

# BOOK OF ABSTRACTS



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**LINCOLN UNIVERSITY**  
TE WHARE WĀNAKA O AORAKI



INTERNATIONAL ASSOCIATION FOR  
CEREAL SCIENCE AND TECHNOLOGY

Published by ICC – International Association for Cereal Science and Technology

Stubenring 12, 1010 Vienna, Austria

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# 16<sup>th</sup> ICC Cereal and Bread Congress

Online Conference

## BOOK OF ABSTRACTS

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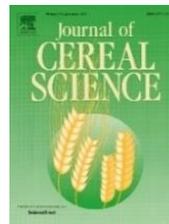
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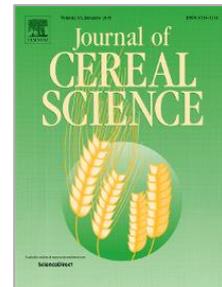
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In partnership with the Online ICBC2021, **The Journal of Cereal Science, published by Elsevier** will be sponsoring 2 ICC Awards for innovative or exceptional work in cereal research. The awardees will be selected from the poster submissions. This support will be in the form of two awards of 500. - EUR each for student or postdoctoral researchers and is aiming at encouraging cereal research. An independent jury will examine posters presented during the congress and will select the awardees. The awards will be presented during the Closing Ceremony of the Online ICBC2021.



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The 16<sup>th</sup> ICBC conference will be held online for the first time and is continuing the established ICC event series.

This cosmopolitan mix of ICBC gathers stakeholders with the comfort of your own home to discuss and share knowledge on the challenges and opportunities facing the cereal science and technology community; to benefit from a network carousel with smart matchmaking, to have 1-on-1 meetings with peers and to explore in a dedicated area for exhibitors and sponsors latest equipment and food trends.

Themes for the conference include:

- Cereal nutrition for health-conscious consumers
- Food safety and security
- Sustainable agricultural technology systems
- Milling and bread making technology
- Novel processing techniques for extrusion and biscuit making
- Noodle quality and acceptability
- Wholegrains, their definition and utilisation in foods
- Molecular approaches to grain breeding
- Global supply chain and trade
- Alternative grain crops
- Analytical methods for quality determination
- Consumer perception of grain-based foods

I hope to meet and talk to as many colleagues and collaborators as I can during the Online ICBC2021!  
On behalf of the Scientific and Organising Committees

Charles Brennan  
Lincoln University

Michaela Pichler  
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# Table of Content

Scientific Committee .....	4
Organising Committee.....	5
Best Poster Award .....	6
Welcome Message .....	7
Table of Content.....	9
<b>ORAL PRESENTATIONS .....</b>	<b>18</b>
<b>Opening Session .....</b>	<b>19</b>
Keynote lectures.....	19
O.01 PREHARVEST SPROUTING: ABOUT FALLING NUMBERS, WHEAT KERNELS AND BAKING QUALITY	20
O.02 DELIVERING HEALTH BENEFITS WITH BAKERY PRODUCTS .....	21
<b>Session 1 .....</b>	<b>22</b>
Cereal Nutrition I.....	22
O.03 EFFECT OF SOLUBLE DIETARY FIBRES ON VISCOELASTIC PROPERTIES OF DURUM WHEAT DOUGH, PASTA-MAKING PERFORMANCE AND GLYCAEMIC RESPONSE OF PASTA.....	23
O.04 EXTENDING STARCH APPLICATIONS AS ABSORPTIVE POLYMER: FROM PRODUCTION TO FUNCTIONAL ROLE. ....	24
O.05 EFFECTS OF SPECIES, BREEDING AND ENVIRONMENTAL CONDITIONS ON ESSENTIAL WHEAT PROTEINS .....	25
O.06 FOOD ORAL PROCESSING BY THE ELDERLY FOR THE DEVELOPMENT OF SOFT CEREAL FOODS FORTIFIED WITH PROTEINS .....	26
<b>Session 2 .....</b>	<b>27</b>
Analytical Methods for Quality Determination.....	27
O.07 A MULTI-SPECTROSCOPIC APPROACH TO STUDY MOLECULAR INTERACTIONS DURING BREAD DOUGH MIXING.....	28
O.08 IMPROVED EVALUATION OF WHEAT DOUGH QUALITY THROUGH ALVEOGRAPH'S PROTOCOL ADAPTATION .....	29
O.09 PERFORMANCE OF THE NEW GLUTOMATIC SYSTEM .....	30
<b>Session 3 .....</b>	<b>31</b>

Alternative Grain Crops I .....	31
O.10 WHY DO SO MANY CONSUMERS PURCHASE "GLUTEN FREE" PRODUCTS? .....	32
O.11 COMBINE WHEAT AND LEGUMES, FROM THE FIELD TO SOFT CAKES: HOW TO MANAGE RAW MATERIAL VARIABILITY USING PROCESS MODIFICATION FOR PRODUCING CAKES OF CONSTANT QUALITY.....	33
O.12 GLUTEN FREE SYSTEMS: WHY WATER PLAYS A MAJOR ROLE .....	34
<b>Session 4 .....</b>	<b>35</b>
Cereal Nutrition II .....	35
O.13 IMPACT OF FOOD ORAL PROCESSING ON THE DIGESTION OF CARBOHYDRATE-RICH FOODS .....	36
O.14 ENHANCING THE NUTRITIONAL PROFILE OF CEREAL GRAINS .....	37
O.15 EFFECTS OF ADLAY SEED (COIX LACHRYMA-JOBI L.) EXTRACTS ON NONALCOHOLIC FATTY LIVER DISEASE AND METABOLIC DYSFUNCTION IN DIET-INDUCED OBESE MICE.....	38
<b>Session 5 .....</b>	<b>39</b>
Milling & Bread Making Technology I.....	39
O.16 STUDY ON THE QUALITY CHARACTERISTICS AND APPLICABILITY OF WHEAT FROM KAZAKHSTAN ON CHINESE TRADITIONAL STAPLE FOOD .....	40
O.17 GLUTEN PROTEIN RESPONSE TO HEAT AND DROUGHT STRESS IN DURUM WHEAT .....	41
O.18 BREAD DOUGH RHEOLOGY – MEASURING IT TO CONTROL THE END PRODUCT QUALITY .....	42
<b>Session 6 .....</b>	<b>43</b>
Food Safety, Security & Breeding.....	43
O.19 TRANSGENIC WHEAT WITH ELEVATED ENDOSPERM TRIGLYCERIDE LIPID - EFFECTS ON GRAIN COMPOSITION AND BAKING .....	44
O.20 ACCUMULATION AND DISTRIBUTION OF EMERGING CONTAMINANT ELEMENTS (GA, IN, AS AND CD) IN RICE .....	45
O.21 DEVELOPMENT, CHARACTERIZATION AND GENETIC STUDIES ON HIGH-FIBRE WHEAT LINES .....	46
O.22 ENHANCING IPM APPROACHES IN THE UK .....	47
O.23 EARLY WARNING DIGITAL SERVICE FOR CONTROLLING THE RISK OF MYCOTOXINS IN CEREALS .....	48
<b>Session 7 .....</b>	<b>49</b>
Alternative Grain Crops II .....	49

O.24 RE-DISCOVERING ANDEAN ‘SUPERFOODS’: QUINOA, KAÑIWA, KIWICHA AND TARWI .....	50
O.25 IN SITU PRODUCED DEXTRAN AS FLAVOUR AND TEXTURE MODIFIER OF SORGHUM OR FABA BEAN ENRICHED WHEAT BREAD .....	51
<b>Session 8 .....</b>	<b>52</b>
Milling and Bread Making Technology II.....	52
O.26 MECHANISM OF ENDO-XYLANASE ACTION ON WHEAT MILLING PRODUCTS UNDER VARIABLE SOLID LOADINGS CONDITIONS.....	53
O.27 EXPLORING DRY GRAIN FRACTIONATION AS A MEANS TO FINDING VALUE OPPORTUNITIES FOR BARLEY CONSTITUENTS.....	54
O.28 THE ROLE OF WHEAT ENDOGENOUS LIPIDS AND THEIR ENZYMATICALLY RELEASED HYDROLYSIS PRODUCTS IN BREAD MAKING .....	55
<b>Session 9 .....</b>	<b>56</b>
Whole Grains.....	56
O.29 WHOLE GRAIN FOOD DEFINITIONS– ARE WE REACHING A CONSENSUS?.....	57
O.30 GROWING THE BUSINESS OF WHOLE GRAIN IN THE AUSTRALIAN MARKET: 6 YEAR IMPACT ASSESSMENT .....	58
O.31 WHOLEGRAIN PARTICLE SIZE AND POSTPRANDIAL GLYCAEMIA IN TYPE 2 DIABETES: A RANDOMISED CROSSOVER STUDY OF WHOLEGRAIN BREADS.....	59
<b>Session 10 .....</b>	<b>60</b>
Noodle Quality .....	60
O.32 NOODLE QUALITY: A MOLECULAR APPROACH .....	61
O.33 UNVEILING THE IMPACT OF PROTEIN QUANTITY AND QUALITY ON TEXTURAL PROPERTIES OF COOKED PASTA.....	62
O.34 MICROBES, BIOACTIVE COMPOUNDS, QUALITY CHARACTERISTICS, AND STRUCTURAL CHANGES DURING STORAGE OF FRESH QINGKE BARLEY NOODLES .....	63
O.35 COOKING PROPERTIES OF ORIENTAL NOODLES CONTAINING HEAT-MOISTURE TREATED STARCH .....	64
<b>Session 11 .....</b>	<b>65</b>
Cereal Nutrition III .....	65
O.036 UTILIZATION OF RESISTANT STARCH TYPE 4 IN BREAD – EFFECTS ON PHYSICAL AND NUTRITIONAL PROPERTIES.....	66

O.37 EFFECT OF BAKING ON THE $\alpha$ -AMYLASE AND $\alpha$ -GLUCOSIDASE INHIBITION OF DJULIS .....	67
O.38 EFFECTS OF CHICKPEA (CICER ARIETINUM) ON METABOLIC DYSFUNCTION BY MODULATION OF GUT MICROBIOTA IN DIET-INDUCED OBESE MICE .....	68
<b>Session 12 .....</b>	<b>69</b>
Milling & Bread Making Technology III .....	69
O.39 THE WHEAT FLOUR/YEAST-BACTERIA MICROBIOME INTERFACE IN BREAD MAKING TO MODIFY THE AROMA, CRUMB, NUTRITIONAL AND SENSORY PROPERTIES OF BREAD .....	70
O.40 IMPACT OF ACIDITY IN LEMON CAKE ON BAKING POWDER REACTIVITY AND FINAL VOLUME ....	71
O.41 CHARACTERIZATION OF ZEIN-LUPIN PROTEIN DOUGH MADE BY COACERVATION FROM ETHANOL OR DILUTE ACETIC ACID PLUS HAND KNEADING AND SHEETING .....	72
<b>Session 13 .....</b>	<b>73</b>
Milling & Bread Making Technology IV.....	73
O.42 ENZYMATIC APPROACH TO ALTERING STARCH FUNCTIONALITY.....	74
O.43 THE BALANCE BETWEEN OVEN RISE AND STRUCTURE SETTING IN POUND CAKE MAKING .....	75
O.44 IMPACT OF WHOLE CEREAL EXTRUDED FLOURS IN GLUTEN-FREE BREAD MAKING .....	76
<b>POSTER PRESENTATIONS .....</b>	<b>77</b>
<b>1. Cereal Nutrition .....</b>	<b>78</b>
P-1.1 IS PROLONGED FERMENTATION DURING BREADMAKING EFFECTIVE IN REDUCING FRUCTANS THAT CAN CAUSE ABDOMINAL DISCOMFORT IN IBS PATIENTS? .....	79
P-1.2 EFFECTS OF ADLAY (COIX LACHRYMAL-JOBI L. VAR. MA-YUEN STAPF.) FORMULA ON DYSMENORRHEA.....	80
P-1.3 BIOMARKERS FOR WHOLEGRAIN CEREAL INTAKE – OVERVIEW AND APPLICATIONS .....	81
P-1.4 LEMON CAKE REDUCED IN SUGAR AND REMOVAL OF BAKING POWDERS.....	82
P-1.5 SUBSTITUTION OF BAKING POWDERS IN A POUND CAKE BY MIXING UNDER CO <sub>2</sub> PRESSURE ....	83
P-1.6 A HEALTHY CHOICE: COLOR WHEAT OVER WHITE WHEAT .....	84
P-1.7 CONCENTRATION OF AVENATHRAMIDES IN VARIOUS OAT FOOD PRODUCTS .....	85
P-1.8 THE GLYCEMIC INDEX OF RICE-PULSES NOODLES.....	86
P-1.9 LOWER STARCH DIGESTIBILITY IN WHITE WHEAT BREAD SUPPLEMENTED WITH MALTOGENIC AMYLASE .....	87

P-1.10 MARKETED INSECT-BASED-PASTA, WHAT IS THE CURRENT STATE? A NUTRITIONAL AND TECHNOLOGICAL STUDY.....	88
P-1.11 IMPACT OF ADDITION OF AYOCOTE BEAN (PHASEOLUS COCCINEUS) AND BLACK BEAN (PHASEOLUS VULGARIS) FLOURS IN BREAD MAKING: NUTRITIONAL AND QUALITY EVALUATION .....	89
P-1.12 IN VITRO STARCH DIGESTION: CHALLENGES WHEN SETTING UP CONDITIONS .....	90
P-1.13 HIGH-QUALITY GLUTEN-FREE SPONGE CAKE WITHOUT SUGAR: THE EFFECT OF NATURAL SWEETENERS ON TECHNOLOGICAL QUALITY AND NUTRITIONAL VALUE .....	91
P-1.14 EVALUATION OF PHYSICOCHEMICAL, TEXTURAL AND GLYCAEMIC PROPERTIES OF EXTRUDED CORN SNACKS ENRICHED WITH RICE BRAN .....	92
P-1.15 EFFECTS OF PROCESSING CONDITIONS ON THE FODMAP CONTENTS OF COMMON WHEAT AND RYE BREADS.....	93
P-1.16 SUBSTITUTION OF SUCROSE BY BRAN IN FINE BAKERY PRODUCTS - POSSIBILITIES AND LIMITS .....	94
P-1.17 EVALUATION OF SOURDOUGH-RELATED LACTIC ACID BACTERIA TO DEGRADE AMYLASE-TRYPSIN INHIBITORS AND GLUTEN.....	95
P-1.18 VARIATION ON WHEAT GLUTEN FRACTIONS AND ON THE EXPRESSION OF TOXIC SEQUENCES FOR GLUTEN DISORDERS, IN TRITORDEUM IN COMPARISON WITH DIFFERENT WHEAT VARIETIES ....	96
P-1.20 INFLUENCE OF TEMPERATURE IN THE PHYSICAL MODIFICATION OF RICE FLOUR ACHIEVED BY LOW-FREQUENCY ULTRASOUND TREATMENT.....	99
P-1.21 CANADIAN HULLESS BARLEY VARIETIES ARE A SOURCE OF BIOACCESSIBLE PHENOLIC COMPOUNDS .....	100
P-1.22 IMPACT OF COOKING DURATION ON CAROTENOID ISOMER CONTENT IN PASTA PREPARED FROM THREE DURUM WHEAT CULTIVARS.....	101
P-1.23 HYDROXYCINNAMIC ACID AMIDES PRESENT IN BROA, A TRADITIONAL ETHNIC MAIZE BREAD .....	102
P-1.24 EFFECT OF BREADS ELABORATED WITH HEALTHY FORMULATIONS (WHOLE MEAL AND REDUCED SODIUM) ON THE BREADMAKING QUALITY.....	103
<b>2. Analytical Methods for Quality Determination .....</b>	<b>104</b>
P-2.1 STUDY OF CEREAL DOUGH AERATION DURING MIXING WITH A TOUCHLESS AIR-JET LASER SYSTEM.....	105
P-2.2 PROFILING ANALYSIS OF TRIACYLGLYCEROLS AND PHYTOSTEROLS IN RICE BY LIQUID CHROMATOGRAPHY-TANDEM MASS SPECTROMETRY .....	106
P-2.3 NEW TEXTURE ANALYSIS SYSTEM TO MEASURE DOUGH EXTENSIBILITY .....	107

