourdough bread were investigated. The sourdough fermentation was initiated by the spontaneous biota of the buckwheat flours and propagated by continuous back-slopping until the stability was reached. *Lactobacillus plantarum*, *Lactobacillus brevis,* and *Pediococcus pentosaceus* were identified in the stable sourdoughs by using culture-dependent techniques. An addition of 10 % buckwheat sourdough did not influence the baking characteristics of wheat bread, which led to similar specific volume (control, 4.8 ± 0.2 ml/g; bread with 10 % sourdough, 4.8 ± 0.2 ml/g) and hardness (control, 288.2 ± 25.9 g; bread with 10 % sourdough, 300.9 ± 28.7 g). However, addition of 20 % buckwheat sourdough decreased the bread volume (control, 4.8 ± 0.2 ml/g; bread with 20 % sourdough, 3.8 ± 0.2 ml/g) and significantly hardened the bread (control, 288.2 ± 25.9 g; bread with 20 % sourdough, 487.4 ± 54. g). Buckwheat sourdough positively influenced the nutritional properties of buckwheat flour and wheat bread, in terms of polyphenols (control bread, 18.6 mg GAE/100 g; bread with 10 and 20 % sourdough, 73.6 and 107.6 mg GAE/100 g, respectively) and phytic acid contents. Overall, the results of this study suggest that buckwheat sourdough could be a suitable formula for enhancing the nutritional properties of wheat bread without influencing the overall quality.

Keywords:
Buckwheat, sourdough, baking

P3.3 DYNAMICS OF PHYSICAL AND CHEMICAL GLUTEN DEHYDRATION INDUCED BY FIBER SUPPLEMENTS DURING DOUGH MIXING

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The dietary fibre supplements mostly alter the rheological behaviour of bread dough by influencing the hydration level of gluten proteins. The supplements are characterised by increased water absorption, which is the cause of physical dehydration of gluten, and the presence of reactive antioxidants, which by modifying the structure of gluten proteins contribute to the chemical dehydration of gluten (Nawrocka et al., 2016). A poorly hydrated gluten network becomes less elastic leading to deterioration of the dough consistency and sensory quality of final bakery products.

Until now, these two types of gluten dehydration have not been quantified in terms of the extent and speed of their course during dough mixing. Therefore, we proposed an estimation method based on a regression model for analysing farinograms of model starch-gluten-fiber blends (Miś et al., 2020). Six commercial dietary fibers were applied as air-dried and pre-hydrated preparations in the amounts of 3%, 6%, and 9%. It has been demonstrated that the changes in the levels of physical (PhD_g) and chemical (ChD_g) dehydration of gluten caused by the fiber supplements during mixing (t) of the model dough well describe the following functions: $PhD_g \cdot (1-\exp(b_f \cdot t))$ and $ChD_g/(1+\exp(b_{chem} \cdot (c_1 + c_2 \cdot \phi_f - t)))$, where: b_f reflects the rate of physical dehydration of gluten by fibre, b_{chem} is the rate of chemical gluten dehydration, c_1 and c_2 indicate the time moment in the mixing process with the maximum dynamics of chemical dehydration.

The results of the research showed that the levels of both types of gluten dehydration were proportional to the dose of the fiber supplement, however, the ratio of PhD_g/ChD_g depended on the botanical origin of the fiber. Except carrot and cacao fibers, the others exhibited dominance of chemical over physical dehydration. The analysis of the physical dehydration dynamics of the analyzed fiber supplements (b_f) did not reveal its correlation with hydration strength of the fibers, although after rejection of the outlier results for the flax fiber, this relationship seems more obvious. The product $ChD_g \cdot b_{chem}/4$ was calculated for determination of the maximum dynamics of chemical dehydration of gluten by fiber supplements. At the maximum supplement dose (ϕ_f = 9%), the fibers was classified into three homogeneous groups: (I) with high dynamics, -0.019 min^{-1} (carob fiber), (II) with moderate dynamics, from -0.013 to -0.008 min^{-1} (chokeberry, flax, and cacao fibers), and with low dynamics, from -0.006 to -0.004 min^{-1} (carrot and oat fibers).

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Miś A., Krekora M., Niewiadomski Z., Dziki D., Nawrocka A. (2020). Water redistribution between model bread dough components during mixing. Journal of Cereal Science, 95, 103035.

Keywords:
Dehydration of gluten network, farinograms, regression model, dietary fibres

P3.4 GLIADINS – PHENOLIC ACIDS INTERACTION - ANALYSIS WITH APPLICATION OF SPECTROSCOPIC TECHNIQUES

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Gliadins account for 40-50 % of the total storage protein of wheat and are classified as α-/β-, γ- and ω-gliadins according to their electrophoretic mobility. The α-/β- and γ- gliadins have similar molecular weight and contain mainly α-helices and β-sheets whereas ω-gliadins are dominated by β-turns. On one hand, gliadins play a very important role in dough rheological properties and thus have a great impact on baked products quality. On the other hand, these proteins due to their sequence and structure are responsible for strong food allergy. It is reported that this negative effect may be reduced by modifying protein structural elements.

Plant polyphenols exist widely in plant and vegetables giving them colour and characteristic taste. Dietary polyphenols have attracted attention due to their numerous beneficial biological functions. As strong antioxidants, they are responsible for scavenging of free radicals in biological system, thus help to prevent neurological, cardiovascular or intestinal disease.

The aim of the studies was to determine the effect of phenolic acids on the structure of gliadin proteins in the model system. We have selected following acids: ferulic and sinapic belonging to hydroxycinnamic group as well as vanillic and syringic belonging to hydroxybenzoic group. Gliadins – phenolic acids complexes were analysed with application of Fourier transform infrared technique and steady-state as well as time resolved fluorescence spectroscopy.

The result of our studies suggested that the mechanism of interactions between phenolic acids and gliadins depends on the chemical structure of acids. Hydroxybenzoic acids (vanillic and syringic) induced hydrogen bond formation between polypeptide chains leading to gliadin aggregation. Additionally, syringic acid can be also located in the hydrophobic pocket. Hydroxycinnamic acids induced different changes in the gliadin structure. Amide I band analysis and steady state fluorescence spectroscopy indicated gliadin disaggregation in the presence of ferulic and sinapic acids.

Acknowledgments:
This study was supported by Polish National Science Centre (OPUS 18, 2019/35/B/NZ9/02854)

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Yan, Z., Zhong, Y., Duan, Y., Chen, Q., & Li, F. (2020). Antioxidant mechanism of tea polyphenols and its impact on health benefits. Animal Nutrition, 6(2), 115–123

Keywords:
Gliadins, protein secondary structure, phenolic acid, spectroscopic methods

P3.5 CHANGES IN THE GLUTEN NETWORK STRUCTURE AND ANTIOXIDANT PROPERTIES INDUCED BY HYDROXYCINNAMIC ACID DERIVATIVES SUPPLEMENTATION

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Nutritional trends toward a healthier diet have promoted the consumption of breads enriched with high fibre or other beneficial components. Plant polyphenols can be used as a supplement to wheat bread. These substances are natural antioxidants that help to keep food fresh and improve overall food quality. Phenolic compounds undergo chemical changes and can interact with protein macromolecules during food production and processing [1].

The aim of the study was to evaluate antioxidant properties and structural changes of gluten after cinnamic acid derivatives supplementation (coumaric acid, caffeic acid, ferulic acid, sinapinic acid). Model dough samples with selected phenolic acids were prepared in a farinograph. Gluten samples were prepared by washing out the gluten from the model dough and lyophilised. To determine gluten structure, the Raman spectroscopy was used. Secondary and tertiary structures were determined by analysing the amide I band, aromatic amino acid microenvironment, and disulphide bridges conformations. Phenolic acids were extracted from gluten samples in methanol. Acid concentrations and antioxidant properties in methanolic extracts were determined with application of UV-VIS spectroscopy. Antioxidant properties were measured using ABTS and FRAP assays.

After supplementation, cinnamic acid derivatives are found in the gluten network. These compounds influenced the secondary and tertiary structure of gluten proteins, as well as the formation of the gluten network, when they were applied to the model dough. The increase of β-sheet-like structures and aggregates from the α-helices and β-turns are the primary structural changes detected in the tested samples. UV-VIS spectra revealed that coumaric acid exhibits the highest level of extraction. This acid's high extractability might indicate that it is the least linked to the gluten network. According to the results of ABTS assay, extract from caffeic acid supplemented gluten had the highest antioxidant activity, while gluten supplemented by sinapinic acid had the lowest. Extracts from caffeic acid-enriched gluten also demonstrated the highest antioxidant activity in the FRAP assay. The results suggest that cinnamic acid derivatives might be used to create supplemented wheat products characterized by health-promoting properties.

Acknowledgments
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Keywords:
Gluten, FT-Raman, antioxidants, phenolic acid

P3.6 INFLUENCE OF THE SELECTED FLAVONOIDS AND THEIR GLYCOSIDES ON THE STRUCTURE OF GLUTEN PROTEINS.

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Polyphenols are classified as health-promoting substances. This is due to their ability to neutralize free radicals that contribute to the emergence of civilization diseases. Among polyphenols, two large groups can be distinguished, such as phenolic acids and flavonoids. They can be added to the bread as components of dietary fiber preparations, and polyphenol extracts. Supplementation of bread with compounds that may have a beneficial effect on health, and may be a good way to diversify and enrich diet. Simultaneously, the use of various types of bread dough additives may disrupt the formation of a gluten network with appropriate mechanical properties, and thus deteriorate the quality of bread [1].

The aim of the research is to determine the effect of selected polyphenols from the group of flavonoids (quercetin, hesperetin) and their glycosides (rutin, hesperidin) on the secondary and tertiary structure of gluten proteins in the model wheat dough. Polyphenols were added in three concentrations 0.05%, 0.1% and 0.2%. The dough samples were prepared in the farinograph. Then, the gluten was washed out from the model dough. Next, gluten was frozen, lyophilized and pulverized. The samples in the form of powder were tested using FT-Raman spectroscopy [2].

Analysis of the results obtained using FT-Raman spectroscopy showed that both the difference spectra for the dough supplemented with aglycones and glycosides give changes in the secondary structure of gluten proteins. These changes are closely related to the structure of the added polyphenols to the model dough. Quercetin and rutin contain only OH groups in their structure and cause similar changes. The changes induced by hesperetin and hesperidin are different and are probably related to the presence of a methylene group in their structure. The addition of quercetin and rutin causes a decrease in the percentage of the most energetically stable conformation (g-g-g), while after adding hesperetin the amount of this conformation does not change compared to the control. The greatest changes in the tryptophan environment are observed after the addition of hesperetin. The tryptophan band intensity increases significantly. This indicates that tryptophan residues hide inside the protein complex upon addition of the compound.

Acknowledgments:
The research was financed under the Preludium 17 Project obtained from the National Science Center, registration number: 2019/33 / N / NZ9 / 02345

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Keywords:
Flavonoids, glycosides, gluten, FT-Raman

P3.7 PRODUCTION OPTIMIZATION OF GOLDEN RICE ANALOGS USING A PASTA EXTRUDER AND RESPONSE SURFACE METHODOLOGY

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The applications of corn and rice flour subjected to the extrusion and optimization process were observed to create the golden rice analog (GRA). A central composite design (CCD) with 2 factors (cornflour and feed moisture) was applied to obtain the optimum conditions for physical and cooking characteristics. The predicted optimum conditions were cornflour (70%) and feed moisture (33.56%), resulting in GRA with conditions 2.62 (g/g), 1.86%, 81.38, 4.32, 28.12, 4.95%, 6.58% and 4 min for water absorption index, water solubility index, lightness, redness, yellowness, water absorption ratio, cooking loss, and cooking time, respectively. Scanning electron microscope (SEM) analysis indicated that as the cornflour concentration was increased from 60-80%, the rice and corn flour bonded well and had a smaller pore size. Moreover, crude protein, crude fat, β-carotene content, and antioxidant activity in the GRA were higher than in Japonica rice.

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Keywords:
Golden rice analog, Response surface methodology, Pasta extruder, β-carotene, SEM

P3.8 DEVELOPMENT AND ANALYSIS OF FUNCTIONAL PASTRY - FERMENTED BLACK GARLIC PINEAPPLE CAKE

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Pineapple cake is a sweet traditional pastry and dessert containing butter, flour, egg, sugar, and pineapple jam or slices widely eaten in Taiwan. However, pineapple cakes are high in calories, each serving (50 grams) contains about 250 calories. The oil-to-calorie ratio and sugar-to-calorie ratio are both higher than 20%, which increase the risk of cardiovascular disease. Black garlic (Allium sativum L.) is an emerging processed food obtained by fresh garlic under high temperature of fermentation. It is rich in bioactive components such as polyphenols, polysaccharides and organic sulfur compounds-S-allycysteine (SAC). Black garlic also shows several biological activities such as antioxidant, anticancer, promoting gastrointestinal motility and liver protection. Therefore, the main purpose of this study is to partially replace the filling of traditional pineapple cake with local black garlic, and to develop and produce a sugar-reduced pastry. First, the production process of pineapple cake is established, and then the filling of traditional pineapple cake is replaced with black garlic in different proportions, and the sensory evaluation of consumers' preference is conducted. Among them, the change of SAC content of black garlic in unroasted and roasted garlic are also quantified by HPLC-UV. The results show that the content of the unbaked (120.33±12.01 mg/g extract) and baked (107.33±18.00 mg/g extract) groups only cause a slight decrease, and the baking process can still retain more than 90 % of the SAC content in black garlic. The results of the sensory evaluation show that apart from the flavor test, there was no significant difference between the control group and the 10% black garlic group in other tests, indicating that the black garlic pineapple cake with 10% replacement has a high acceptance. According to the result, the black garlic pineapple cake has high consumer acceptance, and can retain more than 90% of the SAC content in black garlic after the baking process. In conclusion, this study suggests that the black garlic pineapple cake may be a novel functional pastry by reducing the sugar content of traditional pineapple cake and also containing the functional components SAC.

P3.9 NON-GLUTEN PROTEIN FUNCTIONALITY ON OHMIC-BAKED BREAD PROPERTIES

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The stabilization of gluten-free (GF) batter still remains a great challenge, as CO_2 can easily dissipate during bread-making, resulting in a small and dense bread. Recently, ohmic heating has been successfully applied for baking GF bread, improving bread volume and pore properties (Bender et al., 2019; Masure et al., 2019; Waziiroh et al., 2021). Waziiroh et al. (2021) reported that adjusting the rheological behavior of GF batters is crucial, as batter rheology significantly affects the gas cell expansion during proofing and the ion movement during ohmic heating. However, the gas cell expansion in GF bread does not only rely on starch, but also on proteins that stabilize the GF batter. This study attempts to assess the effect of non-gluten proteins from different sources (plant and animal) on the rheological behavior of GF batter (pasting, rheology, and foam stability) and bread quality after baking with ohmic heating. For this purpose, a correlation matrix, relating the functional properties of the proteins on batter behavior and bread quality was established. Amongst proteins, egg albumin and potato protein exhibited a better functionality on GF bread. Moreover, bread with potato protein showed the highest volume in both baking methods and higher protein digestibility. The result confirmed that potato protein could be a good non-gluten protein source to replace the traditionally used egg albumin in GF bread.

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Keywords:
Gluten-free bread, non-gluten protein, ohmic baking, batter stabilization, rheology

P3.10 TRADITIONAL WHOLE WHEAT FOODS IN CHINA: EFFECTS OF MILLING METHODS ON SENSORY AND NUTRITIONAL QUALITY

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Whole wheat products are enriched with health-promoting components such as dietary fibers and phytochemicals. But their poor sensory property negatively impacts consumers' acceptability. Thus, improvement of sensory property is critical for the increased consumption of whole wheat for the human health. Compared to Western-style bread, the quality determinant of traditional Chinese food is less investigated. This study investigated the effects of five different pilot-scale milling methods on physicochemical properties, bioactive components, Chinese steamed bread (CSB), and Chinese leavened pancakes (CLP) qualities of whole wheat flour (WWF). Cultivar Zhongmai 578, a new cultivar with both great yield potential and exceptional end-use quality was harvested in 2020. The milling experiments were conducted by the facilities of Buhler company in Wuxi, China. WWF1-3 were obtained by the reconstitution of differently processed brans after the separation of bran fraction and starchy endosperm. WWF4-5 were obtained by direct pulverization of whole wheat seeds. Different milling protocols led to WWF1-WWF5 with particle size of 236, 146, 124, 191, 146 µm, respectively. The following analysis indicated that WWF-1 from the reconstitution of brans processed by a hammer mill had the best CSB and CLP quality. WWF-5 from entire grain grinding by a jet mill (65Hz) contained the highest content of dietary fibers and ferulic acid (FA), a powerful natural antioxidant. FA content of WWF1-WWF-5 was 720, 742, 534, 647, and 1002 µg/g, respectively. Intensive milling process produced WWFs with finer particle sizes that are generally considered as preferable, but it also produced more damaged starch that negatively impacted food quality and led to significant loss of health-promoting components. Precise control of the milling intensity for proper particle size and damaged starch content is critical for the improved quality of final products. In summary, our results demonstrated significant effects of milling methods on end-use property and nutritional quality of WWFs. In the future, it is important to develop more sustainable milling protocols that save energy and at the same time increase overall quality of the final products.

Keywords:
Milling methods, dietary fiber, phenolic acid, steamed bread, leavened pancake

P3.11 A UNIQUE APPROACH TO BREAD BAKING BY GAS HYDRATES AS LEAVENING AGENTS

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In the bread baking sector, the traditional baker's yeast, *Saccharomyces cerevisiae*, is still the most often used leavening agent. Carbon dioxide (CO_2) is created by yeast metabolism with the consumption of carbohydrates in the dough, which is a time and energy-consuming process. The consumer interest in foods with low unhealthy content is increasing, so the goal of the current study was to analyze the effect of CO_2 gas hydrates (GH) as a leavening agent in bread. The bread dough was created by kneading it with the GH and was baked at 240 °C for 24 minutes. Figure 1 shows the basic protocol followed for the production of GH bread. By omitting the yeast, different quantities of GH were added to make variants of bread dough (10-60 percent). The efficiency of GH in bread production was assessed by comparing its properties to those of regular yeast bread. The properties studied for the GH bread were leavening volume, pore size distribution, texture, and baking loss. The hardness profile of the GH breads (10-60 %) varied from 28-40 N while that of standard bread was 10.23 N. The best results in terms of different properties studied were observed in GH bread containing 40 % GH. Nonetheless, one of the major obstacles to overcome was the hardness (N) values of the GH bread. The results show that CO_2 GH may be used as a source of leavening in the manufacturing of bread with acceptable textural characteristics.