P-2.4 USING THE GLUTOPEAK® TO BENCHMARK ONTARIO WINTER WHEAT .....	108
P-2.5 THE RELATIONSHIP OF GRAIN AND MILLING CHARACTERISTICS WITH SOLVENT RETENTION CAPACITY AND SWELLING INDEX OF GLUTENIN.....	109
P-2.6 EFFECTS OF COLD TEMPERATURE ON STARCH MOLECULAR STRUCTURE AND GELATINIZATION OF LATE-MATURITY ALPHA-AMYLASE AFFECTED WHEAT .....	110
P-2.7 RHEOLOGY OF FORMULATED GLUTEN FREE BLENDS: USEFUL PARAMETERS TO PREDICT BREAD QUALITY.....	111
P-2.8 MULTISPECTRAL IMAGING TO EVALUATE WHEAT GRAIN TISSUE DISSOCIATION IN PROCESSED-BRAN FRACTIONS .....	112
P-2.9 RAPID FORCE ANALYZER FOR DISCRIMINATING STARCH TYPES.....	113
P-2.10 EFFECT OF FERMENTATION OF OAT FLOUR BY SELECTED LACTOBACILLUS STRAINS ON PROFILE OF VOLATILE COMPOUNDS.....	114
P-2.11 LOW FIELD NMR TO DESCRIBE INTERACTIONS BETWEEN STARCH, GLUTEN AND WATER IN WHEAT-BASED PRODUCTS .....	115
P-2.12 THE PREDICTION OF MOISTURE SORPTION ISOTHERMS FOR FREEZE-DRIED EMULSIONS STABILIZED WITH HYDROPHOBICALLY MODIFIED STARCH .....	116
P-2.13 SOLVENT RETENTION CAPACITY UTILIZING SUPPLEMENTARY SOLVENTS FOR HARD RED SPRING WHEAT QUALITY EVALUATION.....	117
P-2.14 PHYSICOCHEMICAL, THERMAL AND AMYLOPECTIN STRUCTURAL ANALYSIS OF WHEAT STARCHES FROM WAXY, NORMAL, AND HIGH AMYLOSE WHEAT .....	118
P-2.15 HYDROLYSIS KINETICS MONITORING OF CEREAL STARCH GELS BY RHEOLOGICAL MEASUREMENTS.....	119
P-2.16 SOLVENT RETENTION CAPACITY: SUPPLEMENTAL SOLVENTS FOR EVALUATION GLUTEN QUALITY.....	120
P-2.17 GLUTOPEAK TEST FOR PREDICTION OF WHEAT TECHNOLOGICAL QUALITY AND BAKING PERFORMANCE OF BRAZILIAN TROPICAL WHEAT SAMPLES .....	121
<b>3. Alternative Grain Crops .....</b>	<b>122</b>
P-3.1 MILLET AS ALTERNATIVE CEREAL FOR DEVELOPING FOOD PRODUCTS IN THE BRAZILIAN DIET	123
P-3.2 DEVELOPMENT OF GLUTEN-FREE BREAD WITH RED QUINOA FLOUR USING THE MIXTURE DESIGN APPROACH .....	124
P-3.3 ANALYTICAL CHARACTERIZATION OF GLUTEN & GLUTEN FREE RAW MATERIALS.....	125
P-3.4 ANCIENT GRAINS: INTRODUCING THE KABOG MILLET FROM THE PHILIPPINES AS A RICE ALTERNATIVE.....	126

P-3.5 HEMP (CANNABIS SATIVA L) FLOUR OBTAINED FROM SEEDS OF INDUSTRIAL VARIETIES GROWN IN SPAIN: A STUDY OF ITS POTENTIAL AS A HIGH NUTRITIONAL VALUE FOOD INGREDIENT .....	127
P-3.6 QUINOA GERM, PERISPERM & BRAN FRACTIONS: FUNCTIONAL AND RHEOLOGICAL PROPERTIES .....	129
P-3.7 DEPENDENCE OF WATER REMOVAL METHOD IN THE FINAL PROPERTIES OF TEF FLOURS MODIFIED BY ULTRASONICATION .....	130
P-3.8 MODIFICATION OF THE TECHNO-FUNCTIONAL AND PASTING PROPERTIES OF BUCKWHEAT FLOUR BY MICROWAVE RADIATION.....	131
<b>4. Milling and Bread Making Technology .....</b>	<b>135</b>
P-4.1 CHARACTERIZATION OF DOUGH MIXERS PERFORMANCES FOR DESIGN AND SCALE UP.....	136
P-4.2 TAGUCHI DESIGN, A NEW APPROACH TO FORMULATE MIXED FLOUR BREAD .....	138
P-4.3 DEVELOPMENTS IN HUMAN UTILIZATION OF OAT AND RYE IN TERMS OF PROCESSING TECHNOLOGY AND NUTRITIONAL VALUE.....	139
P-4.4 SOURDOUGH BIOTECHNOLOGY NETWORK TOWARDS NOVEL, HEALTHIER AND SUSTAINABLE FOOD AND BIOPROCESSES .....	140
P-4.5 EVALUATION OF GLUTEN-FREE BREAD MADE FROM QUINUA AND BANANA FLOUR, CASSAVA STARCH, LUPINE FLOUR OR WHEY PROTEIN, WITH HIDROXYPROPIL METHYLCELLULOSE (HPMC) AND TRANSGLUTAMINASE, AS IMPROVERS .....	141
P-4.6 IMPACT OF TEMPERING PROCESS ON THE YIELD AND COMPOSITION OF QUINOA FLOUR.....	142
P-4.7 DURUM AND COMMON WHEAT IN BREADMAKING: STRUCTURAL, BIOCHEMICAL, AND RHEOLOGICAL RELATIONSHIPS TO QUALITY .....	143
P-4.8 ANDEAN CROPS: KAÑIWA AND TARWI FLOURS APPLIED TO THE DEVELOPMENT OF GLUTEN-FREE MUFFINS.....	144
P-4.9 DETERMINATION OF TECHNOLOGICAL PARAMETERS OF THE SPONTANEOUS SOURDOUGH FERMENTATION OF HULL-LES BARLEY .....	145
P-4.10 CHARACTERIZATION OF GLUTEN FREE CAKE BATTER WITH WALNUT FLOUR: WATER MOBILITY AND TEXTURAL BEHAVIOR .....	146
<b>5. Food Safety and Security .....</b>	<b>147</b>
P-5.1 THE EFFECT OF HEAT STRESS ON THE NUTRITIONAL COMPONENTS OF WINTER BARLEY (HORDEUM VULGARE L.).....	148
P-5.2 EFFECT OF DROUGHT STRESS ON BARLEY GRAIN QUALITY (HORDEUM VULGARE L.) .....	149
P-5.3 IMPACT OF WAITING TIME BEFORE BAKING AND AMOUNT OF BAKING POWDER ON AERATION DURING KNEADING, OVEN RISE AND FINAL POROSITY OF POUND CAKE.....	150

P-5.4 EFFECT OF DEGREE OF FLOUR WHOLENESS AND NITROGEN FERTILIZATION DOSE AND TIMING OF APPLICATION ON ASPARAGINE CONCENTRATION, AS THE MAIN INDICATOR OF ACRYLAMIDE-FORMING POTENTIAL IN WHEAT .....	151
<b>6. Wholegrains, their definition and utilisation in foods .....</b>	<b>153</b>
P-6.1 CONSUMER’S PERCEPTION OF SORGHUM FOR THE DEVELOPMENT OF A WHOLE GRAIN BEVERAGE .....	154
<b>7. Noodle Quality and Acceptability.....</b>	<b>159</b>
P-7.1 DPP-IV INHIBITORY POTENTIALS OF POLYPHENOLS ISOLATED FROM QINGKE BARLEY FRESH NOODLES: IN VITRO AND MOLECULAR DOCKING ANALYSES COMPOUNDS CONTENT.....	160
P-7.2 DURUM WHEAT SEMOLINA CHARACTERIZATION BY MEANS OF A RAPID SHEAR-BASED METHOD .....	162
<b>8. Consumer Perception .....</b>	<b>163</b>
P-8.1 REVIEW OF THE SENSORY AND PHYSICOCHEMICAL PROPERTIES OF RED AND WHITE WHEAT: WHICH MAKES THE BEST WHOLE GRAIN? .....	164
P-8.2 MAIN VOLATILE COMPOUNDS OF BROA, A PORTUGUESE ETHNIC MAIZE BREAD.....	165
<b>9. Molecular Approaches .....</b>	<b>166</b>
P-9.1 EXTRA SOFT WHEAT GERMPASMS WITH ADDITIONAL PUROINDOLINE GENES ON CHROMOSOME 5A AND THEIR QUALITY CHARACTERISTICS .....	167
P-9.2 ANALYSIS OF THE WHEAT ARABINOXYLAN GENETIC CONTROL AND THEIR EFFECT ON WHEAT QUALITY.....	168
P-9.3 WHEAT RESISTANCE TO RUST DISEASES IN CZECH REPUBLIC NEGATIVELY CORRELATES WITH BAKING QUALITY AND MOSTLY RELIES ON LR37/YR17/SR38 GENE CLUSTER .....	169
<b>10. Novel Processing Techniques for Extrusion and Biscuit Making .....</b>	<b>170</b>
P-10.1 THE EFFECTS OF INCORPORATING MUSHROOM POWDER INTO SORGHUM BISCUITS ON THEIR NUTRITION AND QUALITY CHARACTERISTICS.....	171
P-10.2 TIGER NUT (CYPERUS ESCULENTUS) AS A FUNCTIONAL INGREDIENT IN GLUTEN FREE EXTRUDED SNACKS.....	172
P-10.3 EFFECT OF WHEAT BRAN PRE-PROCESSING ON PHYSICAL PROPERTIES OF 3D-PRINTED SNACKS .....	173
10.4 EFFECT OF EXTRUSION PROCESSING ON ANTIOXIDANT AND GLYCEMIC PROPERTIES OF COWPEA AND WHEY PROTEIN CONCENTRATE FORTIFIED RICE BASED EXTRUDED SNACK.....	174
P-10.5 EFFECT OF DEFATTED PEANUT AND SOY FLOUR OBTAINED BY NEW AQUEOUS METHOD ON QUALITY OF GLUTEN-FREE COOKIES .....	175

<b>11. Sustainable Agricultural Technology Systems.....</b>	<b>176</b>
P-11.1 ESTIMATION OF QUALITY TRAITS IN SOME PAKISTANI WHEAT (TRITICUM AESTIVUM L.) UNDER TERMINAL HEAT STRESS CONDITION .....	177

## ORAL PRESENTATIONS

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Abstracts are listed according to the sessions  
scheduled in the programme

# Opening Session

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Keynote lectures

## O.01 PREHARVEST SPROUTING: ABOUT FALLING NUMBERS, WHEAT KERNELS AND BAKING QUALITY

**Christophe COURTIN**

KU Leuven, Leuven, Belgium

Harald Perten dedicated part of his professional life as a cereal chemist to amylases and preharvest sprouting (PHS) in wheat. PHS, sprouting of cereal kernels when they are still on the ear, results in the production of amylolytic and other hydrolytic enzymes in cereal grains. This decreases the technological quality of wheat and causes problems during processing of affected flour into cereal-based products. Therefore, wheat that is severely sprouted in the field is less suitable for products for human consumption, and is often discounted to animal feed. Following up on the work of Harald Perten, I will present recent findings on PHS of wheat in the field, as compared to knowledge generated using controlled sprouting. I will discuss the functional changes occurring in wheat during PHS and its impact on wheat and bread quality. Strategies to reduce the enzyme activity in flour from sprouted wheat to increase its potential to be used in the food industry are presented and the enhanced quality of the resulting flour will be demonstrated in bread making. The talk will provide a useful background for further research concerning the potential of field-sprouted wheat to be used as raw material in the food industry.

### **Keywords**

Harald Perten, amylase and preharvest sprouting (PHS), wheat, baking quality

## O.02 DELIVERING HEALTH BENEFITS WITH BAKERY PRODUCTS

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The world-wide drive to improve levels of fibre in consumers' diets while at the same time reducing salt, sugar and fat, creates significant opportunities for bakers to develop new and healthier products. This presentation considers the technological basis for such healthier products using real world examples of cakes and doughnuts. The importance of texture and flavour to consumer acceptance of nutritionally enhanced products will be highlighted. It will also examine the critical role of processing in delivering acceptable products for retailers and consumers. It will emphasise to potential for opportunities beyond the current nutritional focus through the manufacture of 'hybrid' bakery products and discuss the technical and consumer challenges that such developments face.

### **Keywords**

Fibre, sugar, fat, texture

# Session 1

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## Cereal Nutrition I

## 0.03 EFFECT OF SOLUBLE DIETARY FIBRES ON VISCOELASTIC PROPERTIES OF DURUM WHEAT DOUGH, PASTA-MAKING PERFORMANCE AND GLYCAEMIC RESPONSE OF PASTA

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Pasta is a starchy staple food, which is a good carrier of health-promoting ingredients that can manipulate the glycaemic response. The aim of this work was to evaluate the effects of soluble DFs on viscoelastic properties of durum wheat dough, pasta-making performance and glycaemic response of dry pasta made under industrial process conditions. The ingredients/fibres chosen were psyllium, Barley Balance, long- and short-chain inulins added individually and in combination to obtain DF-enriched doughs with large differences in rheological properties to understand their role in the manipulation of predicted glycaemic response. Dough rheological properties were investigated using frequency and temperature sweep tests in the linear viscoelastic range. DF-enriched doughs showed large differences in elastic properties between 25 and 95 °C due to differences in the number of interactions between components and the swelling of gelatinized starch granules. A correlation between in vitro glycaemic response of pasta and a swelling index obtained from rheological tests was observed. Swelling of starch granules decreased with the increase in elasticity and water absorption of fibre-enriched doughs up to a critical value. Generally, pasta containing fibres was stickier and gave higher cooking loss. Changes in firmness were dependent on dough viscoelasticity. Proper blend of fibres appeared to solve some issues limiting the use in the product.

In conclusion, viscoelastic properties of DF-enriched doughs are determinant for nutritional and technological performances and their knowledge provides useful information for the development of a functional product. Both sensory quality and health evidence require a certain dough elasticity, which is the result of interactions at molecular scale. It is important to pay attention to the incorporation of DF blend in pasta since antagonist or synergic effects may occur and influence their functionality.

### Keywords

Dietary fibre, pasta, dough rheology, starch digestion, ingredient interactions

## O.04 EXTENDING STARCH APPLICATIONS AS ABSORPTIVE POLYMER: FROM PRODUCTION TO FUNCTIONAL ROLE.

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Cereal starches are generally seen as large polysaccharides with important technological properties for the food industry, either as in their granular state or as gels; and lately, also with great impact on the digestion of bakery products. However, starch offers great possibilities as a biopolymeric material with absorptive capabilities. Particularly, its porosity affects diverse phenomena such as sorption, thermal conductivity, the diffusivity of water as well as mechanical and texture properties. Therefore, it is of great importance to control the porosity extending applications of starch. Starches differ in their granule size, going from the big potato starch followed by wheat starch, tapioca starch, corn starch and finally the rice starch; but they also differ in shape. Likewise, pores are randomly distributed and vary from starch to starch in terms of locations, dimensions and extent. Similarly, hydrogels obtained from starch gelatinization offer a multitude of networks depending on their source. Nevertheless, those features naturally present in starches can be even boosted through physical, chemical and enzymatic methods. Specifically, enzymatic treatments are leading to clean label starches, which currently are acquiring the utmost importance. This presentation will give an overview of how to intensify and control starch's porosity with a proper selection of the source of starch, enzyme and production settings. Information about technological and structural properties of the resulting porous starches and starchy hydrogels will be presented, besides examples of applications as probiotic or mineral carriers, as well as potential physiological role.

### **Keywords**

Starch, enzymes, porosity, microstructure, probiotic

## 0.05 EFFECTS OF SPECIES, BREEDING AND ENVIRONMENTAL CONDITIONS ON ESSENTIAL WHEAT PROTEINS

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Ancient wheat species such as emmer and einkorn are suspected to be less immunoreactive with respect to allergies and intolerances due to their low amounts of amylase-trypsin inhibitors (ATIs). In order to evaluate the impact of genetic variability on ATIs and gluten proteins, different Triticum species, including common, durum, spelt, emmer and einkorn wheat, have been investigated by RP-HPLC and enzymatic assays for ATI content and activity. Based on the results, none of the evaluated wheat species could be considered to less impact human health, as einkorn samples indeed showed lower ATI concentration, but increased enzymatic activity in terms of trypsin inhibition. Additionally, the influence of breeding was assessed for a broad range of common wheat varieties from different breeding periods. Results reveal a considerable improvement of technologically valuable parameters such as gliadin/glutenin ratio and increasing amounts of HMW (gluten high molecular weight subunit), but no increase in immune-stimulating proteins could be observed. However, environmental conditions such as temperature and rainfall have been identified to impact ATI occurrence in developing grains.

### **Keywords**

Amylase-trypsin inhibitor, ancient wheat, triticum, wheat sensitivity

## O.06 FOOD ORAL PROCESSING BY THE ELDERLY FOR THE DEVELOPMENT OF SOFT CEREAL FOODS FORTIFIED WITH PROTEINS

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Elderlies need a higher protein intake than other adults, and, in addition, their oral physiology is generally altered. Thus, in order to develop cereal foods that are fit for this population, the aim of this work is to understand the oral breakdown and bolus formation mechanisms of two products (brioche and sponge cake) fortified with pulse proteins. A panel of 20 subjects aged over 65 years with contrasted dental status and variable salivary flow was recruited. The moisture content, particle size and viscosity of boluses collected during chewing were determined by imaging and rheology. The relationships of these properties with the perception of oral comfort and the elderly's physiology were established. Results showed that salivary flow had a major influence on the viscosity of the bolus, and this was strongly related to the perception of comfort. Fragmentation, on the other hand, depended on the dental status and the texture and cellular structure of the products. To ascertain this relationship, the evolution of the cellular structure and of the mechanical properties of these two cereal foods have been studied by X-ray microtomography under compression in situ, and numerical modelling. Results highlighted large differences in mechanical behavior, at low and large deformations. These differences were related to the walls thickness of the cellular structure, which play a key role in the food fragmentation mechanisms. Finally, the addition of pulse proteins, at levels necessary to obtain the claim "rich in protein", showed that oral comfort was related to dental status rather than to salivary flow, whilst having little impact on the perception of oral comfort of the enriched product by the panel. These findings open prospects for the design of realistic cereal foods that are comfortable to eat and help to meet the nutritional needs of elderlies.

*This work was funded and supported by AlimaSSenS project (ANR- 14-CE20-0003).*

### **Keywords**

Bolus, fragmentation, mechanical modeling, oral comfort, viscosity

## Session 2

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Analytical Methods for Quality Determination

## 0.07 A MULTI-SPECTROSCOPIC APPROACH TO STUDY MOLECULAR INTERACTIONS DURING BREAD DOUGH MIXING

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The comprehension of the interactions at a molecular level is crucial to understand the process of bread dough mixing. Indeed, this first step of bread making has a strong impact on the final structure and quality of the bread. Several physical, chemical and physico-chemical modifications occur during dough mixing and are linked to complex mechanisms involving essentially wheat proteins and water molecules. The hydration of gluten proteins, gliadins and glutenins, in particular, forms a continuous viscoelastic network capable of preserving the gas nuclei that will grow during the fermentation phase. The dough becomes smooth, homogeneous and firm. If kneading continues beyond maximum development, the dough weakens, then collapses and becomes sticky due to increased mobility of its constituents.

As part of the ANR-LabCom Mixi-Lab project, Confocal Laser Scanning Microscopy (CLSM), Terahertz, Raman and NIR spectroscopies were used to investigate molecular interactions when mixing bread dough. These non-invasive spectroscopic methods are fast, nondestructive, accurate and reproducible and allow direct screening into the dough avoiding any artefacts related to sample preparation. Such combined spectroscopic approach provides additional information: water content, water/proteins interactions, structural changes in gluten proteins with the description of the amino-acid side-chains modes (tryptophan doublet, tyrosine doublet, disulphide bridges conformation), network connectivity and irregularities and size of the gluten strips.

For this purpose, dough samples were analyzed by each analytical technique at three mixing levels: under-mixing, optimum mixing time and over-mixing. Spectroscopic responses as well as confocal fluorescence images clearly indicates specific behaviors in the successive stages of mixing. At the end of pre-mixing, dough microstructure is coarse and heterogeneous, water is still available and amino acid residues are slightly burried. At optimum mixing time, aggregates have disappeared and proteins threads have stretched. Water/proteins interactions are maximum and the gluten structure is strenghtened with the presence of more  $\beta$ -sheet secondary structures and intra-molecular g-g-g disulphide bonds. When the dough is overmixed, some breaks in the network connections appear and the gluten network is weakened. Some water is released and the secondary structure of protein is disordered: a decrease in the  $\beta$  sheets is observed as well as a change in a less stable disulfide bond configuration. These conclusions are consistent with the expected behavior of gluten proteins during kneading and show the potential of all these non-invasive spectroscopic techniques for the study of molecular interactions.

### Acknowledgments

This project took place within the MIXI-LAB project funded by the National Agency for Research (ANR – agreement ANR- 15-LCV3-0006-01)

### Keywords

Dough, mixing, vibrational spectroscopies, terahertz, CLSM

## O.08 IMPROVED EVALUATION OF WHEAT DOUGH QUALITY THROUGH ALVEOGRAPH'S PROTOCOL ADAPTATION

### Arnaud DUBAT

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Most of the quality control tools commonly used by the industry were invented 60 to 100 years ago. From a marketing perspective, and particularly in a world where ephemeris becomes standard, such longevity is quite amazing. Some will prefer a certain kind of device, others another brand, but one thing is sure; most of the analytical protocol used today worldwide to assess the quality of grain and or flour were established more than 50 years ago. And we must recognize that these tools are doing a good job when it comes to decide if the flour we buy corresponds to certain required specifications.

But at the same time, we must also be aware that our cereal world has deeply changed over the last 5 decades. Wheat varieties have greatly evolved, baking processes also. We are now using enzymes, other types of grains, even pulses or hemp in the flours and the list goes on. Yet, we are still using the same control tools and the same protocols as always

So, maybe the time has come to think out of the box. Not for the beauty of it, but because it really can help our analytical, and control processes to reach another level. Maybe it is time to invent the tools, protocols that really suits what our real needs are today (and tomorrow).

In this presentation, we will give example of what is achievable when breaking the barriers of established rules. We will illustrate how, when the goal is clearly defined, we can enhance the performance of existing tools. The first example will focus on the application of the Alveograph to Mozzarella cheese bubble blowing...definitely not a cereal but this illustrates that when the objective is set, using the right tools in an adapted manner can help us push the boundaries of what is possible. From this starting point, we will explain how, today, we can use the Alveograph to blow bubble from whole wheat flour. The third example will illustrate how can we predict a long test (Alveograph from wheat) with a 10 minutes test on a new tools (Mixolab) taking benefit of the protocol adaptation potential.

At the end of the day, the current protocols are a commonly accepted language and this is something of great value. But at the same time, research, R&D, and even quality control would find a lot of benefits to think differently more often and particularly look at different way to do their analyze. Because it may be that this new way brings much more information than the standard one.

### **Keywords**

Alveograph, mixolab, whole wheat flour, quality

## O.09 PERFORMANCE OF THE NEW GLUTOMATIC SYSTEM

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The milling, baking and pasta industries rely on wheat and flour quality information to produce cost effective, fit-for-purpose products. Protein content and quality are equally important considerations for suitability of the wheat, semolina or flour for its intended use. Gluten is the functional component of wheat protein that contributes to dough characteristics and influences end product quality. The Glutomatic system is the world standard (ISO Standard 21415-2:2015, ICC Standard No. 155 and 158, and AACC Method 38-12.02) for testing gluten quantity and quality in wheat, flour, durum and semolina, giving measures of Gluten Index (GI, gluten strength), water binding (WB), and wet (WG) and dry gluten (DG) contents. The system consists of a Glutomatic instrument to form gluten from meal or flour, a centrifuge to initially dry the gluten ball and to separate its weak and strong components, and a Glutork to dry the gluten. PerkinElmer has recently introduced a new Glutomatic system (GM 2000), with update designs for the Glutomatic and centrifuge, and added features such as automatic initial saline dispense and results calculation; touch screen for user controls; and USB connectivity to allow connection to a balance and printer, saving data to database, and transfer to LIMS system. This poster summarises the comparison of the new Glutomatic system to the original system, and discusses the added features of the new system. Twenty flour and meal samples with wide ranging protein contents and qualities were tested on both the original and new Glutomatic systems, and the results compared. The new system gave results that were comparable to the original system, with similar precision (repeatability coefficients of variation <5.0% for all measured parameters on both systems). The new Glutomatic system has improved (automated) features that will reduce overall test time, improve usability and data management, without compromising on results.

### **Keywords**

Gluten, protein, quality, flour, meal

## Session 3

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### Alternative Grain Crops I

## 0.10 WHY DO SO MANY CONSUMERS PURCHASE "GLUTEN FREE" PRODUCTS?

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The requirement by consumers for “gluten free” products has developed over the last 20 years and currently at least 10% of the Australian population purchases gluten free products. The latest clinical research from the US suggest that 6% of the population react to gluten who are not coeliacs. We also know that up to 15% of the population have gut symptoms related to the ingestion of FODMAPs. When consumers purchase gluten free products these are generally also low in FODMAPs so we do not know whether the consumer is reacting to the gluten, the FODMAPS or both. We suggest that the problem is related to the change in bread making that took place during the 1970s and 80s following the introduction of the Chorleywood bread process,1961(no time dough) from the UK. This process virtually eliminated all bulk fermentation of the dough and allowed bread to be made in a very short time period. This rapid and cheaper baking process has been adopted in many countries including Australia and New Zealand. Evidence is accumulating that during long fermentation of dough gluten undergoes changes and there is also significant degradation of FODMAPs. Bread processing prior to these changes involved long fermentation of the dough. There are now many anecdotal reports from consumers who are “gluten free” but say they are able to tolerate bread made by long fermentation sourdough processes. We have carried out baking trials and we have also studied commercial breads in the marketplace comparing the ‘no time dough’ process against long fermentation yeasted doughs and long fermentation sourdough processes. We will compare the composition and structure of the Gliadins as well as the degradation of FODMAPs across the three different methods of making bread. We expect that this data will help to confirm our hypothesis explaining the reasons for the “gluten free” phenomenon. We have also noted that the introduction of unfermented dried gluten into a range of foodstuffs through the 1970s and 80s may have exacerbated the situation for those with gluten sensitivity.

### **Keywords**

Gluten Free, FODMAPS, gliadin, fermentation, non coeliac gluten intolerance

## O.11 COMBINE WHEAT AND LEGUMES, FROM THE FIELD TO SOFT CAKES: HOW TO MANAGE RAW MATERIAL VARIABILITY USING PROCESS MODIFICATION FOR PRODUCING CAKES OF CONSTANT QUALITY

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The cereal-legume association has advantages at the agronomic (less fertilizer and pesticide, increased productivity) and nutritional (protein profile more balanced than cereal alone) levels. To limit energy consumption along the chain, it may even be worthwhile to harvest and transform the two types of seeds together into flour. However, sowing, driving in the field, transforming into flour without ever-separating wheat and legumes leads to a great variation in the composition of mixed flours. The impact on soft cake quality of such a flour variability has to be managed at the manufacture level. The way the soft cakes are structured throughout the manufacturing process was studied. The impact of characteristics of mixed pea-wheat flours (particle sizes and legume-cereal ratio) on the softness cakes and on the cellular structure of the crumb was determined. A multi-criteria and multi-constraints model was developed. It makes it possible to correct variations in the quality of cakes induced by a variation in flour characteristics by modifying the parameters for mixing ingredients and baking. The efficiency of the multi-criteria and multi-constraints model was verified through an instrumental but also a sensory characterization of cakes.