Keywords:
Gas hydrates, bread, baking, leavening, food applications

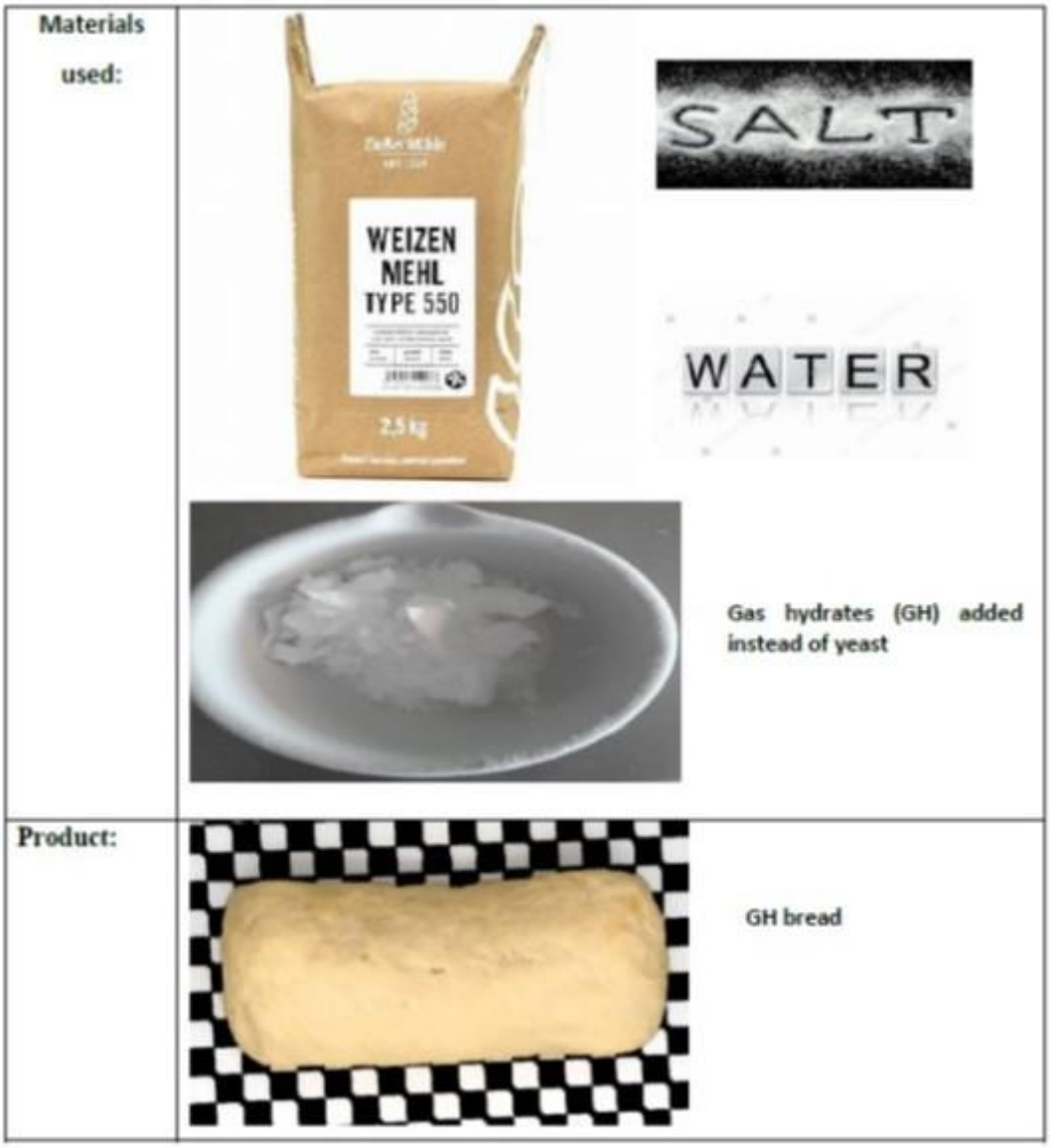

Figure 1: Basic protocol followed for the production of GH bread.

P3.12 GAS HYDRATES AS A LEAVENING AGENT IN BLACK-AND-WHITE COOKIES

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Bakery and cereal products are a basic part of today's diet, which includes a wide variety of breads, biscuits, and confectionery varieties. The elastic gluten structure, that is formed during the kneading of flour, can contain the leavening gases produced during rising for any type of baked product. However, some chemical leavening ingredients like ammonium bicarbonate cause adverse side effects such as the formation of acrylamide, a carcinogen, in black-and-white cookies.

This research aims to use carbon dioxide (CO2) gas hydrate as a leavening agent in black-and-white cookies. CO2 gas hydrates comprises of CO2 gas as a guest molecule in a hydrogen-bonded ice matrix. Despite the ample experiments on CO2 gas hydrates in other disciplines, there is a need to carry out more analysis to elucidate different applications of gas hydrates in food products and clearly authenticate its sustainability.

Standard recipe protocol was followed for the baked product, except that CO2 gas hydrates were used as the leavening agent, with a baking time of 15 minutes for black-and-white cookies. Once baking is done, the texture profile, volume, moisture content, and pore size of cookies were measured to compare the leavening effect of gas hydrates with the standard recipe. By varying the proportion of gas hydrates from 10-60 %, an analysis of the performance of CO2 gas hydrates as a leavening agent was carried out and the baking process for the food product was optimized from then on. Notably, the gas hydrate produced with leucine as a promoter was able to achieve a higher volume in the cookies compared to normal gas hydrates. When using gas hydrates as baking agent, the volume achieved was 50 % of the volume achieved when using ammonium bicarbonate (Fig. 1). The springiness, a quality-determining factor of the pastry texture, reached a comparable value when ammonium bicarbonate was replaced by gas hydrates. Hence, standard recipes with gas hydrates as a leavening agent for black-and-white cookies are in the process of aiming to replace conventional baking agents such as ammonium bicarbonate and baking powder.

Figure 1: Black-and-white cookies with ammonium bicarbonate (left) and with gas hydrates (right) along with the cross section of the same.

P3.13 IMPACT OF THE HEATING RATE ON THE EFFICACY OF MALTED FLOUR; APPLIED TO FLAT BREADS

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The baking industry faces the challenge of food waste due to the short shelf-life of bakery products, mainly attributed to the staling rate altering taste, texture, among other quality properties. This phenomena is magnified with increasing heating rate during baking (Bou Orm, 2021), resulting in firmer crumb. Flat bread is characterized by its rapid baking at high temperatures (ca. 300°C, 2 min per side), resulting in heating rates up to 50°C/min (against ca 7°C/min for conventional baking) for which staling rate is expected to be high. Up to date, the most accepted technique against staling is the addition of exogenous (often "bacterial") enzymes such as xylanase and amylase. Malted flour addresses the interest of a natural source of enzymes; however, the corresponding enzymes can't compete with bacterial enzymes which are much heat stables than endogenous enzymes. This contribution aims at investigating the performance of a malted flour with respect to the heating rate. A wheat based malted flour was produced using a conventional germination diagram (4 days @ 18°C). The enzymatic activity was assess using the kit Malt-Amylase,Megazyme. Bread (100 g flour, 57g water, 1g dry yeast, 1.8g salt, 0.3 g malted flour) was prepared using a miniaturized heating system based on a peltier heater (Bou Orm, 2021); three heating rates were compared (5, 20 and 40°C/min). The staling was monitored by measuring the Young modulus of the baked crumb and the melting enthalpy of amylopectine crystallites during 2 weeks storage at 10°C. The dough stickiness was assessed using a kieffer ring system, showing that the malted flour yielded higher stickiness. Results showed a significant impact of the heating rate on the kinetics and magnitude of staling. The amylopectin retrogradation was higher with increasing heating rate, showing a lower action of the malted flour's enzymes. Results are discussed against existing literature, showing that malted flour addresses several challenges in the case of rapid baking conditions such as those encountered with flat bread products.

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Keywords:
Bread baking, enzymes, malted flour, flat bread, texture

P3.14 EFFECT OF STORAGE ON QUALITY CHARACTERISTICS OF VEGAN FORMULATION OF TRADITIONAL RICH DOUGH PRODUCT "TSOUREKI"

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The rich dough baked product (RDBP) "tsoureki", is a traditional Greek baked good with a special texture, taste, flavor and other quality attributes, critical for consumer acceptance which should be maintained during storage. This product is produced using constituents of animal origin. In order to keep pace with consumers' demands for plant over animal-based foods, this research focused on the study of the effects of storage conditions on the quality characteristics of a reformulated traditional RDBP-tsoureki based on ingredients of vegetable origin. Hence, the animal-based ingredients, including butter, milk, and eggs were substituted with shortenings, soya milk and apple pulp, respectively. Such a substitution could create structural, textural and physicochemical modifications affecting the final product's shelf-life. The selected storage temperatures were 25°C, 35°C and 45°C, while the storage time ranged from 0 to 14 days. Quality characteristics were monitored during storage, including moisture content, water activity, TBA values, colour, textural properties and sensorial characteristics. Results showed that storage time and temperature had an influence on quality characteristics. Specifically, the water activity and moisture content of the product decreased with storage time, while hardness was increased both instrumentally and sensorially. The products' crumb colour decreased during storage, resulting in a darker product. Overall, this study shows that tsoureki's vegan formulation can maintain positive quality characteristics for up to 10 days and be accepted by consumers.

Keywords:
Rich dough baked good, vegan, sensory evaluation, shelf-life, texture

P3.15 PHYSICOCHEMICAL PROPERTIES OF SURPLUS BREAD AS A CIRCULAR RESOURCE IN BAKERIES

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Surplus bread represents a significant part of food losses in Belgium. Research shows that 3-9% of the total production in Belgian industrial bakeries is lost or wasted. Today, this flow mainly goes to livestock feed or biogas production. Although, this surplus bread can also be valorised within the human food chain.

This research selected nine major surplus bread and bread product streams derived from industrial and small bakeries in Flanders. Bread was dried and milled in order to get a food safe raw material with a prolonged shelflife that can be reused in the bakery as an ingedient. For this the physicochemical properties of these circular resources were determined.

When using a Cross Beater Mill, particle sizes distribution of the bread flours differ depending on the type of bread. Moreover bread flours showed a higher water absorption capacity (1,51- 3,39 g/g) than wheat flour. The water binding capacity (1,86-5,08 g/g) depends also on the type of bread flour. Bread flours from fully baked products obtained minor pasting properties, while three par-baked and freeze stored bread products showed low pasting properties compared to wheat flour.

Based on the results these new circular bread flours offer potential for product development in bakery and in addition they can contribute in reducing food losses.

Keywords:
Surplus bread, water absorption capacity, water binding capacity, pasting properties

P3.16 ROLE OF PHYSICAL PROPERTIES OF OAT GROATS AND FLAKES FOR PROPERTIES OF OAT FLAKE FLOUR

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The aim of this study was to understand how physical properties of oat groats and flakes affect the characteristics of oat flake flour. This was conducted by investigating the relationship between the chemical composition and the physical characteristics of two oat flour batches consisting of 30 Finnish oat ingredients. It was hypothesized that hardness of oat groat and physical properties of oat flakes show significant relationship with the physical properties of the oat flours, including flour water holding capacity, particle size, bran-endosperm separation by air classification and flow properties. Hardness values of oat groats of the first batch were related to the chemical composition and physical properties of oat flours such as behaviour of flour in air classification. Furthermore, the physical properties of the oat flakes were connected to the particle size properties of both flour batches, although the connections were different for the two batches. Separation of bran and endosperm particles of oat flours by dry fractionation was connected to the chemical composition as well as particle size distribution of the flours. Furthermore, it was shown that flowability properties of oat flours affect the bran-endosperm separation of oat flour by dry fractionation. The current data implies that hardness of oat groats and physical properties of the flakes are related to the physical properties of the subsequent oat flours after milling.