### Keywords

Cake, quality, process, wheat-legume crops association, multi-criteria and multi-constraints model

## O.12 GLUTEN FREE SYSTEMS: WHY WATER PLAYS A MAJOR ROLE

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The number of patients suffering from coeliac disease has increased over recent years and, hence the demand for gluten-free products rose. Developing gluten-free products requires the optimal mix of functional ingredients, but also the amount of water plays a major role in the final product quality. Several methods to determine the optimal water content in gluten containing dough systems are well known, while the adjustment in gluten-free systems seems to be challenging and only feasible by the trial-and-error approach. Recently, Brabender GmbH & Co. KG developed an attachment for the Farinograph, the so called FarinoAdd-S300, which can be used to measure consistencies of gluten-free bread formulations.

### **Keywords**

Gluten free, Water absorption, Farinograph

## Session 4

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### Cereal Nutrition II

## O.13 IMPACT OF FOOD ORAL PROCESSING ON THE DIGESTION OF CARBOHYDRATE-RICH FOODS

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Oral processing is the first step in food digestion. It is a complex physiological process that involves the physiological characteristics of the individual performing the chewing action, and therefore differs among people depending on factors such as age, gender, facial anatomy and dentition status. There is some evidence that individual chewing style may contribute to inter-individual variations in physiological responses of foods. In our research, we examined the chewing behaviour of consumers, and investigated the influence of chewing behaviour on the digestion of carbohydrates-rich foods, not only using in vitro gastrointestinal digestion and colonic fermentation models, but also by measuring the blood glucose levels after consumption. The results showed that chewing behaviour and chewing outcome varied significantly among individuals, resulting in large differences in carbohydrate digestion. Long chewers produced a higher postprandial glycaemic response due to the increase in the food surface area and greater saliva addition to bolus, whereas shorter chewers produced a higher amount of total short chain fatty acids (particularly lactate) in in vitro colonic fermentation due to the larger amount of undigested carbohydrate available for fermentation. Next generation sequencing analysis revealed that the short chewers' microbiome had an increase in the relative abundance of Bifidobacterium and Lactobacillus. Food structure breakdown in the mouth during chewing also varied for different age and ethnic groups, and the differences in food structure breakdown in the mouth during chewing largely affected their blood glucose concentrations. In this presentation, we will address the importance of understanding the variance in consumer oral processing behaviour to design food products that deliver desired functionalities for target consumer groups, with some research examples.

### Keywords

Chewing behaviour, glycaemic response, colonic fermentation, age, ethnicity

## O.14 ENHANCING THE NUTRITIONAL PROFILE OF CEREAL GRAINS

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Globally approximately 50% of dietary energy intake is derived from cereals. In industrialised countries, this drops to about 30% and is associated with consumption of more highly refined products that are lower in complex carbohydrates and dietary fibre, and higher in fat and sugar. This is correlated with increased rates of obesity and chronic diseases, or diseases of affluence, such as type-2 diabetes. With this in mind our group has focussed our research on altering the nutritional profile of cereals to produce nutritionally enhanced grains that can be used in existing processing lines but result in end products that are healthier for consumers.

Using conventional breeding techniques, we have developed a range of novel healthy cereal grains with unique fibre and nutritional profiles. BARLEYmax™ is a natural wholegrain with twice the dietary fibre of regular grains, four times the resistant starch and a low glycaemic index. Products containing BARLEYmax™ are available in Australia, Japan and the US. HealthSense™ flour is made from a high-amylose wheat that contains more than ten times the resistant starch found in regular wheat. It is commercially available in the US. Kebari® is an ultra-low gluten barley, in which the gluten content has been reduced to below the levels that WHO recommends for classification as gluten free, that can be used for brewing and food uses. We are actively developing the next generation of healthy grains including thick aleurone nutrient dense rice and high betaglucan cholesterol lowering wheat.

### **Keywords**

Nutrition, health, diet, chronic disease

## O.15 EFFECTS OF ADLAY SEED (COIX LACHRYMA-JOBI L.) EXTRACTS ON NONALCOHOLIC FATTY LIVER DISEASE AND METABOLIC DYSFUNCTION IN DIET-INDUCED OBESE MICE

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Non-alcoholic fatty liver disease (NAFLD), closely related to metabolic dysfunction, leading to a higher risk for the development of progressive liver disease, such as nonalcoholic steatohepatitis (NASH), liver cirrhosis, and hepatocellular carcinoma (HCC), is a common liver disease worldwide. To date, no pharmacotherapy targeting NAFLD has received general approval. A kind of medical plant, adlay (*Coix lachryma-jobi* L.), which has been used as traditional Chinese medicine, is a promising approach to solve this global issue. In this study, we established the NAFLD mice model by feeding a high-fat diet (HFD) for 10 weeks; meanwhile, ethanolic or water extracts of adlay seeds (ASE or ASW, respectively) was treated in the HFD mice. The treatment with ASE and ASW ameliorated hyperglycemia and improved the glucose tolerance in the HFD-induced obese mice. The hypercholesterolemia in HFD mice were reduced by the ASE and ASW treatment. In addition, the ASE and ASW supplementation attenuated hepatic lipid accumulation and inflammation, and had no harm to kidney. Our study showed the regulatory potential of the extraction of adlay seeds on alleviating NAFLD, as well as related liver and metabolic diseases.

### **Keywords**

Adlay, hyperglycemia, hypercholesterolemia, on-alcoholic fatty liver disease

## Session 5

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### Milling & Bread Making Technology I

## O.16 STUDY ON THE QUALITY CHARACTERISTICS AND APPLICABILITY OF WHEAT FROM KAZAKHSTAN ON CHINESE TRADITIONAL STAPLE FOOD

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Steamed bread and noodles as the traditional staple food are deeply loved in China. In order to study the quality and applicability of wheat from Kazakhstan for steamed bread and noodles, 14 Kazakhstan wheats and Chinese commercial wheat samples were selected in 2017, and 6 wheats collected from Kostanay province, 5 wheats from Astanan province and 3 wheats from Akmola province. The protein content, gluten content, gluten index, sedimentation value, falling number, starch pasting properties and farinograph properties of wheat flour were measured, and the sensory evaluation of steamed bread and noodles were conducted. The results showed that the average value of color  $a^*$  and  $b^*$  value of Kazakhstan wheat flour was  $-1.93 \pm 0.23$  and  $10.67 \pm 0.92$ , respectively. The average protein content was  $12.0 \pm 1.5\%$ , wet gluten content was  $28.8 \pm 4.5\%$ , gluten index was  $97 \pm 4$ , sedimentation value was  $62.6 \pm 9.2\text{ml}$ , and the dough stability time was  $11.6 \pm 12.3\text{min}$  (the index amplitude varied from 3.9min to 53.9min). 21.4% and 64.0% of the wheats reached the requirement of wet gluten content and stability time in China's second-level standard of "strong gluten wheat (GB/T 17892-1999)". The color  $a^*$  value and falling number of Kazakhstan wheat flours were significantly lower than those of Chinese commercial samples ( $P < 0.05$ ), but the gluten index and sedimentation value were significantly higher than that of Chinese commercial sample ( $P < 0.05$ ). The Kazakhstan wheat flours have the characteristics of high  $b^*$  value, low gluten content and strong gluten quality. The wheat hardness and color  $a^*$  value of flour in Akmola were both evidently lower than that of Kostanay and Astanan, and there were no significant difference in other parameters of wheat flour from three regions in Kazakhstan. The total score of sensory evaluation of noodles made by Kazakhstan flour were 70-80. The elasticity was markedly higher than that of Chinese commercial sample, but the average color score was only 6.6 points (all of 10 points) and there was no significant difference on other quality traits between these samples. The total score of Chinese steamed bread of wheat from Kazakhstan were between 75 and 82, the elasticity was obviously higher but the internal structure and color score were significantly lower than that of Chinese commercial sample. Therefore, Kazakhstan wheat can be used to improve the elasticity and chewiness of steamed bread and noodles, but it has a negative effect on food color.

### **Keywords**

Kazakhstan wheat quality, Chinese steamed bread, noodles, sensory evaluation

## O.17 GLUTEN PROTEIN RESPONSE TO HEAT AND DROUGHT STRESS IN DURUM WHEAT

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Protein content and composition is very important in durum wheat in relation to pasta quality. Gluten proteins account for 80% of wheat grain protein and are the largest contributor to wheat quality. The aim of this study was to determine the effect of heat and drought on protein quantity and quality in durum wheat using chromatography and proteomics. The field experiments were conducted in Mexico by CIMMYT under six different environmental conditions; optimum conditions, flood irrigation, medium drought stress, severe drought stress, medium heat stress and severe heat stress conditions. Size exclusion and reverse phase high performance liquid chromatography was used to analyse high and low molecular weight glutenins. Two dimensional polyacrylamide gel electrophoresis followed by liquid chromatography tandem mass spectrometry (LC-MS/MS) was done on two selected cultivars to determine the effect of the stress conditions on the expression of proteins. Stress conditions had a large effect on large unextractable polymeric proteins and total unextractable polymeric proteins, especially medium heat stress and severe drought stress. There was a large cultivar effect evident in the expression of proteins, indicating that results cannot be generalised for all cultivars. Both medium and severe heat and drought stress caused a significant up-regulation of some glutenin protein spots, which were further analysed with LC-MS/MS.

### Keywords

Durum wheat, glutenin, proteomics, heat and drought stress

## O.18 BREAD DOUGH RHEOLOGY – MEASURING IT TO CONTROL THE END PRODUCT QUALITY

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Indonesia continues to be one of the largest wheat importing nations globally, sourcing nearly all of its 7.4 mmt of imported wheat during 2015 from Australia and Canada.

Bread dough development is a poorly defined concept but commonly relates to changes in the rheological properties of the dough under defined test conditions.

The rheological properties of dough have always been important for bakers in the delivery of specific bread qualities. In artisan bakeries where the dough may be moulded by hand, it is a relatively easy task to adjust the pressures applied during dough moulding to compensate for variations in dough consistency. Typically, consistency is adjusted through optimised (maximised) recipe water level. However, dough rheology not just about consistency (dough softness) and properties such as elasticity and extensibility play critical roles in determining end-product quality. Modern dough mixing methods have necessitated an improved understanding between energy input, temperature rise and control of final temperature which adds to the challenges facing bakers operating in warm climatic conditions, such as SEA. The use of ice and cooling jackets on mixers contributes to more consistent dough ex-mixer but adds to the baker's energy bill (and ultimately to the price of bread).

The objective of this study has been to develop a test method based on the Warburton's stickiness rig test (WST) (TA-XT2iPlus) for dough consistency and dough stickiness and to understand the effects of higher shear rates on dough to give insights relevant for commercial dough processing arrangements. In this paper series of experiments, including level of bakery water added, salt levels, sugar levels, final dough temperature and delays in processing will be discussed in relation to bread dough rheology and the impact on final product quality. While bread volume remains a key evaluation test there are other more subtle but as important bread characteristics which are influenced by flour properties and the subsequent dough rheology.

In this context we will consider the formation of the cell structure which as note earlier, is derived from mixing and the control of gas bubble coalescence.

### **Keywords**

Bread quality, bread dough rheology, warbutons stickiness rig

## Session 6

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Food Safety, Security & Breeding

## O.19 TRANSGENIC WHEAT WITH ELEVATED ENDOSPERM TRIGLYCERIDE LIPID - EFFECTS ON GRAIN COMPOSITION AND BAKING

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Various studies on the impact of endogenous lipids on baking have been inconclusive and sometimes contradictory. These have relied chiefly on minor varietal or environmental differences, lipase treatments, or defatting and reconstitution treatments. While there is a loose literature consensus that removing or modifying triacylglycerides (TAG) to more polar forms is desirable, this conclusion is challenged by the fact that bakeries add lipids, predominantly TAG, during processing. We have set out to test the impact of elevated levels of TAG when produced endogenously in starchy endosperm in transgenic wheat. Transgenic genotypes were produced with the introduction of four genes: endosperm-specific promoters driving maize Wrinkled1, Arabidopsis DGAT1, and sesame oleosin, plus a selectable marker gene. The resulting wheat lines have consistently produced grain with a substantive increase, up to 8 fold, in the endosperm of TAG over five generations, including two seasons in the field. No change in polar lipid content was observed. Lipid droplets were readily visualized and evident throughout the starchy endosperm. We have studied the increase in TAG and changes to fatty acid profile throughout grain development. Compared to control seed, the high oil wheat had a shift to oleic acid at the expense of polyunsaturated fatty acids. While seedling growth or grain yield were not significantly diminished, average individual seed weight and diameter were slightly reduced. No significant changes could be shown in content of starch, protein, or betaglucan in field grown wholemeal flours, however there was an increase in  $\alpha$ -amylase and free glucose. Peak RVA viscosity in the presence of AgNO<sub>3</sub> was unchanged. Preliminary baking indicated a decrease in loaf volume, however larger scale and replicated baking results will be available for presentation at the conference.

### **Keywords**

Lipid, triglyceride, GM wheat, bread, baking

## O.20 ACCUMULATION AND DISTRIBUTION OF EMERGING CONTAMINANT ELEMENTS (GA, IN, AS AND CD) IN RICE

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Rice (*Oryza sativa* L.) is an important staple food served as the main dishes to provide the calories for people in many areas of the world. Although the amount of rice consumption decreased to around 44 kg/person/year, the cooked rice and the rice processed products are still the major carbohydrate source of Taiwanese. The awareness of the emerging contaminant elements (ECEs) used in highly developed high-tech industries, such as semiconductor manufacturing, are brought great attentions. The threaten of ECEs on the environments, including water, soil, and agriculture, should be monitored to prevent from the risk on the humanbeings. The country having an over-intensive agriculture like Taiwan, the survey of accumulation and distribution of ECEs in the domestic cultivated rice grains is the first task to evaluate the influence of ECEs on the rice fields currently. In this study, there are 27 rice samples, including 14 Japonica rice, 4 Indica rice, and 6 colored rice, collected from domestic farmers and agricultural research and extension stations. Within 27 rice samples, there are 26 paddy and 1 brown rice. The rice samples were dehulled and polished before determinations. The 4 elements, gallium (Ga), indium (In), arsenic (As), and cadmium (Cd) were analyzed by using ICP-MS. The results show that the distribution of Ga in rice gain is husk > bran > brown rice > polished rice, in all rice samples. Compared with other elements, the amount of Ga is much higher, and the colored rice has the highest content of Ga in husk (2.80 mg/kg dm) and in bran (1.52 mg/kg dm) among all rice samples. After dehulling and polishing, the content of Ga in 5 polished Tainan No. 11 (TN11) collected from different locations are all below 0.98 mg/kg dm (maximum) with the averaged value of 0.49 mg/kg dm. Generally speaking, the In is evenly distributed in the husk and bran in rice grain and there is no significant difference among the rice types (Japonica, Indica, and colored rice). The distribution of As is rice grain is bran > husk > brown rice > polished rice. Among three types of rice, the minimum, maximum, and averaged contents of bran are 0.45, 1.48 and 0.84 mg/kg dm in Japonica rice, 0.38, 0.77, 0.58 mg/kg dm in Indica rice, and 0.29, 1.44, 0.89 mg/kg dm in colored rice. The distribution of Cd in rice grain is husk > bran, brown rice and polished rice. The Cd contents of polished rice from all of rice samples are all below the 0.4 mg/kg dm, which are all meet the Standard for the Tolerance of Heavy Metals in Rice (Ministry of Health and Welfare, Taiwan). More rice samples collected from rice fields with information of soil and irrigation water conditions are necessary for building the data bank of ECEs of rice grains. This data bank will provide valuable information for setting the standards of ECEs tolerance in rice and farmland irrigation water.