Keywords:
Oat groat hardness, oat milling, flaking, air classification

P3.17 WATER UPTAKE AND GERMINATION BEHAVIOR OF FABA BEAN (VAR. MINOR AND VAR. MAJOR)

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Early-stage water uptake and germination behavior of faba bean (*Vicia faba* L.) var. minor and var. major

Legumes are underutilized as food ingredients although they have a high protein content with a well-balanced amino acid composition especially when consumed with cereals. Low utilization rate of legume seeds, such as faba bean (*Vicia faba* L.), is due to the antinutritional compounds as well as the poor technological functionality and sensory quality. The most natural alternative for reducing antinutritional compounds, such as raffinose oligosaccharides, present in faba beans is germination during which the physiological machinery of a seed is activated in order to release nutrients for the growth of the seedling. However, the germination behavior of faba beans is not adequately known in order to design industrial-scale processes.

In this study, germination behavior of two distinct faba bean varieties was studied systematically by hyperspectral imaging enabling monitoring of detailed spatial distribution of early-stage water uptake. It was hypothesized that this essential hydration phase initiating germination takes place mainly via embryo in faba beans. In addition, water uptake and germination rate of faba beans were determined in trials on plates and in automated malting equipment.

Based on the results, early-stage water uptake in faba beans occurred evenly from the outer layers of the beans. Germination on petri dishes and in pilot-scale showed that minor-type faba beans moistened and germinated significantly ($p<0.05$) faster and retained also water better through germination than larger, major-type faba beans.

It was show by this study that small- and large-seeded or minor- and major-type faba bean varieties set different requirements to the germination process, which need to be taken into account in larger scale germination processes.

Keywords:
Faba bean (Vicia faba L.), germination, water uptake, hyperspectral imaging

P3.18 PROTEASE ACTIVITY IN THE FERMENTATION OF HULL-LESS BARLEY SOURDOUGH

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The usage of high-quality grain materials in combination with fermentation as a sustainable grain processing technology allows to obtain a product with qualities that are beneficial for the human health. Traditionally wheat and rye sourdoughs are used for bread baking, but barley and germinated barley can be used as alternative raw material to make the sourdough. There is a lot of research confirming that hull-less barley varieties (*Hordeum vulgare L.*) are raw materials of food with high value and have unique and balanced nutrient compositions (Sterna et.al, 2021).The sourdough fermentation is an ancient biotechnological method of grain processing that has traditionally been used in preparation of wholegrain bread. Proteolysis in the fermentation of sourdough influences not only the structure, volume, flavor and taste of bread produced from these sourdoughs, but they also have the main role in degrading of grain proteins and splitting of allergic peptides, thereby reducing the allergic properties of grain proteins (Ganzle et al., 2008). The goal of the research was to determine the activity of endo-protease in the spontaneous hull-less barley sourdough and in the sourdough with starter culture. The spontaneous sourdough was prepared using a three stage protocol with backslopping procedure. Previous studies have shown that after three backsloppings, the dominating species of lactic acid bacteria in the hull-less barley spontaneous sourdough *is Pediococcus pentosaceus* (Reidzane et.al., 2021). To increase the proteolytic activity in the hull-less barley sourdough, the starter cultures of species of lactic acid bacteria *Lactiplantibacillus plantarum* un *Pediococcus pentosaceus* that produce peptidases were used. The activity of proteases was measured after three stages of backslopping, and after 10 days while backslopping the sourdough every 12 hours. For each sourdough the pH, TTA were determined and microbiological tests were performed. To determine the activity of endo-protease, azocasein as substrate was used. The highest activity of endo-protease 9.74 U/ml was found in the barley sourdough with starter culture after three stages. The pH of this sourdough was 3.6, TTA: 12. The pH of spontaneous sourdough was 3.8, TTA: 13. The lowest activity of proteases was found in the spontaneous barley sourdough after 10 days of backslopping procedures.

The activity of proteases in fermentation process of barley sourdough is significantly increased by using the cultures of *L.plantarum* un *P.pentosaceus*.

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Keywords:
Hull-less barley, sourdough fermentation, protease activity

P3.19 EFFECT OF AGRONOMICAL PRACTICES AND INDUSTRIAL PROCESSING ON NUTRITIONAL, SANITARY AND TECHNOLOGICAL QUALITY OF SOYBEAN

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The growth of plant protein demand and the increasing thrust for nitrogen fixing crops, in rotation strategies, represent two pillars for legume diffusion [1]. Furthemore, legumes are a central topic of the European Green Deal. In this scenario, soybean (*Glycine max* L.) seems to have a key role to be used as food ingredient, because its good yields and agronomy, the high content and quality of protein, among arable crops, and the overall nutritional value. Soybean, at once, presents issues related to anti-nutritional compounds, which can cause loss of nutrients during digestion [2]. To develop a food supply chain based on soybean ingredient, it is necessary to explore the effect of genotype, environment, crop management and first industrial processing on yield, quality and organoleptic aspects of soybean grains. The effect of cropping system has been investigated in North West Italy, by comparing sowing dates, plant densities, nitrogen fertilizations and fungicide applications. Field comparisons have been set up to examine conventional cultivars that differ for precocity, seed dimension, hilum colour and genotypes. In all seed samples, the proximal composition (proteins, lipids, dietary fiber and sugars) and the concentration of bioactive compounds (phenolic compounds) have been analysed. Finally, different soybean varieties have been processed to assess the effect of primary operations on seeds composition (antioxidant power and phenolic acids) and organoleptic profile. This study provides new insight into the possibility to create a soybean supply chain for food industries.

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P3.20 RHEOLOGICAL PROPERTIES OF GLUTEN FREE SOURDOUGHS

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Production of gluten-free bread with good quality characteristics requires finding of various technological solutions to compensate for the baking benefits of wheat and gluten. Similar problems arise with development of sourdoughs from gluten-free cereals. Our study aimed to explore the viscosity of sourdoughs obtained from teff, sorghum, corn and rice by using selected lactic acid bacteria strains and to compare it with sourdoughs produced from wholegrain wheat flour. Determination of sourdoughs viscosity and assessment of their rheological properties is a challenging task because of the diversity in the chemical composition of the crops, the individual characteristics of the microbial strains, the technological parameters and a number of other conditions. Sourdoughs were prepared with single starter cultures of *Pediococcus acidilactici* 02P108 (PA), *Pediococcus pentosaceus* 12R2187 (PP) and *Enteroccocus durans* 09B374 (ED). The viscometric studies - dependence of the shear stress on the shear rate were modeled according to the following power law: $\eta=K_p\gamma^n$, *where* K_p - consistency index, n – power law index.

The data from the performed studies show a significant influence on the parameters of the model. The power law index n for all tested samples is less than 1, which identifies fluids as pseudoplastic. The addition of starter cultures in corn and rice flours lead to an increase in the power law index, with strongest dependence observed in corn flour, where the flow behavior is close to Newtonian (n = 1).

The obtained data on the studied parameters are useful to describe the differences in the behavior of different sourdoughs and the selection of the most appropriate flour matrices and sourdough starter cultures.

P3.21 PREDICTING THE MOISTURE CONTENT OF ORGANIC WHEAT AT THE END OF THE FIRST TEMPERING STAGE

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The tempering process is an important process in wheat flour milling that requires appropriate adjustments to achieve the desired level of flour quality and yield. The objective of the study is to build a decision support tool to help adjust the tempering tempering parameters to condition the wheat grains properly according to wheat properties, wheat blends and the type of flour desired. For this, a regression model is developed to predict the percentage increase in moisture content of organic wheat at the end of the first tempering stage. To select the best regression model according to our inputs variable, four models are build and compared : ordinary least squares (OLS), LASSO, RIDGE and ElasticNet. A case study was conducted in a mill located in Quebec region to build and evaluate the regression models. Their performance are evaluated based on R-square and MSE (Mean Square Error) metrics. The models are based on wheat properties (initial wheat moisture content, wheat protein content and wheat temperature), process parameters (target wheat moisture content, wheat flow rate, wheat quantity and rest time) and tempering conditions (water quantity, date, humidity and temperature). The increase in wheat moisture obtained during the first tempering step varied between 0% and 5%. The results show that the LASSO model outperforms the others in predicting the final wheat moisture increase with an average prediction error of 0.18%.

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Keywords:
Wheat tempering, organic cereal grains, regression, prediction

P3.22 EFFECT OF OZONE TREATMENT DURING KNEADING ON WHEAT DOUGH RHEOLOGY COMPARED TO ASCORBIC ACID ADDITION

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An extensible and stable gluten network is important for a viscoelastic wheat dough and final bread quality. The quantity and quality of gluten depends on the wheat variety and growing conditions. To compensate for these differences, ascorbic acid (ASC) is often added to wheat flour, thereby oxidatively strengthening the dough. The objective of this study was to investigate the effect of doughs, kneaded in an ozone-containing atmosphere with respect to rheology by measurements with the Farinograph (n = 3), the oscillating rheometer (n = 6), and dough extensibility tests (Kieffer-Rig, n = 12). Two series of tests were carried out with ASC-free or ASC-containing (ASC addition of 0.003 % on a flour basis) with type 550 wheat flour. The dough was gassed with ambient air or ozone (20 mg/L) during kneading and compared with the untreated samples.

Farinographic measurements showed an increase in maximum consistency by 4 and 6 %, dough development time by 1 and 136 %, and stability by 18 and 87 % as a result of air and ozone fumigation, respectively. The degree of dough softening was reduced. The combination of ozone treatment and ASC addition to the flour resulted in a change of the kneading curve. After 10 minutes of kneading, a second peak appeared and raised dough development time further by 402 %.

Therefore, the further rheological measurements were carried out with doughs after 10 minutes of kneading. Ozone treatment improved the viscoelastic character. G' and G'' increased due to air and especially by the ozone treatment, and the loss angle decreased accordingly, indicating a greater increase in storage modulus. The differences between the doughs with and without ASC are not significant. The maximum elongation resistance increased slightly with air treatment and more with ozone. The extensibility behaved inversely and decreased by air and ozone treatment. Except for the ozone treatment, the doughs with ASC had slightly higher elongation resistance and lower extensibility than the doughs without ASC.

If it is assumed, that ozone increases the degree of cross-linking of gluten proteins, the increase in viscoelastic character as well as the increase in maximum elongation resistance can be explained. Thus, ozone strengthens the gluten network in wheat dough and may represent an alternative to classical flour treatment agents. Notable differences due to ASC were only visible in the Farinograph results and were not significant in the other measurements.

Keywords:
Flour modification, ozone, dough rheology, wheat quality

P3.23 THE USE OF WILD PLANTS FOR THE PRODUCTION OF A FUNCTIONAL PASTA

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According to a FAO definition, wild plants (WEPs) are "plants that grow spontaneously in self-maintaining populations in natural or semi-natural ecosystems and can exist independently of direct human action". In Italy, the use of alimurgical WEPs has always been a relevant feature of local cultures and they are widely spread in different traditional recipes. Increasing evidences suggest that WEPs may have great potential as sources of unusual colors and flavors and dietary supplements, mainly fiber, proteins and different minerals. Moreover, they provide high amounts of bioactive compounds, such as flavonoids, proanthocyanidins, flavonols, vitamin C, tocols (vitamin E), carotenes (vitamin A) and xanthophylls that, due to their antioxidant activity, play a key role in reducing the risk to develop several degenerative diseases in humans. To date, while safety is still of paramount importance, the nutritional and caloric composition of foods is becoming equally relevant. In addition, if food also provides health benefits beyond basic nutrition it could be considered as a ''functional food''. In this context, pasta, due to its widespread use and popularity, is an ideal matrix for the incorporation of unconventional ingredients or raw materials, so that to realize a different innovative healthy food. The aim of this work was the production of pasta enriched with different wild and commercial leafy vegetables, considering their significant quantities of bioactive compounds. The nutritional and sensorial characteristics of the made final products were evaluated, with particular attention to the content of tocols and carotenoids. Using balanced formulations and appropriate technologies, leafy vegetables pastas proved to be a good alternative food, with high nutritional and sensorial quality and high healthy properties.

P3.24 PRODUCTION OF EXTRUSION PRODUCTS FROM WHOLE BARLEY AND WHOLE WHEAT FLOURS

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Extrusion cooking technology has gained popularity in the food processing industry in recent years due to its versatility, energy efficiency and lower operating cost. It does not result in a considerable level of waste. The purpose of this study was determining optimum parameters for the production of extrusion products from different cereal grains (whole barley and whole wheat flours). In this study, laboratory scale twin screw extruder was used (Feza Makine, Istanbul, Turkey) and optimum parameters were determined for the production of expanded extrusion products from these cereal flours. For the production of extrusion products, the following parameters were investigated: screw speed (150 and 200 rpm), exit die diameter (1.5 and 3.0 mm), cutting knife speed (2000 and 3000 rpm), extruder exit die temperature (115°C and 130°C) and flours from different cereal grains (whole barley and whole wheat flours). Other parameters such as material feed rate and feed moisture content (14, 16, 18, 20 and 22%) were also determined to obtain the desired product texture. The crispiness and crunchiness features of extrusion products were analyzed by using TA.XTplus Texture Analyzer. The specifications of extrusion products were determined by analyses of expansion index, bulk density, hardness and crispness and the production parameters were optimized based on of the quality characteristics of the extrusion products.

Keywords:
Extrusion, whole barley flour, whole wheat flour, expansion ratio

P3.25 PROXIMATE COMPOSITION, IN VITRO PROTEIN DIGESTIBILITY AND FATTY ACID PROFILES OF COMMERCIAL CEREAL-BASED DAIRY ANALOGS

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Plant-based protein products as alternatives to animal-based protein counterparts are becoming increasingly available given their alignment with the increased environmental, health, and ethical focus of consumers. Among these are plant-based dairy alternatives, which respond to increased lactose intolerance as well as veganism. One of the most important challenges in such product development is the need to select appropriate ingredients, combined with appropriate technologies in order to guarantee the development of environmentally friendly, nutrient-rich foods that maintain their sensory attractiveness in terms of flavor and texture. In this perspective, cereal-based ingredients are positioned as promising ingredients given their technological versatility, richness in protein, fibre, vitamins, minerals, and important phytochemicals that synergistically contribute to important biological activities contributing to alleviating several non-communicable diseases. On the other hand, the important fibre contents may contribute to glycaemic and cholesterolemic control as well as satiety promotion. Different cereal bases will most certainly impact differently these properties in the final products. The aim of this study was to assess the proximate composition, in vitro protein digestibility, and fatty acid profiles of three cereal-based preparations, namely oat-base, spelt-base and sorghum-base that were used in the development of yogurt, ice-cream, and cheese analogs, respectively.

Protein, fat, total carbohydrates, sugars, fibre, and ash contents were determined according to AOAC methods. The in vitro protein digestibility (IVPD) of the samples was determined by the combination of the methods of Arte et al. (2015) and Elmaki et al. (1999) with some modifications. The fatty acid composition was based on the conversion into fatty acid methyl esters (FAME) followed by analysis with GC-Flame ionization detection (FID).

Cereal-base type and associated formulation impacted the final proximate composition; protein content varied between average values of 1.5 g/100 g yogurt to 2.5 g/100 g cheese and is below average content of conventional dairy products, one of the main challenges within this product category. On the other hand, fibre content was two-fold higher in the sorghum ice-cream analog and present at values between 1.6 g/100 g yogurt to 2.7 g/100 g cheese. Adaptation of portion sizes and adjustments of formulations may enable fibre nutritional claims. Fat contents were always lower in cereal-based analogs in comparison to conventional animal-based counterparts. Among the three dairy analogs, the cheese alternative revealed the highest content as a consequence of the added coconut oil to improve texture mimetization. Such addition was also reflected in the higher saturated fatty acid fraction. Oleic acid (C18:1n9) and linoleic acid were the most predominant unsaturated fatty acids in the oat-base and spelt-base yogurt and ice cream alternatives, respectively. Protein digestibility differed among the three dairy alternatives as a consequence of the different cereal bases as well as food structures.

These results provide important insights on nutritional information and behavior to be used for future product development or improvement contributing to improving consumers' acceptance.

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Keywords:
Cereal-based dairy analogs, innovative food products, health, nutritional value, digestibility

P3.26 SOLUBLE ARABINOXYLANS, FREE FERULIC ACID AND ANTIOXIDANT CAPACITY OF EXTRUDED-FERMENTED BREWERS´ SPENT GRAIN

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Brewers' spent grain (BSG) is a material rich in hemicellulose, composed of arabinoxylans (AX). However, the high crosslinking of this material causes low availability of AX, for which it is necessary to apply different treatments. The objective of this research was to increase the release of arabinoxylans through solid-state fermentation with *Fusarium oxysporum* f. sp. *lycopersici* using extruded brewery spent grain. First, the BSG was subjected to two types of physical treatments: extrusion at 20% moisture, 200 rpm and 50 ◦C (BSGe), and blade milling (BSGm). The chemical composition was determined for each sample (BSG, BSGe and BSGm). Subsequently, the solid-state fermentation process (SSF) was carried out on each sample. The fermentation kinetics at 30 ◦C were monitored for 7 days. Once the SSF concluded, AX were extracted, and the purity of AX was determined by the phloroglucinol colorimetric assay. Finally, the total phenolic compounds, phenolic acids and antioxidant capacity by DPPH were quantified. No significant differences ($p \geq 0.05$) in the protein, lipid, ash or total dietary fiber contents were found among the samples. No significant difference ($p \geq 0.05$) in the content of soluble fiber was found, although BSGe and BSGm had higher values than BSG. On the other hand, the yields of soluble AX exhibited significant differences ($p \leq 0.05$) among nonfermented samples (BSG, 0.03%; BSGm, 0.53%; BSGe, 0.70%) and with SSF (BSG, 2.95%; BSGm, 6.24%; and BSGe, 9.58%). In addition, the contents of free phenolic compounds and free phenolic acids and the percent inhibition of free extracts by 2,2-diphenyl-1-picrylhydrazyl (DPPH) differed significantly ($p \leq 0.05$) between samples subjected to SSF and nonfermented samples. Therefore, extrusion and SSF treatment increased AX release from BSG as well as the antioxidant capacity of the extracts.

Keywords:

Brewers' spent grain; arabinoxylans; extrusion; solid-state fermentation; Fusarium oxysporum; antioxidant capacity

POSTERS – TOPIC:

Grain Biodiversity and Food Security

P4.1 ASSESSMENT OF ANTIOXIDATIVE ACTIVITY AND TOTAL POLYPHENOL CONTENT IN VARIOUS QUINOA GENOTYPES

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Quinoa (Chenopodium quinoa Willd.) is a pseudo-cereal domesticated in the Andean Mountain region approximately 7,000 years ago. Recently, the production and consumption of quinoa seeds have been increasing thanks to their superior nutritional value and a great number of biologically active compounds. In addition, quinoa leaves, traditionally consumed as green vegetables, are a very good source of protein, vitamins, and minerals. Therefore, various quinoa genotypes were grown in Crop Research Institute Prague as one of the first trials to obtain primary data on the nutritional profile of quinoa cultivated under climatic conditions in the Czech Republic. In this study, the antioxidant activity (AA) and total polyphenol content (TPC) were determined in 72 quinoa seed samples over three consecutive years 2018–2020. Moreover, 69 quinoa leaf samples from the year 2021 were subjected to the same analyses. In the seed samples, the mean AA was approximately 2.1 mmol trolox equivalent (TE)/g DM. There was no statistical significance in AA among three years. The AA of colored genotypes (red, orange, brown color) was higher than the mean AA values of non-colored genotypes. In leaves, the mean AA reached approximately 30 mmol TE/g DM. The mean value of TPC was 25.5 mg gallic acid equivalent (GAE)/g DM in seed samples and 233 mg GAE/g DM in leaves. Statistical analysis proved statistical differences in TPC over the three years of the study with the highest mean TPC observed in the year 2020. Higher TPC may also correspond to favorable climatic conditions during the year 2020. Colored genotypes did not possess significantly higher TPC than white genotypes. The correlation between AA and TPC was not clearly determined in seeds and leaves of quinoa. It can be concluded that the examined properties varied through the growing season and/or among varieties. Nonetheless, quinoa seeds and leaves are still considered an excellent source of antioxidants and bioactive chemicals in the human diet, comparable to other pseudocereals.