### **Keywords**

Rice, gallium (Ga), indium (In), arsenic (As), cadmium (Cd)

## O.21 DEVELOPMENT, CHARACTERIZATION AND GENETIC STUDIES ON HIGH-FIBRE WHEAT LINES

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It was previously demonstrated that the arabinoxylan content of the wheat grain is a highly heritable trait and an appropriate target for breeding. However, increasing the fiber content of wheat grain has, until now, been limited by the lack of molecular markers for this trait.

In order to increase the fiber content of wheat, crosses were made between the high fiber cultivar Yumai 34 and three Central European varieties (Lupus, Mv-Mambo, Ukrainka). The physical properties (test weight, thousand-kernel weight, flour yield, kernel hardness), composition (protein, gluten, total-AX and pentosan, WE-AX and pentosan) and processing quality (gluten index, Zeleny sedimentation, Farinograph parameters) of the grain were compared for thirty-one breeding lines (F7-F9) and the four parents in a three-year field experiment. Increases of 0.5% in the WE-AX content and 1% in total AX content of the flour were achieved, with an improvement in dough properties. Three of the lines had yields that were competitive with the official control varieties.

The genotype (G) determined 65.61% and 52.44% of the total variance in protein and starch content, respectively, in this high-fiber sample set and their broad-sense heritability (H<sup>2</sup>) values were also high (0.851, 0.828). The ratio of genetic variance to total variance was low in the case of the TOT-pentosan (9.64%) but the G×E interaction effect (53.62%) was high. Genotype determined 26.27% of the total variance in WE-pentosan with 0.825 heritability and the variance ratio was even higher when the main component of the pentosans, WE-AX was measured using GC method (58.33%) (H<sup>2</sup>= 0.840), confirming its utility in breeding programmes. The composition of WE-AX (the arabinose:xylose ratio) was also highly determined by genotype (41.33%) (H<sup>2</sup>=0.721). A Toborzo/Tommi RIL population was also developed for genetic studies comprising 221 lines. A strong QTL for WE-pentosan content was identified on chromosome 1B with other QTLs were also identified on chromosomes 2A, 2D, 4D 3B, 5A and 6B. Multi-trait evaluation showed the effect of further markers on chromosomes 1D, 3A, 4B and 5B. The markers on chromosomes 2A and 5B were shown to be related to the content and composition of arabinoxylan in the bran fraction. Several of the markers related to fiber content were located very close to genes controlling plant development (Rht1, Rht2, Ppd-D1). This may relate to the fact that the plant developmental factors have strong effect on the compositional properties of the seed in this population.

Funded by projects GINOP-2.3.2-15-2016-00029, COST Action 18101, K112169, 2018-2.1.11-TÉT-SI-2018-00010, János Bolyai (MR) Fellowship. Rothamsted Research receives grant-aided support from BBSRC and the work forms part of the Designing Future Wheat strategic programme (BB/P016855/1).

### Keywords

Arabinoxylan, breeding, cereals, dietary fiber, triticum aestivum

## O.22 ENHANCING IPM APPROACHES IN THE UK

### Dhan BHANDARI

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Integrated Pest Management (IPM) may be regarded as a system that integrates all suitable methods of pest control to keep insect pests, plant pathogens and weed populations below the levels that cause economic harm. However, it has been difficult to implement as a widely adopted agronomic practice, particularly as it has been easier and cheaper for farmers to circumvent IPM by using cost-effective agrochemicals. Now, pressures are increasing rapidly for environmental change, both regulatory and socially, along with increasing pesticide resistance and the lack of new pesticides; thus, highlighting the urgency for implementing the solutions that an effective IPM system can provide.

The Agriculture & Horticulture Development Board (AHDB, UK farm levy board) has recognised the challenges in persuading UK farmers and agronomists to fully embrace IPM and to change their decision-making behaviour and ability to assess risk. It has currently invested in a major new IPM strategy that is building on high quality research undertaken in the UK and elsewhere globally and identifying and commissioning critical new research that is required to address the gaps in knowledge that will establish better links to practical husbandry. The new approach involves collaborative working with a range of leading organisations carrying fundamental research as well as practical research to develop new tools that will enable assessment of risk and facilitate decision-making on using chemical treatments only where necessary. The programme includes establishing the efficacy of alternative products (e.g. biopesticides) and alternative crop selection/husbandry and developing improved field monitoring and forecasting of pests and diseases.

AHDB will be working closely with industry to change long-standing behaviour to maximise the benefits of IPM to the food supply chain. This will be achieved through excellent research and knowledge exchange delivered by AHDB with best practice demonstrated on-farm. It will be particularly important to measure the impact that the new IPM practices, including cultivations, rotations, biopesticides and new varieties, may have on crop quality and marketability. Metrics measuring the success of the enhanced IPM approach include the use of AHDB's Farmbench tool, specifically adapted for assessing the financial impact on business. Data generated from AHDB's complementary Contaminants Monitoring project will be interrogated to ensure that there would be no increases in levels of mycotoxins such as DON and ZON arise and whether specific pesticide residues fall in commercial grain samples because of implementation of IPM anticipated in coming years. This approach will allow us to review and modify the AHDB IPM system to optimise its effectiveness

### **Keywords**

Integrated Pest Management, agrochemicals, decision-making, alternatives, pesticides

## O.23 EARLY WARNING DIGITAL SERVICE FOR CONTROLLING THE RISK OF MYCOTOXINS IN CEREALS

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Oats are clearly the most susceptible to Fusarium infection and toxin formation in Finland, and in Nordic countries. Since 2012, the Natural Resources Institute Finland (Luke) has developed a regional map-based forecasting model based on Finnish safety monitoring programme (FSMP). FSMP has been carried out as part of a National Quality Strategy in Finland since 1999. The aim of this programme has been the systematic analysis and documentation of grain quality and safety data, including the agronomic variables behind of each sample. The temperature and humidity of the growing season affect the Fusarium infestation and growth and the way they produce toxins. Fusarium molds infest cereals all the way through to harvest. The most critical points are the weather conditions for emergence, flowering and a few weeks before harvest.

The EU's Digital Single Market Strategy puts agriculture as one of the five industries that can be strongly promoted by digitalisation. The vision speaks of smart farming, which puts the farmer and his data warehouse at the heart of development. Inspired by this vision, Luke developed the Early Warning digital service from a map-based regional forecasting model. The goal of the service is to reduce the risk of mycotoxins by digitally integrating real-time information on farmer cultivation methods, measurements during the growing season and weather conditions, and incorporating this information with the grain in the chain.

The Early Warning service combines the 1x1 km 3-hour weather forecast of the Finnish Meteorological Institute and Luke's measurements of mycotoxins. The result of the service can be estimated with traffic light colors, which informs the farmer of the regional Fusarium risk. The farmer himself can also supplement and refine the forecast with his own farm information. The farmer may record data on seed quality, crop rotation, tillage and DON result for the previous year.

### **Keywords**

Mycotoxins, DON, risk estimation, early warning, mycotoxin control

## Session 7

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### Alternative Grain Crops II

## O.24 RE-DISCOVERING ANDEAN 'SUPERFOODS': QUINOA, KAÑIWA, KIWICHA AND TARWI

**Ritva REPO-CARRASCO-VALENCIA**

Andean Native Grains Research Centre (CIINCA), National Agrarian University La Molina, Lima, Peru

A fast-growing global population means an increasing need for more nutritious, affordable, and environmentally sustainable food. Currently, proteins from animal sources are an important part of Western diets. These proteins have a negative environmental impact in terms of greenhouse gas emissions and usage of land and water. Recent research also suggests that diets high in animal proteins could have negative effects on human health. Moreover, there are ethical issues related to the animal farming industry. By contrast, Andean grains such as quinoa (*Chenopodium quinoa* Willd), kañiwa (*Chenopodium pallidicaule*), Andean amaranth, kiwicha (*Amaranthus caudatus*) and tarwi (*Lupinus mutabilis*) are good sources of high-quality plant-based protein that is more environmentally sustainable. Compared to more common grains in Western diets, their proteins are of higher quality, as defined by the composition of amino acids. All Andean grains are rich in lysine, the first limiting amino acid in common cereals. Quinoa protein also has higher levels of methionine. These grains are very good sources of high-quality oils, with nutritionally adequate essential fatty acid compositions. In addition, both dietary fiber and flavonoid content are remarkable. In quinoa, the main flavonoids are quercetin and kaempferol, while in kañiwa they are quercetin and isorhamnetin. Quercetin content in kañiwa is particularly high. Flavonoids are phenolic compounds with important antioxidant, anti-inflammatory and anticarcinogenic properties. In addition to these health benefits, Andean grains grow in diverse environmental conditions and altitudes of up to 4000 meters above sea level. The starch of Andean grains has noteworthy rheological properties that make them promising ingredients for various food preparations. Traditionally, indigenous Andean populations have consumed them as whole grains or as flour for the preparation of stews, desserts, beverages and soups. In conventional bakery products, substituting wheat flour with 10% quinoa or 20% amaranth does not significantly affect consumer acceptability, while improving nutritional value. Due to the absence of gluten, Andean grain flours can be used for preparing gluten-free foods such as breads, pasta and beverages with enhanced nutritional and sensory properties. These grains are also increasingly being used as an alternative ingredient for foods targeted at celiac disease patients or gluten-sensitive consumers. Given their notable health benefits, Andean grains offer great promise for the development of functional food products and for novel applications in the culinary industry. Peruvian cuisine has been widely praised in Western media; Peru has been designated as the world's top culinary destination several years in a row. Global markets could offer an opportunity for the dissemination of Andean grain-based food preparations and recipes.

### **Keywords**

Quinoa, amaranth, lupin, gastronomy, Andean crops

## 0.25 IN SITU PRODUCED DEXTRAN AS FLAVOUR AND TEXTURE MODIFIER OF SORGHUM OR FABA BEAN ENRICHED WHEAT BREAD

**Kati KATINA**, Yaqin WANG, Ndegwa MAINA

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High fibre and plant protein enriched food consumption is increasing in popularity. However, the utilisation of wholegrains or plant proteins in bakery products are limited by the sensory characteristics. In bread production, for instance, above 30% of wholegrain sorghum or faba bean flour substitution results in undesirable attributes such as darker crumb color, lower bread volume, harder texture and bitter taste or beany flavour. Bitterness in wholegrain sorghum is caused by phenolic compounds, especially condensed tannins. Beany flavor in originating from lipid derived off-flavours. Microbial bioprocessing is a potential 'clean label' strategy to enhance acceptance, which can help improve the texture, nutrition, and sensory quality of wholegrain sorghum or faba bean enriched bread. The bioprocessing method can be tailored to produce functional metabolites such as enzymes, acids, and dextrans. The enzymes and acids produced may result in modification of nutrients and flavour active compounds. Dextrans are texture enhancing polymers, which reinforce the gluten network and bind water, resulting in increased volume, moisture mouthfeel, and crumb softness. Furthermore, previous studies showed that addition of hydrocolloids resulted in a decrease in perceived flavour intensities. Therefore, the improved bread structure due to dextran application might affect the flavour/taste perception of the final bread.

The present work aimed to evaluate: 1) the flavour and texture profile of the bioprocessed sorghum and faba bean bread vs control sorghum/bean bread, by a trained sensory panel; 2) the chemistry behind the flavour perception, by identification and quantification of flavour active compounds such as phenolic compounds (LC-MS), sugars (HPAEC-PAD), and acids (HPLC); 3) the effect of dextran application in controlling specific flavour (e.g bitterness and sourness) sensation of bread, using magnitude estimation.

The results demonstrated that bioprocessing with dextran production could modify the structure and flavour/taste of wholegrain sorghum and faba bean enriched breads. Dextran presence significantly increased softness, cohesive structure, and moisture mouthfeel of the bread compared to control. The dextran-enriched sorghum bread also showed markedly reduced intensity of sour smell/taste and bitter taste. Dextran was suggested to reduce the diffusion of taste molecules from the food matrix to the taste receptor cells thus giving less flavour perception.

### **Keywords**

Sourdough, dextran sorghum, faba bean, wheat bread

## Session 8

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### Milling and Bread Making Technology II

## O.26 MECHANISM OF ENDO-XYLANASE ACTION ON WHEAT MILLING PRODUCTS UNDER VARIABLE SOLID LOADINGS CONDITIONS

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Endo-xylanases are used in many cereal-based productions, to improve either processing or final quality of the product. However, the composition and microstructure of the plant cell walls in grains exhibit a huge variability between the different tissues of the grain and its milling fractions (bran, shorts, flour). Especially arabinoxylan is the main component of the cell walls in grain and exhibit very different structures in the starchy endosperm and the outer layers. It is the target of endo-xylanase but the structure variability largely limits the efficiency of the enzymes. Several xylanases have been very well characterized in diluted medium, but this does not allow anticipating their behaviour in real conditions such as food/feed processing. In real conditions, enzymes are confronted to a high solid content medium. This can be achieved in two ways: the solid phase can be constituted predominantly of the substrate of the enzymes, or the substrate can be entrapped in a solid matrix of other polymer(s) (starch, proteins...) on which the glycoside-hydrolases are inactive but which make their access to their substrate more difficult. Therefore the present study was designed to assess the mechanism of xylanases on different wheat fractions: whole grain flour, bran and white flour wheat bran under varying conditions of solid loadings (5 to 75% w/w). Two endoxylanases with different behaviours (solubilizing vs degrading) were tested on wheat fractions. The enzyme action was investigated through the solubilisation rate and the product profiles. On white flour the two enzymes achieved a total solubilization of AX whatever the water content. For wheat bran, AX solubilisation decreased with decrease in hydration with the two endoxylanases. However, the solubilizing endoxylanase was more impacted than the degrading one as 50% appeared as a threshold value beyond which solubilization no longer increased. The structure of the solubilized polysaccharides changed slightly with water content, as indicated by the evolution of the arabinose/xylose ratio of the solubilized products. The enzyme action in lowly and highly hydrated media and product profiles will be discussed in light of low field NMR relaxometry experiments investigating water dynamics and distribution.