Keywords:
Antioxidative activity, polyphenols, pseudocereals, quinoa

P4.2 GENETIC DIVERSITY OF GRAIN QUALITY TRAITS OF WHEAT LANDRACES FROM THE VIR COLLECTION

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Wheat landraces are populations, which can consist of several subspecies well adapted to local agro-climatic conditions. Due to the natural selection, alleles of genes for adaptability to adverse environmental factors and high grain quality have been accumulated in landrace genotypes for thousands of years. Collection of the All-Russian Institute of Plant Genetic Resources (VIR) is unique, 39% of accessions from VIR wheat collection are wheat landraces and 25% of them were included before 1940. The evaluation of the genetic diversity by the main loci associated with grain quality is important for breeding. The purpose of this study was identification SNP loci associated with grain quality traits in wheat landraces from the VIR collection. The study was conducted at Omsk State Agrarian University during 2020 and 2021 in the southern forest-steppe of Western Siberia. The material were 94 wheat landraces from different ecological and geographical groups (numbers of accessions in parenthesis): Kuban (4), Volga region (13), Central and North-Western regions of Russia (2), Ural (6), Western Siberia (19), Eastern Siberia (8), Far East (5), Kazakhstan (24) and Central Asia (13). Early, medium, and late maturing checks were also planted. Genotyping of the landrace collection using 65 KASP assays in the LGC Genomics laboratory (UK) was carried out, including grain quality traits. Higher thousand kernel weights for two years in varieties from Kazakhstan (37.4–42.9 g), as well as varieties from Saratov, Samara, Rostov, and Volgograd regions of Russian Federation (38.0–40.2 g) were noted. There were no significant differences in the accumulation of protein and gluten in grain between varieties. The varieties from Kyrgyzstan had higher values for these traits (18.8 and 35.9%, respectively). Two KASP assays for high-molecular-weight glutenin subunits (HMW-GS): *Glu-B1al* (Bx7 OE) and *Glu-D1d* were identified. The highest frequency of occurrence of *Glu-B1al* alleles in the ecological groups of accessions from Far East (80%) and Kuban (50%), for *Glu-B1al* allele in the groups of accessions from Kazakhstan (25.0%) and Central Asia (38.5%) were noted. The *Gpc-B1* gene, which determines increased grain protein content in 3 accessions from Mordovia, Novgorod region, and Kazakhstan was identified. The *TaGS-D1a* allele, associated with increased grain weight was widespread in accessions of all ecological groups. The *TaSus2-2*B gene was identified in 12.5% of samples from Kazakhstan, and the *TaGASR-A1* gene in 12.5% of accessions from Far East, and 15.4% of accessions from Central Asia. Landrace accessions with a genes pyramid for improvement of the bread making quality and grain size: Lutescens 5 (Rostov), Belozerskaya (Mordovia), (Sverdlovsk), Golokolosaya Belokoloska (Altai Territory), Tulunka (Irkutsk), Beloturka (Kazakhstan), Teremok (Kazakhstan), Chinese (Kazakhstan) and Krasnaya (Tajikistan) were selected. These accessions of landraces are recommended for creating the initial material and expanding the genetic diversity of wheat varieties on loci associated with grain quality traits.

Acknowledgments:

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Keywords:

Wheat landraces, KASP assays, grain quality traits, protein content

P4.3 TOTAL PHENOLICS AND ANTIOXIDANT ACTIVITY OF ORGANICALLY GROWN GREEK CEREAL LANDRACES

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Background: Loss of the locally adapted landraces/varieties represents a serious problem not only for the biodiversity but also for the nutraceutical's content present in modern cultivars. Thus, the aim of this study was to provide new insights into the content of phenolics and antioxidant capacity of Greek cereal landraces.

Methods: A total of 11 samples comprising five wheat (*T. durum* (2), *T. Aestivum* (1), *T. Dicoccum* (1), *T. Monococcum* (1)), two barley, one oat, one rye, one maize and one millet landraces/varieties, organically cultivated, were studied. Their flours were obtained from a certified organic producer in Greece (Antonopoulos Farm, Dilofo, Greece). Total phenolic and flavonoid content were determined in the respective flours and meals. Moreover, the antioxidant properties of the flours were determined by applying three different assays (DPPH, ABTS, and FRAP). Two commercial wheat flours of *T. Dicoccum* were used for comparative reasons.

Results: The levels ofTPC in all the wheat landraces were higher than inthe control commercial wheat flours. Among the non-wheat samples, those of barley showed the highest levels of TPC values. Different assays showed differences in the antioxidant activity of the studiedsamples. Barley landracesalways performed better.

Conclusion:The flours from wheat landraces as well as from the other cereals showed higher phenolic content and antioxidant activity compared to commercial wheat flours obtained from modern cultivars. Identification of landraces with a high amount of antioxidant compounds could provide health benefits to the consumers as well as promote their cultivation and stimulate a sustainable economy.

Keywords:
Antioxidant capacity, total phenolic content, total flavonoid content, landrace

POSTERS – TOPIC:

Grain Quality, Safety & Analytical Tools

P5.1 CHARACTERIZATION OF THE BREAD DOUGH'S BEHAVIOR DURING KNEADING BY MODELING THE POWER CURVE

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Characterization of the bread dough's behavior during kneading by modeling the power curve
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Last years, the food industry has multiplied the number of flour references used, which have different behaviors during kneading. The physical changes of the flour biopolymers that occur during this stage depend on the mechanical energy delivered to the dough by the kneader, developing the gluten network. Tracking the power curve P(t) provides an indicator of the kneading time to reach the optimum network structure, for processing and bread quality. However, the curves are difficult to handle because the usual method involves reading a dozen parameters at specific points. The objective is therefore to adjust the curve P(t) by a mathematical model to extract the characteristic parameters. The power curves obtained by mixing dough at 67% hydration on a spiral mixer for 36 wheat flours, are fitted by a Gaussian law (R^2mean=0.97). Four parameters are then extracted: the power at the end of frasing, the standard deviation of the curve SD, the time to reach the maximum power and the power of the dough during its texturation. They are correlated to those from the initial method but they better explain the variability of the kneading curves of the flours (Adjustment: 91.2%; Initial method: 82.7%). Furthermore, the extensibility capacities of the dough (L and G from the Chopin alveograph) are correlated with SD, which provides information on the tolerance of the flour to kneading. These results underline the importance of the dough extensibility during kneading.

This work was carried out within the framework of a Cifre agreement n°2020/0687 between the firm La Boulangère & Co and the research laboratory INRAE.

Keywords:
Modeling, maximum texturing power, kneading tolerance , maximum kneading time, power at the end of frasing

P5.2 IMPACT OF FLOUR MIXING ON PROLAMIN ASSEMBLIES IN THE GLUTEN BY FIELD FLOW FRACTIONATION (ASFLFFF)

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Gluten is a three-dimensional network made up of the reserve proteins (prolamins) of the cereal: glutenins and gliadins. The glutenins form the network and give the gluten its elastic properties, while the gliadins, are responsible for the viscous properties of gluten. Traditionally, these proteins insoluble in water, are extracted from solutions containing surfactants and a sonification step. This efficient extraction technique tends to denature the conformation and molar mass of the proteins. A mild extraction was implemented using a "good solvent" extraction method (water/ethanol, 50/50 v/v) allowing the extraction of prolamins with limited denaturation. Thanks to this gentle extraction coupled with force flow fractionation methods (AsFlFFF), it was possible to study the whole proteins present in the extract and to study their structures and interactions. The presence of assemblies composed mainly of glutenins and ω-gliadins in the gluten network was revealed. Moreover, Ramos et al. 2021 showed that the rheological properties of a gluten gel are influenced by the content of assemblies present in the gel. To better understand the dynamics around these assemblies, different prolamin extracts from flour and gluten were studied. The first AsFlFFF analyses show differences in profiles depending on the source of the prolamin, with notably a lower population of assemblies for flour proteins than for gluten proteins. This difference in population can be explained by the mixing of the dough during the production of the gluten. Based on these results, the flours were mixed at different times to measure the impact of mixing. Thus, the fractograms obtained in AsFlFFF show a correlation between the rate of assemblies and the dough mixing time. Indeed, the proportion of assemblies increases when the mixing time is longer.

Moreover, the content of assemblies is different according to the variety of flours used. According to the variety, the amount of assemblies can be 2 times greater, this important difference is explained by the proportion of glutenin in the extracts. Indeed, there seems to be a close relationship between the amount of assemblies and glutenins in the extract which is dependent on the flour.

Thanks to AsFlFFF coupled to MALS, it is possible to study the conformations of the objects without deformations. It was also possible to show that the assemblies are spherical objects whose conformation does not seem to be affected by mixing. These results suggest that the assemblies are in equilibrium in the solvent.

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Keywords:
Proteins, Assemblies, Field Flow Fractionation, Wheat, Gluten

P5.3 SEPARATION OF WHEAT PROTEINS ON A FRIT INLET ASYMMETRICAL FLOW FIELD FLOW FRACTIONATION SYSTEM (AF4)

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AF_4 [1] is a sub-technique widely used of Field Flow Fractionation (FFF) that separates molecules based on their size from 1nm to 50µm. Although each FFF techniques has its own specificity, they are all based on the same principle: an external force perpendicular to the flow of the channel is applied in order to fractionate all analytes. Moreover, particles are pushed towards the channel wall and a balance between the perpendicular force field and the Brownian diffusion of the molecules allows to the small molecules to move away from the channel wall and elute faster than the larger molecules.

Food sector is the leading consumer of wheat, with segmented products and consumption patterns that meet specific requirements in terms of quantity and quality. Facing to this development, progress in characterization is essential and the use of common analytical instruments is necessary for the better understanding of protein composition in wheat.

With this work, our objective was to answer to the following questions: Is AF_4 able to give the protein composition of wheat samples? What type of information can it provide in addition to the SE-HPLC analysis ?

In a first time, analyses of wheat samples were carried out by normal AF_4. But we observed that wheat proteins were very sensitive to shear, leading to steric elution that was incompatible with AF_4 analysis. Steric elution[2] is a phenomenon leading to a reversal of the normal mode of elution of the sample and leading to co-elution of particles of different sizes in the steric transition region. This results in a loss of information to determine the size of total protein samples.

In a second time, our studies explore the use of a Frit-Inlet [3], [4] channel. In classical AF_4, the fractionation consists of two steps: focus and injection. In the focus stage, the perpendicular flow keeps the samples at the top of the channel allowing them to reach an equilibrium state. But this focusing step may cause aggregation of the components and hide the native state of the proteins. Frit-Inlet, has a channel design modified from AF4 by introducing a small inlet frit at the beginning end of the depletion wall so that sample relaxation can be made hydrodynamically by the use of the compressing action of the frit flow entering through the small inlet frit. Components are separated according to their size by their diffusion coefficient. Quantitative detector is UV (214nm) and MALS is used to determine molecular weight, size and conformation and we show in this work, that Frit-Inlet AF4 does not produce any artefact and is a preferred FFF method for the separation of wheat proteins.