### Keywords

Enzymes, arabinoxylans, white flour, whole grain

## O.27 EXPLORING DRY GRAIN FRACTIONATION AS A MEANS TO FINDING VALUE OPPORTUNITIES FOR BARLEY CONSTITUENTS

**Marta IZYDORCZYK**

Canadian Grain Commission, Winnipeg, Canada

Malting barley varieties are potentially the most profitable commodities for producers; however, barley selected for malting purposes has to meet stringent quality requirements. Excessive grain protein concentration is often the reason why barley is rejected for malting grade and sold at a lower price on the feed market. The objectives of this study were to explore dry grain fractionation as a means to valorize high protein malting barley by producing high fibre fractions for human nutrition and starchy fractions for adjunct brewing. Several malting barley varieties were milled into various streams using milling equipment commonly used in wheat milling without prior dehulling of the grain. The milling streams were combined into two high yield fractions, flour (50.2 to 51.6% yield) and fibre-rich fractions (with 41.5 to 43.7% yield), thus making the fractionation process commercially feasible. Various strategies to effectively partition the flour and fibre fractions will be discussed. The fibre-rich fractions were enriched in  $\beta$ -glucans, arabinoxylans, minerals, phenolic compounds, tocopherols, tocotrienols, and glutelins; they can be used as valuable food ingredients for prevention and/or control of many food-related health issues, such as obesity, high blood pressure, heart disease, diabetes, and certain types of cancer. The amount of  $\beta$ -glucans in the fibre fractions represented 88-91% of the total content of  $\beta$ -glucans originally present in the whole grain samples. Arabinoxylans contained in the fibre fractions represented 66-74% of the total arabinoxylans present in the whole grain, with the remaining portions partitioned between the flour fractions (5-7%) and the hulls (25-30%). The unique physicochemical properties of barley  $\beta$ -glucans and arabinoxylans and application of fibre fractions in food products will be discussed. The flour fractions substantially enriched in starch proved to be valuable adjunct material for a partial replacement of barley malt. Mashing experiments with up to 40% replacement of malt with flour fractions showed significant improvements of malt extract without any negative effects on malting quality parameters, such as wort beta-glucans, wort viscosity and the average degree of polymerization of starch dextrins.

### **Keywords**

Barley, grain fractionation, beta-glucans, arabinoxylans

## 0.28 THE ROLE OF WHEAT ENDOGENOUS LIPIDS AND THEIR ENZYMATICALLY RELEASED HYDROLYSIS PRODUCTS IN BREAD MAKING

Sara MELIS, Jan DELCOUR

KU Leuven, Leuven, Belgium

While lipids occur in wheat flour in only low levels (2-3%), they tremendously affect bread loaf volume (LV) and crumb structure. Lipases are lipid degrading enzymes. They are excellent research tools and potential alternatives for certain additives in bread making. Although the impacts of different wheat flour lipids on LV and crumb structure are quite well established, knowledge on the functional effects of their enzymatically released hydrolysis products in bread making is scarce. Likewise, the mechanisms underlying the impact of lipids on bread quality remain largely unclear.

In this context, we investigated **the role of wheat endogenous lipids and their enzymatically released hydrolysis products in bread making**. Hereto, lipases were used as research tools in bread making with different wheat flours. Two lipases for commercial bread making, one for degumming edible oils and one used in detergent compositions were applied. Conventional bread making flour as well as flour from soft wheat cultivar Alpowa and three hard near-isogenic wheat lines derived thereof were used. Dough and bread were prepared according to a straight-dough method. Dough liquor (DL), a fraction considered to be representative for liquid films surrounding gas cells in dough, was obtained by ultracentrifugation.

The **impact of lipids on bread quality** was studied by relating lipase-induced changes in the dough lipid population to those in bread LV. Conversion of endogenous lipids into their corresponding lysolipids increased LV. In spite of being minor flour constituents, lipids are thus excellent targets for improving bread quality. This positive effect of lipases was however restricted by the unavoidable accompanying release of detrimental free fatty acids. An appropriate balance between different types of lipids is thus crucial in bread making. We were able to propose in detail which reactions are preferably catalysed by a bread making lipase. Our findings are of use in the development of new lipases and wheat varieties for bread making.

Our experimental setup allowed to propose a **mechanism whereby lipids impact bread quality**. It entirely relies on the ability of lipids to directly stabilize gas cells in dough by aligning at gas/liquid interfaces. Although this mechanism is in line with recent views of other researchers, its validity could not be proven by relating lipase-induced changes in DL composition and properties to such changes in LV. An indirect impact on gas cell stability of lipids was demonstrated by evaluating the effect of lipase on dough rheology with an uniaxial dough extension test. Including lipase in the recipe significantly increased dough extensional viscosity. Altogether, we speculate that the impact of lipids on bread LV results from both their indirect and direct effect on gas cell stability. Our findings contribute to a unified theory on the role of lipids in bread making.

### Keywords

Wheat flour lipids, lipases, gas cell stability, dough liquor, dough uniaxial extension

## Session 9

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### Whole Grains

## O.29 WHOLE GRAIN FOOD DEFINITIONS– ARE WE REACHING A CONSENSUS?

### Alastair ROSS

AgResearch, Lincoln, New Zealand

Consumers who are aware of the health benefits of whole grains will look for products that are both tasty and have a high wholegrain content – something which is often visible based on the name of a product and logos that tout the wholegrain content. There is little controversy around a definition of whole grains as food ingredients. However agreement around definitions and logos for wholegrain foods is challenging as they are extremely diverse. Definitions underpin what foods can be labelled whole grain and how the wholegrain content can be highlighted to consumers. They also function as an incentive to product developers to increase the whole grain content of foods. Over the past fifteen years there have been many suggested wholegrain food definitions and different logos that have been used to make it easy for consumers to pick out wholegrain foods, yet there is still a lack of consensus, in part due to differences in laws surrounding labelling. Recent work to develop a wholegrain food definition has highlighted that labelling based on reporting the actual amount of whole grain in a product is the most practical solution, but that setting a threshold for when a food can be labelled as a ‘wholegrain food’ is difficult due to different cultural expectations around whole grains. Further, there is a current lack of specificity in the scientific literature on how much whole grain needs to be in a food in order for there to be benefits, not universal consensus on if foods labelled as ‘whole grain’ should meet healthy nutrition criteria or not. Thresholds for wholegrain foods should be grounded in the best possible science to ensure that whole grain labelling and logos retain credibility. The Whole Grain Initiative, an international consortium is working towards a consensus definition of a wholegrain food. Universal acceptance of both a definition and a logo framework will do much to simplify communication of the wholegrain content of food products and should be an important goal in the future. This talk will summarise some of the different definitions and labelling systems used, and highlight some of the controversial areas surrounding labelling with suggestions for where labelling of wholegrain foods may be going in the future.

### **Keywords**

Whole grain, Definition, Food, International

## O.30 GROWING THE BUSINESS OF WHOLE GRAIN IN THE AUSTRALIAN MARKET: 6 YEAR IMPACT ASSESSMENT

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Introduction: The Australia New Zealand Food Standards Code does not regulate the use of on-pack claims describing the amount of whole grain in foods. In July 2013, The Grains & Legumes Nutrition Council (GLNC) established a voluntary Code of Practice for Whole Grain Ingredient Content Claims (the Code) providing guidance for whole grain content claims, with cut-off values & suggested wording  $\geq 8$ grams,  $\geq 16$ g and  $\geq 24$ g per manufacturer serve (contains; high and very high in whole grain). The aim of this project was to report uptake of the Code by manufacturers, changes in numbers of whole grain products and claims on-pack since 2013 and 2016. Methods: An Impact Assessment of the Code was undertaken in August 2019, comparing current registered manufacturers (“users”) and their products to the total number of products in the market deemed eligible for registration through GLNC grain food product audits since 2013. Reporting focused on breakfast cereals; bread products; crispbreads, crackers, rice/corn cakes; rice, pasta, noodles, couscous, other grains (e.g. quinoa, buckwheat, freekeh), and grain-based snack bars. Results: As of June 30 2019, there were 33 Registered Users and 655 Registered Products in Australia and New Zealand representing 43% of eligible manufacturers and 65% of eligible whole grain foods. Three-quarters (74% and 76%) of eligible breakfast cereals and bread products were registered with the Code in 2019, followed by 62% of grain-based snack bars, whereas only 37% and 34% of crispbread, crackers, rice/corn cakes, and rice, pasta, noodles, couscous and other grains were registered. Since the last impact assessment in 2016 there has been a 28% increase in the number of whole grain foods making claims on-pack – including registered and unregistered products. Conclusion: Since 2013, uptake of the Code claims by industry has been strong, which has led to clearer, more consistent on-pack communication regarding whole grain content.

### Keywords

Whole grain, grains, food labeling, food regulation, public health

## O.31 WHOLEGRAIN PARTICLE SIZE AND POSTPRANDIAL GLYCAEMIA IN TYPE 2 DIABETES: A RANDOMISED CROSSOVER STUDY OF WHOLEGRAIN BREADS

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**OBJECTIVE** Wholegrain foods vary in the extent of their processing. We have investigated whether wholegrain wheat particle size in bread influences postprandial glycaemia in type 2 diabetes.

**METHODS** Four breads and three glucose standards were tested in randomised order. Postprandial glycaemia (iAUC) was measured in the three hours following consumption of four 100% wholegrain breads. Breads were made with: 100% roller-milled wholemeal flour (median grain size 75µm); 100% stoneground wholemeal flour (median grain size 640µm); 50% roller-milled wholemeal flour and 50% kibbled wholegrain wheat (median grain size 1265µm); and 40% roller-milled wholemeal flour, 30% wholegrain wheat, and 30% kibbled wholegrain wheat (median grain size 2240µm). Breads were fibre and macronutrient matched.

**RESULTS** Fifteen adults (64±10 years, HbA1c 58±13 mmol/mol, diabetes duration 11±8 years) completed the study. All breads produced a lower iAUC response than the glucose control (793 ± 297 mmol L-1min-1). The postprandial glycaemic response varied between breads, despite all being 100% wholegrain. The iAUC for the three breads made with commercially-milled flour ranged from 375-641 mmol L-1min-1, and there was an inverse linear trend for grain particle size  $P = 0.039$ . The iAUC for stoneground wholegrain bread (503 ± 327 mmol L-1min-1) was smaller than predicted from mean wholegrain wheat particle size.

**CONCLUSIONS** The structural integrity of whole grains in bread is a determinant of the postprandial glycaemic response. The extent to which whole grains are milled influences the speed of their digestion, with larger wholegrain structures improving postprandial glycaemia in adults with type 2 diabetes. These findings have implications for dietary advice and support a revision of the definition of the term 'whole grains'.

### Keywords

Wholegrain, glycaemia, type 2 diabetes, NCD management

## Session 10

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### Noodle Quality

## O.32 NOODLE QUALITY: A MOLECULAR APPROACH

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The relationship between wheat starch molecular structure and its physicochemical properties (swelling power, pasting and thermal properties) important for the eating qualities of noodles was examined. Swelling power was negatively correlated with amylose content and positively correlated with the amount of amylose long chains and short amylopectin chains. The peak viscosity of starch was negatively correlated with the amylose content and the amount of long amylopectin chains and positively correlated with the average length of longer amylopectin chains and the amount of short amylopectin chains. The onset and peak gelatinization temperatures were negatively correlated with amylose content and the degree of branching. Molecular mechanistic explanations for these observations are provided. This provides the first associations between starch fine molecular structures (instead of only amylose content) responsible for starch properties of importance in making noodles. This provides a potential additional tool for selecting wheat varieties for noodle manufacture.

### **Keywords**

Wheat starch, fine structure, swelling power, pasting properties, thermal propertioes

## O.33 UNVEILING THE IMPACT OF PROTEIN QUANTITY AND QUALITY ON TEXTURAL PROPERTIES OF COOKED PASTA

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The texture of cooked pasta is one of the key factors influencing the end use quality of durum wheat. It is well documented that protein concentration is important to pasta cooking quality. However, the relationship between gluten strength and pasta texture is complex and inconclusive. The objective of this study was to elucidate the impact of protein content, gluten strength, and their interaction on pasta cooking quality. Composites of three Canadian durum varieties (Brigade, CDC Verona and Kyle, representing strong, moderate strong and weak gluten, respectively) at various protein levels (11, 13, 15, and 17%) were prepared from 2017 harvest samples submitted by producers. Durum samples were milled into semolina using a four stand Allis-Chalmers laboratory mill, and spaghetti was produced with a customized micro-extruder and dried at 85°C. Pasta samples were cooked at fixed time of 8 min, fully cooked time (FCT, disappearance of white centre core), and over-cooked time (FCT+2 min). Textural properties were measured with TA-XT2i texture analyzer. For pasta made from durum with low (11%) and very high (17%) protein, gluten strength exhibited a minor impact on pasta firmness while the quantity of protein played a dominant role in texture at all three cooking times. The increase of wheat protein content from 11 to 17% resulted in ~75% higher pasta firmness for all three cultivars. Interestingly, the significant impact of gluten strength on pasta firmness was demonstrated in durum samples with medium (13%) and high (15%) protein contents, accounting for 40 to 52% variation in peak cutting force. Strong (Brigade) and moderate strong (CDC Verona) varieties had similar pasta firmness, but the weak (Kyle) variety showed significantly softer texture, particularly at longer cooking times. These results showed that impact of gluten strength on pasta firmness is protein content dependent. Pasta extruded from semolina with low or very high protein content will have a non-continuous gluten matrix (not enough to cover starch granules during cooking) or a very extensive gluten matrix, respectively. The impact of gluten strength on pasta texture is minimal at these two ends of protein content. The beneficial effect of moderate to strong gluten on pasta cooking quality was revealed at medium to high protein levels, commonly seen in commercial durum production in Canada. Developing durum wheat varieties with medium to high protein potential coupled with moderate to strong gluten is crucial to produce pasta with superior cooking quality.

### **Keywords**

Pasta, durum wheat, protein content, gluten strength

## O.34 MICROBES, BIOACTIVE COMPOUNDS, QUALITY CHARACTERISTICS, AND STRUCTURAL CHANGES DURING STORAGE OF FRESH QINGKE BARLEY NOODLES

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**Introduction:** With the improvement of people's health awareness, new trends in eating habits and consumer demand for functional wheat-based noodles have emerged. Hence, to meet the adequate intake of bioactive compounds in a human daily diet, it is necessary to develop wheat-based new multigrain food products. Fresh Qingke barley noodle (FQBN) is a convenient wheat-based product rich in bioactive compounds, and has been favored by Asian consumers. Nevertheless, due to the high initial microbe quantity and high moisture content, FQBN is prone to spoilage, and some physicochemical and structural changes occur during noodle storage. These changes have resulted in waste and potential food poisoning. Hence, it is critical to identify the types of quality changes during the deterioration.

Current study determined the total plate count (TPC), total mold count (TMC) changes, microbial diversity, bioactive components content, protein structure changes in FQBN during storage at  $25 \pm 1$  °C, which aims for a comprehensive understanding of the relationship between microorganisms, noodle quality and structural changes of protein during noodle deterioration. Results: An increase in TPC and TMC occurred after 12 h, and *Pantoea*, *Erwinia*, *Bacillus* for the bacteria, *Penicillium* and *Aspergillus* for the mold became dominant spoilage microorganisms at the end of storage. In addition, the microbial growth models were built for both TPC and TMC, and the microbial growth models were well fitted by Logistic model, with higher fitting precision. The fitting equations were  $Y=3.7642-3.7/[1+(t/26.597)^3.1]$ ,  $R^2=0.9942$  and  $Y=1.7553-1.7546/[1+(t/19.8)^3.4]$   $R^2=0.9999$ . Due to the polyphenol oxidization the total phenol and flavonoid contents decreased from 77 mg/100g and 36 mg/100g to 49 mg/100g and 18 mg/100g, respectively. The pH value, color, textural properties, and cooking quality decreased significantly ( $P < 0.05$ ).

Besides, the protein structure also changed with the increase of storage time. The disulfide (SS) bond content decreased from 2.9  $\mu\text{mol/g}$  to 1.6  $\mu\text{mol/g}$  while the free sulfydryl (SH) content increased 0.9-1.3  $\mu\text{mol/g}$ ; the cost of a significant reduction in  $\alpha$ -helix and  $\beta$ -sheets, induced an increase in the random coil with the deterioration of FQBN. The relative abundance of strong bounded water decreased while the relative abundance of weakly bounded water and free water increased, which indicated the destruction of the structure of protein encapsulating starch in FQBN. **Conclusion:** The shelf life of FQBN is 17 h at 25 °C. Changes of TPC, TMC, SS/SH bond content, protein secondary structure, and water state significantly affect the shelf life and noodle quality of FQBN. Therefore, using some preservatives and physical sterilization methods, as well as adding some fortifiers is the appropriate choice to enhance shelf life and improve quality of FQBN.

### Keywords

Fresh qingke barley noodles, microbe diversity, noodle quality, protein structure, water state

## 0.35 COOKING PROPERTIES OF ORIENTAL NOODLES CONTAINING HEAT-MOISTURE TREATED STARCH

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Oriental noodle is one of the staple foods in Taiwan, and is consumed as noodle soup or on its own. In order to suit a wide range of recipes, partial substitution of all-purpose flour with starch in the formulation is a common practice for the manufacturers to tailor the cooking and textural properties of noodles. However, information on utilizing physically modified starch, particularly for the starch after heat-moisture treatment (HMT), in the formulation is still limited. In this study, the flour formulations containing 10-30% (w/w) tapioca starch after HMT at 95-96 °C for 2 h then holding at either 50 or 80 °C for further 2 h were used for the preparation of oriental noodles. The swelling at 90 °C and pasting properties of the composite flour plus the cooking and textural properties of the noodles were also analyzed to elucidate the effect of adding 10-30% HMT starch with different temperature profiles on the properties of noodles. Results showed the swelling power of flour increased when starch was added, and the increasing extent depended on the ratio and HMT condition of added starch. With native starch, the swelling power increased considerably with increasing the ratio of substitution. In contrast, the increasing effect on swelling power was relatively marginal when HMT starch was used. A similar tendency was also observed for the increases in peak viscosity of composite flour during gelatinization. For the noodles, the inclusion of starch led to marginal changes in cooking loss and swelling index, regardless of the ratio and HMT condition of starch. The changes in tensile strength and hardness, however, were found to depend on the HMT condition of starch. With native starch, similar tensile strength but decreased hardness were observed as compared to those of the control. In contrast, increases in both textural properties were manifested when HMT starch was incorporated. The findings of this study not only demonstrate the effect of addition of starch on the properties of composite flour and oriental noodles, but also propose a viable means to tailor the characteristics of noodles by inclusion of HMT starch.

### **Keywords**

Oriental noodle, Starch, heat-moisture treatment, cooking properties, textural properties

# Session 11

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## Cereal Nutrition III

## O.036 UTILIZATION OF RESISTANT STARCH TYPE 4 IN BREAD – EFFECTS ON PHYSICAL AND NUTRITIONAL PROPERTIES

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Interest in Resistant starch (RS) as a food ingredient has been increasing because of its potential physiological benefits. Resistant starch resists digestion in the small intestine, passes to the colon and is fermented there by the gut microbiota. In comparison with conventional fibers, such as bran, RS generally results in end products with better sensory and nutritional properties. The aim of this study was to investigate the effects of resistant starch type 4 (RS4) supplementation on the bread quality as well as nutritional properties such as mineral bioavailability, bile-acid (BA) binding capacity and in vitro glycemic index (GI) values. For this purpose, RS4 samples were added into the bread formulation at different levels (15%, 20%, 25%). Wheat bran (WB) was also used at 15% level in the bread formulation for comparison.

RS4 supplementation of bread provided better appearance, crust color, loaf volume and texture than WB supplementation. Beside these positive effects on bread quality, RS4 supplementation also had favorable effects in the nutritional properties. The TDF content of the bread sample supplemented with RS4 was significantly higher as compared to the bread supplemented with WB at the same level. Bread samples supplemented with RS4 and WB had lower in vitro GI values than the control sample. However, RS4 supplementation caused a greater decrease in in vitro GI values of the bread samples compared to WB supplementation. Bile acid (BA) binding capacity of the bread samples increased significantly with both RS4 and WB supplementation. RS4 supplementation caused increases in Ca, Zn and Fe bioavailability values compared to the control bread, while WB supplementation resulted in lower mineral bioavailability values. The overall results indicated that RS4 can be a better dietary fiber source than wheat bran in terms of mineral bioavailability and BA binding capacity and RS supplementation level could be increased, without substantial adverse effects on bread quality.

### **Keywords**

Resistant starch type 4; in vitro glycemic index; bile acid-binding capacity; mineral bioavailability

## O.37 EFFECT OF BAKING ON THE $\alpha$ -AMYLASE AND $\alpha$ -GLUCOSIDASE INHIBITION OF DJULIS

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Djulis (*Chenopodium formosanum*) was traditionally used as one of the staple foods in Taiwan aboriginals. Besides starch and protein, it contains lots of phenolic compounds and was highlighted recently as a good source of functional foods in type II diabetes. It becomes interesting to know how the thermal process such as baking will affect their bioactivity. Phenolic compounds in cereal plants were found effective to retard glycemic response resulting by bread. In addition, baking process was reported to significantly improve the inhibition ability of black tea on enzyme ( $\alpha$ -amylase and  $\alpha$ -glucosidase). In this study, we tried to investigate the effect of different baking condition on the different parts (whole grain, dehulled grain and hull) of Djulis and the changes of their phenolic compounds. Results showed that, the best inhibition on  $\alpha$ -glucosidase (50%) and  $\alpha$ -amylase (70%) as well as total phenol and antioxidant capacity were found in the hull. After baking, the inhibition of  $\alpha$ -glucosidase and  $\alpha$ -amylase in Djulis hull were changed to 70% and 66%, respectively, which might be due to the significant changes of phenolic compounds. Further HPLC analysis showed that esculetin, rutin, chlorogenic acid and ferulic acid in Djulis might play an important role on the inhibition of enzyme ( $\alpha$ -amylase and  $\alpha$ -glucosidase) through blocking the active site of the enzyme.

### Keywords

Djulis, baking, glycolytic enzyme, polyphenols

## O.38 EFFECTS OF CHICKPEA (CICER ARIETINUM) ON METABOLIC DYSFUNCTION BY MODULATION OF GUT MICROBIOTA IN DIET-INDUCED OBESSE MICE

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The high prevalence of obesity is a major public health issue in modern societies. Visceral obesity has been shown to be closely associated with chronic inflammation, which may result in insulin resistance, type two diabetes, cardiovascular diseases, and fatty liver diseases. Food enters the gastrointestinal (GI) tract and interact with the microbiota therein. Recent studies have shown that an imbalance of the intestinal microbiota contributes to inflammation, obesity, and several metabolic disorders. The health benefits of healthy food have received great attention in recent years. Chickpea (*Cicer arietinum*) is reported to be a healthy ready-to-eat food, which is rich in fiber and bioactive compounds. Therefore, an animal model of metabolic syndrome, mice with a high-fat diet (HFD), was used in this study to examine the effect of chickpea as healthy supplement on modulation of gut microbiota. Our results indicated that chickpea (CP) inhibited hyperlipidemia in HFD-induced obese mice. In addition, the CP supplementation attenuated hepatic lipid accumulation and showed the effect on improving kidney function. By analysis of gut microbiota, the  $\beta$  diversity and NMDS revealed a distinct clustering of microbiota composition for each treatment group. CP fed mice were more abundant in *Clostridium saccharolyticum* and *Butyricicoccus pullicaecorum*, and the genus level of *Coprococcus* and *Butyricicoccus*, compared with the HFD group and these bacteria were reported to a depletion in obese individuals and even possessed the anti-inflammatory capabilities. We also used the Sorenson index (Sørensen–Dice index) to measure the similarity between microbiota at different diet, and showed the similarity of gut microbiota composition between each groups varied greatly. These results indicate that CP has promising bioactivity in regulating hyperlipidemia, hepatic steatosis and kidney function by modulating the composition of the gut microbiota.

### **Keywords**

Chickpea, hyperglycemia, fatty liver disease, kidney function, gut microbiota

## Session 12

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Milling & Bread Making Technology III

## O.39 THE WHEAT FLOUR/YEAST-BACTERIA MICROBIOME INTERFACE IN BREAD MAKING TO MODIFY THE AROMA, CRUMB, NUTRITIONAL AND SENSORY PROPERTIES OF BREAD

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Yeast and bacterial communities inhabit a sourdough starter to make artisan bread, and in this study the interactions of microorganism derived from Australian sourdough starters are shown to provide positive flavour, aroma, crumb and nutritional properties to bread. An investigation of Australian sourdough starters found that they contained *Saccharomyces cerevisiae* and *Kazachstania exigua* yeasts. When these yeasts were inoculated alone to ferment wheat flour in an extended fermentation, the bread had a heterogeneous crumb structure, a deeper colour and a distinctive chemical aroma profile than those made with commercial baker's yeast. When bread was made combining these yeasts individually and in combinations with lactic acid bacteria also isolated from these sourdough starters, including *Lactobacillus plantarum*, *L. brevis*, *L. rossiae*, *L. casei*, the bread aroma profiles and crumb structure were more distinctive, with compounds associated with sour aromas produced, altered crumb structures and preferred by sensory panels. The use of defined mixed cultures as the leaven in wheat bread-making, by exploiting the microbial diversity of artisan Australian starters, can produce bread with distinctive and attractive aromas, altered gluten structures and crumb properties. Diverse microbes interact with the macromolecules in dough in very specific ways to affect food quality and we argue that understanding the potential of microbes in the context of diversity in wheat flour from different wheat varieties is a new variable to be considered in achieving final product specifications.

### **Keywords**

Yeast, bacteria, dough, fermentation, flavour

## O.40 IMPACT OF ACIDITY IN LEMON CAKE ON BAKING POWDER REACTIVITY AND FINAL VOLUME

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The aeration of a cake is an important aspect of cake quality; the cake expansion during baking is driven by the water vaporization partly and for the most by the neutralization of the sodium bicarbonate (SB) by the acidic component from the baking powder mix. In the case of products like lemon cake, the low pH of the batter yield an early reaction of neutralization during the preparation of the batter, resulting in a reduced final cake volume (FCV). A low pH may also modify the starch gelatinization temperature and protein denaturation temperature. An overview of this challenge as well as solutions are proposed in this presentation.

A miniaturized baking platform was used consisting of a closed cabinet in which a mixer was installed and of a baking oven equipped with laser displacement transducers (LDT) to monitor the volume change of the cake during baking and cooling. A CO<sub>2</sub> analyzer was connected to the mixing cabinet and to the baking oven to measure i)CO<sub>2</sub> production during mixing and ii)the matching between the CO<sub>2</sub> release during baking and the height of the cake. An excess of CO<sub>2</sub> production in the early stage of baking had a negative effect on FCV. It appeared that a reduction of the neutralizing acid added in the batter had a positive effect on FCV, this latter being linked to the batter pH. An excess of acid component (even with low DRR) or a low pH yield an excess of neutralization of the SB during mixing; this solubilized CO<sub>2</sub> is released before the batter/crumb transition occurring at ca 95°C resulting in a peak in volume early during baking followed by a cake collapse (evidenced by the LDT). The CO<sub>2</sub> escapes from the batter too early, during the first step of baking. The starch gelatinization temperature as protein denaturation temperature were slightly lowered with decreasing pH but not enough to modify the batter-crumb transition. Gluten and egg denaturated proteins coagulate as a gel. This gel forms with starch, a skeleton that stiffens the structure. Recipe optimization and baking strategy are therefore closely linked and a strategy in optimization of the FCV is proposed.

### **Keywords**

Baking powders, ROR, cake, volume, aeration

## O.41 CHARACTERIZATION OF ZEIN-LUPIN PROTEIN DOUGH MADE BY COACERVATION FROM ETHANOL OR DILUTE ACETIC ACID PLUS HAND KNEADING AND SHEETING

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Maize has great potential for formulating gluten-free foods as it is readily available and inexpensive. However, zein, the maize prolamin proteins has severe limitations in leavened dough for bread making due to its hydrophobic and tightly-packed structure in the protein bodies, which prevents both the water absorption and protein inter-chain reactions needed for hydration and development of a viscoelastic gas-holding dough. There is evidence that the addition of a small protein to commercial zein (essentially  $\alpha$ -zein) can enhance its viscoelastic properties. Also research has demonstrated that the use of a small amount of Australian sweet lupin legume flour in wheat-based dough has the potential to improve the dough functional properties.

Therefore in this research, isolated lupin protein was combined with a commercial zein viscoelastic mass-type dough prepared either by coacervation from aqueous ethanol or with dilute acetic acid by hand kneading plus sheeting. The objective of this study was to determine if lupin protein can act as a co-protein to improve the viscoelastic properties of zein.

Zein prepared with aqueous ethanol and combined with lupin protein formed a sediment when coacervated with cold water. This was probably due lupin protein's insolubility in aqueous ethanol. However, combining the zein and lupin doughs separately prepared in dilute acetic acid and water, respectively produced a stable dough. This zein:lupin dough was cohesive with lots of entangled fibres. However, the rheological analyses revealed that this dough was far less extensible than a zein dough alone. Furthermore, when formed into a model bread dough, a zein: lupin-starch composite, it could not hold air nor be inflated into a bubble by the Alveograph. The absence of observable new molecular weight bands by SDS-PAGE; indicated that zein and lupin protein did not covalently interact to form a copolymer in any of the formulations. Notwithstanding this, zein-lupin protein dough has some but limited viscous flow and elastic properties. It is therefore proposed to investigate the use of lupin protein as co-protein with total zein (zein comprising all subunits and hence more cysteine residues than commercial zein), which may covalently bond the cysteine in lupin protein to produce a dough with better and more wheat flour-like functional properties.