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Keywords:
AF4, SE-HPLC, Frit-Inlet, wheat proteins, high molecular weight

P5.4 PROFILING ANALYSIS OF FUNCTIONAL COMPONENTS IN RICE

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In addition to essential nutrients, phytochemicals in cereals have attracted consumers' attention by increasing health awareness. This study explores the phytochemical profiles in six rice varieties using ultra-performance liquid chromatography-electrospray tandem mass spectrometry (UHPLC-DAD-HRMS) to compare brown with polished rice samples. Bran and germ are richer in phospholipids, sphingolipids, phytosterols, tocols, and polyphenols than endosperm. The content of phospholipids was in the range of 0.67 ~ 4.54 mg/g, and phosphatidylcholine was the major component in brown rice. Lignocerate (24:0) sphingosine was the major ceramide component accounting for 16 ~ 32% of sphingolipids (0.41 ~ 1.33 mg/g) in brown rice. Cycloartenyl ferulate, known as γ-oryzanol, was the major steryl ferulate phytosterol (135.83 ~ 262.02 μg/g). The brown rice samples also contained a similar amount of β-sitosterol in their free form (205.21 ~ 262.66 μg/g). The contents of α-tocomonoenol (10.34 ~ 27.86 μg/g) and γ-tocotrienol (11.41 ~ 18.06 μg/g) were higher than the content of α-tocopherol (8.45 ~ 12.61 μg/g) in brown rice samples. Brown rice contained a minuscule amount of phenolic acids (trace ~ 3.23 μg/g), and the *p*-coumaric acid was the major component. The sugar composition profile of soluble dietary fiber was also conducted to understand the properties of the major prebiotics of rice. The contents of mentioned phytochemicals in polished rice samples were significantly lower than the brown rice. This study provides information for brown rice quality control of functional components and supports promoting whole-grain consumption for health.

P5.5 ROLE OF ENVIRONMENTAL CONDITIONS AND GENOTYPES ON QUALITATIVE TRAITS OF RYE IN MARGINAL ALPINE ENVIRONMENTS

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Rye (*Secale cereale* L.) is a minor cereal crop cultivated for centuries in mountainous areas, due to its stronger adaptation to unfavourable environmental conditions compared to other cereals. Rye landraces have recently drawn researchers' attention being a potential source of several disease resistance genes and genetic variability in response to stresses such as low temperatures, drought, and low fertility. In addition, the high nutritional value of the grains makes rye a valuable raw material to produce functional ingredients and value-added baked goods, having low glycaemic index and high content in health-related substances. The aim of the present contribution was to investigate the influence of environmental conditions and genotype on the content of several bioactive compounds and antioxidant capacity of whole-meal rye flours, considering also agronomic traits, sanitary risks, and rheological parameters. During 2019-20, seven local rye landraces, sampled from the Alps in North-West Italy, were grown in two different environments (at 450 and 900 m a.s.l., hilly and mountainous site, respectively) and were compared with two commercial rye cultivars and one bread wheat.

Grain yield was found to be significantly higher in the commercial rye varieties, followed by wheat and rye landraces. The latter ones were characterized by a lower protein content than wheat, but greater compared to the commercial ryes. The field trial at 450 m a.s.l. showed a significant higher grain yield but lower protein content when compared to the field at 900 m. Both landraces and commercial ryes were found to be subjected to the ergot disease. Regarding chemical traits, the β-glucan content was found to be significantly higher in all rye genotypes compared to wheat. Growing environment had a significant effect on soluble phenolic acids, whose content was higher in the sample collected in the hilly site than the mountainous one. Antioxidant capacity, measured by ABTS and FRAP assays, was significantly higher in rye genotypes than wheat for both experiments, and a significant benefit was confirmed in bread loafs made with the substitution of 40% of whole-meal rye flour. However, bread volumes were significantly affected by rye flour addition compared to the wheat control. The substitution led to an increase in the a* (redness) and a reduction of L* (brightness) value. As far as the rheological parameters are concerned, whole-meal rye flours were characterized by lower dough development time and stability than mixed flours made by whole-meal rye and wheat.

In conclusion, rye varieties were characterised by a higher content of antioxidant compounds in comparison with the wheat control, particularly rich of fibres, β-glucans, and soluble phenolic acids, which give a significant potential to rye genotypes for health promoting effects. However, a challenge with rye-based foods is making them attractive and widely accepted to consumers, overcoming the poor baking quality and protein content of the grains. The development of innovative processing tools, combined with crop breeding, based also on the local landrace variability, is crucial to develop high value supply chains for marginal environments, enhance the health benefits of rye and reach new consumers.

Keywords:
Rye, alpine landraces, ergot disease, bioactive compounds, technological quality

P5.6 CEREAL HUSKS: VERSATILE ROLES IN GRAIN QUALITY AND SEEDLING PERFORMANCE

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Cereals possess a one seeded fruit, whereby the seed coat and the fruit coat are fused together generating the caryopsis. This caryopsis may be covered by floral bracts to generate two types of DUs, namely florets, whereby the caryopsis is enclosed by the lemma and the palea (e.g., *Avena sterilis*) or spikelet, whereby the floret(s) is further covered by the glumes (*Triticum turgidum var dicoccoides*). Here, we highlight the dead coverings enclosing the caryopsis in cereals, namely, the husks as an integral component of the dispersal unit that play multifaceted roles in grain biology. Thus, besides protection and dispersal means, husks function as a refined maternal supply of proteins and metabolites for enhancing growth and development, combating potential pathogens as well as conferring tolerance to abiotic stresses. These attributes might have broad implications to crop performance, plant population dynamics and diversity in ecological systems, as well as to conservation of genetic resources in seed banks.

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Keywords:
Cereal dispersal unit; husk; dead organs enclosing embryo (DOEE); caryopsis; proteome; allelopathy; seed germination; seedling performance; ex situ conservation; seed banks; non-genetic maternal supply

P5.7 EFFECT OF TIMINGS AND CHEMICAL COMPOSITION OF PESTICIDES ON RESIDUE CONTENT IN SOYBEANS AND CHICKPEAS.

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In recent years, the consumption of plant-derived protein products has led to an increase of legume cultivation to obtain ingredients for food sector. Moreover, consumers require safer sanitary standards, with particular attention to pesticides. As for cereals, on soybeans and chickpeas there is a great interest to verify contamination risk, by the most common phytosanitary products, to define cultivation regulations with low contamination risk [1].

Specifically, food industries want to reach the zero-residue level (< 0.01 mg/kg) for phytosanitary products [2][3]. The purpose of this study was to determine the residue level of different pesticides, e.g. herbicides, fungicides, insecticides, in soybean and chickpea grains, as affected by active ingredients and timing of application. In 2021-22 growing season, field trials have been set up in North West Italy by cultivating chickpea (cv. Gavdos) and soybean (cv. PR91M10), also considering different timing of sowing. Herbicide application for both crops referred to the main available pre-emergence and post-emergence herbicide mixtures, applied at label rate. Fungicides and insecticides, differing for chemical classes, have been applied from flowering to the end or ripening, at different growth stages. After the harvest, 200 g of whole grains have been analyzed with a multimethod for the determination of pesticide residues using GC- and LC-based analysis following acetonitrile extraction/partitioning and clean-up by dispersive SPE - Modular QuEChERS-method (UNI EN 15662:2018).

Results showed the absence of herbicide residues in grains of both crops for all the active ingredients compared (a.i. aclonifen, clomazone, metribuzin, piridate, pendimentalin, s-metolaclor applied in pre-emergence and aclonifen, bentazone, imazamox, piridate, propaquizafop in post-emergence). On the contrary, a significant different concentration of fungicides and insecticides was reported according to the active ingredient and the timing of application considered. Regarding strobilurins, azoxystrobin has been detected for chickpea (0.047 mg/kg > residue zero) and soybean (0.024 mg/kg > zero residue), whereas pyraclostrobin has never been found. Boscalid residues were found on chickpea (0.002 mg/kg < zero residue) and soybean (0.048 > zero residue). Triazoles were present only on soybean: epoxiconazole (0.027 mg/kg > zero residue) and tebuconazole (0.026 mg/kg > zero residue). Regarding insecticides, lambda-cyalothrin has never been found, but acetamiprid was present on chickpea (0.023 mg/kg > zero residue) and soybean (0.023 mg/kg > zero residue). Concerning soybean, acetamiprid passed the maximum residue level (0.01 mg/kg) imposed by European Union. For both crops, timings of application closer to harvest (pod formation for soybean and seed filling for chickpea) increased the presence of residues on grains. The experiment evidenced that grain contamination risk depends firstly on the chemical class of active substance and secondly on the timing of application. These aspects represent the starting points for the achievement of a zero risk contamination disciplinary for legume cultivation, intended for food use. Moreover, the less impacting products can be considered in the sustainable approach suggested by F2F program.

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P5.8 DIASTATIC RYE MALT IMPACT ON DIFFERENT QUALITY RYE FLOUR ENZYMATIC AND RHEOLOGICAL PROPERTIES

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Rye is significantly exposed to growing conditions as well as climate change. At present, both the development of grain varieties and climate change have resulted in rye yields with high FN and maximum viscosity (Oest et al., 2020, Bushuk, 2017). This further affects the baking property and fermentation capacity of the dough. Due to the high activity of enzymes, especially alpha-amylase, rye diastatic malt additives balances the quality of rye flour and ensure the formation of sugars (Vasyukova et al., 2020, Hrušková et al., 2018). It is of particular importance in the preparation of bread using technologies that include flour scalding, pregelatinization and medium and long fermentation times. Three samples of rye flour with different enzymatic activity were used (FN 160, 296, 336). Rye malt samples with diastatic power (DP) 120, 303 and 459 were used, malt was added in different amounts (0.5, 1, 1.5%). The flour - malt mix was determined by FN, rheological properties (Amylograph), enzymatic activity (alpha, beta amylase). The obtained results show that all added malt of different activity significantly affects the falling number of rye flour correspondingly reducing FN and increasing enzymatic activity. When analyzing alpha-amylase activity in flour samples with different FN, the alpha-amylase activity was in the range of 0.09 - 0.19 (CU)/g, while the addition of 1% different malt increased the activity by 0.19 - 0.38 (CU)/g depending on the DP of the added malt. Comparing between malt with different activity and different addition concentration, adding less active malt (DP120) 1.5% can achieve a similar effect as adding more active malt (DP303, DP459) 0.5%. A set of different quality indicators is important for stabilizing quality. Using rye diastatic malt, it is possible to adjust the quality of rye flour.

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Keywords:
Alpha-amylase, beta-amylase, sugars, falling number

P5.9 DEVELOPMENT OF SMALL-SCALE BAKING TEST FOR IMPROVING THE QUALITY OF MINOR CEREAL BASED BAKERY PRODUCTS

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The utilization of minor cereals, like rye and oat, in the bakery products brings technological challenges, since a viscoelastic gluten-like protein network similar to wheat is less or not able to form in these dough matrices. However, the methodology for determining the technological quality is less developed than in case of wheat. Properly applied methods are essential to reveal the technological properties and end product quality of raw materials and to understand the macromolecular effects behind them. The aim of our research is to develop routinely applicable baking trials with good repeatability and reproducibility, based on the methods already available for wheat and partly for rye. Further aim is to characterize the baking quality of minor cereal varieties and milling fractions using different types of dough fermentation and to understand the effects of different technological processes on the investigated parameters.

The chemical composition of the selected rye and oat varieties, and special rye flours produced by industrial fractionation were measured by standard methods (ISO, AOAC). The rheological properties were determined by instuments routinely used in wheat quality testing (Mixolab, farinograph, rapid viscoanalyzer). The baking trials were carried out in small-scale following the logic of previously developed methods related to wheat. Short fermentation process with baker's yeast, and long sourdough fermentation process were applied. After getting a better insight of the pasting properties of the flours and doughs, the applied methods needed to be optimized, since the different cereal species showed various baking behaviours. Our results showed that after optimization, the differences can be detected between varieties regarding baking parameters, like specific volume and crumb texture. The investigation of factors influencing quality, such as variety and carbohydrate composition can be deduced for each cereal species, and the effects of different technological operations, such as heat treatment and fractionation can be determined. According to the results, chemical composition and rheological behaviour highly influence the baking quality, and samples with both higher nutritional value and more acceptable technological behaviour can be identified. In the future, the molecular background of the pasting and baking properties will be investigated for getting a deeper insight of the role of the macromolecules, especially the non-starch carbohydrates. The effects of sourdough fermentation will be also investigated further, since sourdough brings several new prospects in product development. Our work is connecting to the goals of the BME – Biotechnology TKP grant of EMMI and is supported by the "GalgaGabona" project (2017-1.3.1-VKE-2017-00004). This work is also connected to the work from COST Action 18101 SOURDOMICS.

Keywords:
Oat, rye, bread, method development, baking quality

P5.10 IMPROVEMENT OF QUICK WHEAT QUALITY ASSESSMENT BY COMBINING RAMAN, FLUORESCENCE, AND NEAR-INFRARED SPECTROSCOPY

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Along the wheat value chain quick quality assessment is mainly based on protein content due to its simple determination based on near-infraread spectroscopy. Especially at grain intake in wheat mills and wheat trade rapid quality determination of bread wheat is crucial. The disadvantage of this established method is the low correlation between protein content and the baking behavior as well as dough properties. Instead of predicting only protein content, this research aims to predict dough properties and baking behavior directly by combining complementary information from near-infrared, Raman and fluorescence spectroscopy. Several proven data preprocessing and regression algorithms were evaluated, including partial least-squares regression (PLSR) and genetic algorithm (GA).

A highly diverse sample set of 415 wheat samples from a wheat hybrid breeding program was analyzed as whole grain, whole grain flour, and extracted flour. Protein content, wet gluten, loaf volume, water uptake and the extensograph parameters resistance to extension, extensibility, ratio number and energy were selected as quality parameters. The linear correlations R^2 between protein content and other quality parameters were lower than 0.5 except for wet gluten (0.83) which makes the sample set ideal for assessing wheat quality independent of the protein content. The best predictive models yielded a 10-fold cross-validated coefficient of determination $^{R^2}$ of 0.973, 0.873, 0.774 and 0.835 for protein content, wet gluten, loaf volume and water uptake.

The prediction accuracies are well suited for screening purposes in wheat breeding and allow better quality assessment compared to protein content along wheat supply chains.

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Keywords:
Data fusion, prediction, spectroscopy, wheat quality

P5.11 CONTENT AND INHIBITORY POTENTIAL OF WHEAT AMYLASE-TRYPSIN INHIBITORS AS PUTATIVE TRIGGERS OF WHEAT-RELATED DISEASES

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Although wheat is one of the most important crops in the human diet, its consumption can be linked to several adverse reactions, including celiac disease, wheat allergy, and non-celiac wheat sensitivity. In addition to gluten proteins, which are considered to be the dominant triggers of these wheat-related diseases (WRDs), a group of non-gluten wheat proteins called amylase-trypsin inhibitors (ATIs) has been identified to be involved in the clinical pathogenesis of WRDs [1]. As their name implies, ATIs are able to inhibit the enzymatic activity of human and mammal amylase and trypsin leading to incomplete digestion of starch and proteins which can cause gastrointestinal symptoms such as gas production, abdominal pain and bloating [2]. To study this protein class in detail, this study comprises the quantification of ATI contents by RP-HPLC as well as the determination of *in vitro* inhibitory activities in modern wheat (*Triticum aestivum*) samples according to recently published methods [2,3]. In addition, individual samples were blended to form a sample mix that was used to validate the methods. This study revealed that ATI levels and their inhibitory potential against amylase and/or trypsin are not correlated. Consequently, both ATI concentrations and inhibitory activities need to be evaluated to help understand their role in wheat sensitivities.

POSTERS – TOPIC:

Market Trends

P6.1 THE ROLE OF CEREALS IN THE INDUSTRY OF PLANT-BASED FOODS

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Current trends in human feeding promote a more plant-based diet, for several reasons (Estell et al., 2021). Ethical and environmental concerns are among the most common reasons why people chose to avoid animal-based products (Alcorta et al., 2021; Beacom et al., 2021). Also, there is an increasing perception that the excessive consumption of animal-based products is associated with higher risk of developing chronic diseases (Papier et al., 2021). Thus, the demand for innovative and sustainable plant-based solutions is increasing exponentially. Such products must meet not only the nutritional requirements for a healthy diet but also be widely acceptable by the consumers in terms of flavour and texture, while being produced in an environmental-friendly manner and with the least possible industrial manipulations (Food and Agriculture Organization of the United Nations, 2016). Several plant bases can be used based on their specific characteristics, nutritional and sensorial advantages, and possible applications. They are currently employed as substituents of animal-based products and can be grouped mainly into four distinct groups: cereals, legumes, nuts, and tubers. In particular, cereal grains are a major constituent of human diets around the world. Amongst the most consumed cereals, wheat, rice and maize are the most widely used. Other cereals and pseudo-cereals of interest include oat, millets, sorghum and spelt (Rosentrater & Evers, 2018). Cereal grains are a major source of plant-based protein in the human diet, being only surpassed by the legumes in terms of protein content, when considering their proximate composition (Ibrahim et al., 2020; Taylor & Duodu, 2017). The main protein reservoir in cereals are the storage proteins, mainly present in the seeds. Cereals are also key contributors to increase the dietary energy, mainly through the digestion of starch as well as a good source of fibers, vitamins and minerals (Wrigley, 2015). In addition, cereals also contain other bioactive compounds in their composition, such as polyphenols, antioxidants, vitamins, and minerals, including calcium, magnesium, zinc and iron (Zhou et al., 2012). Indeed, the consumption of cereal-based food – mainly whole grain cereals – has been associated with ameliorated conditions in certain diseases, including type 2 diabetes, cardiovascular diseases and certain types of cancer (Montonen et al., 2003; Revilla et al., 2009).

Herein, we intend to provide a perspective on the characterization of relevant cereal-based alternatives (oat, rice, spelt, sorghum, millet cereal bases prepared in collaboration with Frulact S.A, Portugal in comparison with other plant bases in the market, highlighting the main nutritional (protein, fat, carbohydrate, fibre and ash contents determined via AOAC methods) and sensorial advantages of each and possible applications. The technological challenges and innovative strategies that are currently employed to produce cereal-based food products were identified and will be discussed, with emphasis in the quality and safety of the final products. Finally, examples of industrial applications, collected within a market study with collection of data from the MintelÒ Database, will be provided in the several categories of cereal-based food analogues.

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Keywords:
Cereals, food innovation, food market trends, nutrition, plant

POSTER – TOPIC:

Other

P7.1 ASSESSING THE ROPE SPOILAGE POTENTIAL OF BACILLUS SPP. IN BREAD

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Increasing consumer demand for preservative-free bread, as well as global warming give rise to the spoilage phenomenon of ropy bread. This kind of bread spoilage is characterized by sticky and stringy degradation of the bread crumb, slime formation, discoloration, and an odor reminiscent of rotting fruit. Several Bacillus species have been associated with ropiness. Nevertheless, the underlying mechanisms behind ropy bread spoilage remain unclear and systematic approaches allowing the characterization and quantification of rope formation are lacking. The aim of this study was to assess the rope forming potential of Bacillus strains based on a comprehensive screening protocol. Physiochemical spoilage characteristics were quantified combining color measurement and dynamic changes in bread texture properties. To that end, six type strains, namely Bacillus subtilis, B. inaquosorum, B. spizizenii, , B. licheniformis, B. sonorensis and B. pumilus from international culture collections, as well as four B. subtilis isolates from food processing environments were selected and their identity confirmed by 16S rDNA and gyrA gene sequencing. Rope formation was examined by an experimental setup, in which bread slices were inoculated with Bacillus spores and physiochemical properties were assessed. Further, amylase formation of the selected strains was established. In addition, the four Bacillus isolates from food processing environments were used for baking tests of inoculated doughs. The baked loaves were also examined using color and texture analysis. The results of this research revealed strain-specific effects on bread properties. The findings of this study highlight the necessity of a uniform procedure to assess the rope forming potential of Bacillus spp. in order to support high quality bread production and prevent food waste.

Keywords:
Bacillus, bread quality, rope spoilage

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