### **Keywords**

Dough, Commercial zein, Lupin protein, Copolymer, SDS-PAGE

## Session 13

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Milling & Bread Making Technology IV

## O.42 ENZYMATIC APPROACH TO ALTERING STARCH FUNCTIONALITY

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Enzymatic modification of starch can modulate its functionality. Amylomaltase (4- $\alpha$ -glucanotransferase) is an enzyme which elongates amylopectin chains using amylose as a substrate. In this study, amylomaltase from *Thermus thermophilus* was used in situ during hydrothermal processing in a Rapid Visco Analyser wheat starch model system. Size-exclusion high performance liquid chromatography was used to study the changes in the fine molecular structure of amylose and amylopectin chains. Different enzyme dosages impacted starch properties in a different manner and three dosage categories could be considered. Under otherwise standardized conditions, at a low amylomaltase dosage [0.45 enzyme units (U)/g starch dry matter (dm)], hot and cold paste viscosities were significantly increased due to partial trimming of the longer amylose chains, which enabled better associations of amylose chains and the formation of stronger gels. Intermediate enzyme dosages (1.8 - 9 U/g starch dm) led to an increase of the peak viscosity by up to 7%, which was attributed to gradual, yet specific, degradation of amylose which facilitated starch swelling and, consequently, viscosity development. To the best of our knowledge, ours is the first report of an increase in peak viscosity as a result of in situ supplementation of a starch-modifying enzyme. At higher dosages (18 - 45 U/g starch dm), this effect was minimized probably due to simultaneous amylopectin degradation, whereas amylose was more intensively degraded resulting in very low cold paste viscosities. In parallel, it was shown that amylose fragments served as a substrate for the elongation of amylopectin branch chains. The elongation of amylopectin chains enhanced double helix formation, as confirmed by the increasing melting enthalpies measured with Differential Scanning Calorimetry. This study shows that different dosages of amylomaltase modify starch polymers resulting in novel functionality.

### Keywords

Starch-modifying enzyme, Starch pasting

## O.43 THE BALANCE BETWEEN OVEN RISE AND STRUCTURE SETTING IN POUND CAKE MAKING

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During baking, pound cake batter expands up to a point when the structure turns into a stable solid. The phenomena related to the structure formation are described as oven rise, starch swelling and gelatinization and protein network formation (PNF).

Egg yolk low density lipoproteins (LDL) are important in the stabilization of interfaces before and during baking. Changes in the lipoproteins (protein and lipid extractability) were monitored during baking and linked to batter and cake properties (oven rise, volume and texture). Lipid-protein interactions showed to be important during interface stabilization (oil-water and gas-water) in the batter and during oven rise. At the point of maximal oven rise proteins are incorporated in the network and more lipids appear as 'free'. However, adding 'free' yolk lipids in the recipe has a negative impact, showing the crucial role of the lipoprotein integrity for cake quality.

We unraveled the PNF and compared its importance to that of starch gelatinization and the related swelling. Starch suspensions, egg slurries and batters were studied with Differential Scanning Calorimetry (melting of starch crystals and denaturation of proteins) and Rapid Visco Analyser (changes in viscosity). This was done for different sugar concentrations. The conversion from liquid to solid was measured as viscosity increase during heating. At pound cake batter sugar concentrations, egg proteins initiate the PNF and that way the liquid-solid conversion. The main conversion is that when the egg white protein ovalbumin becomes involved. Wheat proteins gliadin and glutenin are far less important for the protein network than in bread making. Ovalbumin co-incorporates wheat gliadin and the proteins of LDL in the network. The incorporation of LDL proteins in the network therefore also determines the point of maximal oven rise. At this point, the gas cells open and the structure needs to be stabilized. The latter is guaranteed by a further swelling of gelatinized starch granules which completes the transformation. The timing of both PNF and starch swelling strongly depend on the sugar concentration, giving the latter also a crucial role.

To conclude, four components dominate the balance between oven rise and structure setting in the baking process: the egg white protein ovalbumin, the egg yolk lipoprotein, wheat flour starch and sugar. LDL mediates the oven rise, ovalbumin dominates the protein network formation, starch supports the conversion towards a solid structure, and sugar directs the timing of the whole conversion. This study therefore provides key points to aim for egg-free, gluten-free or sugar-free cakes.

### **Keywords**

Baking conversion, Structure formation, Oven rise, Gelatinization, Protein network

## O.44 IMPACT OF WHOLE CEREAL EXTRUDED FLOURS IN GLUTEN-FREE BREAD MAKING

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The use of wheat flour is essential in the production of bakery products since this technology depends largely on the technological properties of gluten proteins. Gluten is composed of glutenins and gliadins, responsible for the unique characteristic of appearance, color, taste, and texture in these products. Gliadins (prolamines) are the low molecular weight gluten fraction, which is directly related to the development of celiac disease in those individuals sensitive to wheat proteins, barley, rye and / or their derivatives. In addition, the over consumption of refined flours (white flours), where pericarp and germ are removed, is associated with the prevalence of obesity and other metabolic syndrome diseases, since these products are rich in digestible starch with rapid absorption in the intestine. In order to improve the texture of gluten-free breads, hydrocolloids (gums), starches, enzymes and physical pretreatments (hydrothermal, drying and extrusion) have been used to increase the viscoelastic properties of the dough to simulate the effect of wheat gluten. In this work, gluten-free whole grain flours of corn, rice and sorghum were processed at 25% moisture in a twin screw extruder at 200 rpm, total feed rate die temperature of 80 °C to produce non-expanded extrudates that were dried and milled into fine flours. The empirical rheological property using a Farinograph was used to measure water absorption (maximum consistency) of the raw and processed flours used to be further analyzed in an oscillatory rheometer, where viscous ( $G''$ ) and elastic ( $G'$ ) modules were measured in the linear viscoelastic region. The water absorptions of raw wholemeal wheat flour and the extruded flours of corn, sorghum and rice were 68.8, 100.3, 96.8 and 103%, respectively, obtaining the maximum consistency values of 500, 600, 720 and, 800 UB. Lower values of water absorption in the extruded flours lead to reduced bread volume. The baking test indicated that was not possible to obtain acceptable gluten free breads produced with 100% extruded processed flours, but blends (1:1) of extruded and non-extruded flours provided good gluten-free breads comparable to whole meal wheat flour in terms of crumb texture, air bubble distribution and specific volume. Addition of germinated flour of millet also helped to improve textural and other properties as a natural alternative of bread improver. Rheological data (frequency sweep) showed an interesting quick evaluation along Farinography to evaluate gluten-free formulation prior to baking test and non-severe thermoplastic extrusion can be used as important tool to improve viscoelastic properties of whole grain flours for preparing gluten-free wholemeal breads.

### **Keywords**

Bread dough rheology, whole grain cereals, extrusion cooking

## POSTER PRESENTATIONS

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

## 1. Cereal Nutrition

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## P-1.1 IS PROLONGED FERMENTATION DURING BREADMAKING EFFECTIVE IN REDUCING FRUCTANS THAT CAN CAUSE ABDOMINAL DISCOMFORT IN IBS PATIENTS?

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Abdominal discomfort from consuming wheat-based foods (often termed as “wheat belly”) can be attributed to several food components including fructans (an intolerance in patients with irritable bowel syndrome (IBS)), gluten (an immunological response in coeliac patients) or amylase trypsin inhibitors (ATIs) found in these foods. Reducing fructans by utilising processing techniques may alleviate discomfort in IBS patients when wheat-based foods are consumed.

Yeast-leavened bread doughs are baked after a short fermentation period, whereas sourdoughs require longer fermentation periods for leavening and are reported to be more easily tolerated by IBS patients. It is thought that a short fermentation period may contribute to bread intolerance by resulting in colonic fermentation of short-chain carbohydrates (such as fructans and sugars) present in the bread.

Twenty wheat bread doughs, using yeast and the same wheat flour but 19 different sourdough starters, plus a yeast only control, were fermented for 24 hours after mechanic dough development (MDD) mixing. Fructans were measured in the same dough at 0 hour and 24 hour time points. After 24 hours fermentation, fructan concentration was reduced in all doughs (by 35–100%), with the decrease being statistically significant (at the 5% level) in 10 of the 20 sourdoughs. Fructans were not detected in four of the sourdoughs after 24 hours fermentation. The control dough also showed a significant reduction (76%) in fructan concentration, implying that a sourdough starter is not necessarily required for a significant reduction of fructans, but perhaps the prolonged fermentation period is.

Therefore, a 24-hour fermentation period is effective in reducing fructans in bread doughs using yeast with or without a sourdough starter. The subsequent breads have potential to alleviate or minimise abdominal discomfort in IBS patients, which could have positive consequences for the health of IBS patients who still wish to consume wheat breads. This also provides a market opportunity for reduced-fructan or fructan-free wheat breads for IBS patients, who make up 15% of the worldwide population.

### **Keywords**

Fructans, FODMAPs, sourdough fermentation, wheat bread, irritable bowel syndrome (IBS)

## P-1.2 EFFECTS OF ADLAY (*COIX LACHRYMAL-JOBI L. VAR. MA-YUEN STAPF.*) FORMULA ON DYSMENORRHEA

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Chinese herbal medicine, nutraceuticals, functional food ingredient and dietary supplements are important for health improvement, and disease risk reduction. Naturally occurring dietary phytochemicals have been recognized for possessing many health-promoting effects. Moreover, many phytochemicals have been used in the treatment of female reproductive disorders such as dysmenorrhea, polycystic ovary syndrome (PCOS) and female-related cancer (breast, ovary and endometrial cancer). My laboratory study focuses on whether phytochemicals can improve female reproductive disorders in vitro and in vivo studies. We found that phytochemicals in cereal and herbal including adlay (*Coix lachrymal-jobi* L. var. *ma-yuen* Stapf.), licorice (*Glycyrrhiza uralensis*), and grape seed extracts could improve female reproductive disorders. In this presentation, we will review and focus on the important functions of adlay (*Coix lachrymal-jobi* L. var. *ma-yuen* Stapf.) hulls extract in female reproductive disorders including primary dysmenorrhea. Primary dysmenorrhea occurs as a result of over release of prostaglandins due to the destruction of the endometrial cells in the uterus. The present study aimed to investigate the adjuvant effect of adlay formula in reducing the symptoms of primary dysmenorrhea. This clinical trial conducted on students of the university. Each participant was randomly assigned to A or B group. The A group received 10 g of adlay formula in the period of the menstrual cycle. The B group received 10 g of placebo in the period of the menstrual cycle. The results show that adlay formula supplements effectively relieved menstrual pain compared with the placebo. Adlay formula supplements effectively decrease PGF2 $\alpha$  and testosterone release compared with the placebo. The dysmenorrhea symptoms also decreased after adlay formula interventions. Since the classic medical treatments have significant side effects in some consumers, we recommend the use of dietary supplements from cereal to reduce the symptoms of primary dysmenorrhea and promote overall female health. The current knowledge is also useful for the development of functional food for promoting female health.

### **Keywords**

Adlay, dysmenorrhea, smooth muscle, uterus contraction

## P-1.3 BIOMARKERS FOR WHOLEGRAIN CEREAL INTAKE – OVERVIEW AND APPLICATIONS

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Wholegrain cereal foods are associated with reduced risk of a wide range of diseases, yet a lot of the intervention study evidence for whole grains having an effect on markers of disease risk is mixed. A key contributing factor to the mixed evidence is the problem with accurately recording the wholegrain foods people have eaten, and the amount and type of whole grains they have eaten. Wholegrain cereals are particularly tricky due to their diversity and wide range of foods that they can be found in, as well as obtuse labelling of the wholegrain content of foods and difficulty in accurately recognising foods that contribute to wholegrain intake. An independent method for assessing wholegrain intake without relying on diet recall methods can help to improve estimates of wholegrain intake. Several biomarkers of wholegrain intake have been proposed, which cover wheat, rye, barley and oats, and the pseudocereal quinoa. An increasing body of literature supports their use and has found that supplementing diet recall data with biomarker data can help to improve estimates of wholegrain intake and identify when compliance to interventions is inadequate. Additional applications include identifying gluten intake and proportion of different cereal grains consumed. However there remains a need to identify markers of brown rice and corn intake, as well as other less commonly consumed cereals and pseudocereals, and a need to expand application into populations outside of Europe. Use of biomarkers of wholegrain intake are becoming an essential component of clinical and population-based work studying the effect of whole grains on health.

### **Keywords**

Whole grain, biomarker, alkylresorcinol, nutrition

## P-1.4 LEMON CAKE REDUCED IN SUGAR AND REMOVAL OF BAKING POWDERS

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CAKERS project aims at developing pound cake reduced in sugar with a reduced caloric response. This main objective will be achieved by reformulating the cake using a specific sweetener, Miraculin (a glycoprotein contained in the fruit of *Synsepalum dulcificum* delivering sweet taste in acidic food) and bulking agent. One originality of the project lies in the fact that an acidification of the cake will be targeted; this acidification will be used as a mean i) to control starch gelatinization temperature and to mitigate the depression of the gelatinization temperature when sweeteners are used, ii) to be able to obtain sweet taste from Miraculin (N3S project – New salt-sugars substitutes), iii) to support shelf life issues.

Cake contain ca 25% of sugar (sugar= saccharose /sucrose). Sucrose has a major functional role during baking and shifts the gelatinization temperature of starch at ca 90°C (~60°C for bread). The 50% water-sucrose syrup contained in the batter is also able to solubilize gliadins, providing specific batter rheology. In such conditions, starch gelatinization is partial and covers a partial loss of crystallinity and the melting of non gelatinized starch polymers. When sweeteners are used in a cake, the gelatinization temperature is usually depressed, resulting in a higher level of starch gelatinization, and potentially in a higher glycaemic response during cake consumption. Another issue lies in the increase in water activity addressing shelf life issues. An acidification of the matrice is proposed to i) increase the gelatinization temperature, ii) reduce the degree of starch gelatinization and iii) lower the water activity to mitigate the risk of mold growth. In this project, we also intend to take benefit of Miraculin as a sweetner.

This project aims, under a global approach, at investigating the impact of the incorporation of selected sweeteners/bulking agent and the impact of acidification on pound cake structure, texture, sensorial acceptance and overall caloric value. According to the European regulation, a cake “reduced in sugar” (-30% vs control) must also correspond to a substantial reduction of the caloric value (-30%); however, such claim (reduced in vs -30% calory) is impossible to reach. The challenge is therefore to support the “no added sugars” claim, requiring further efforts that will be presented based on miraculin.

### Keywords

Sucrose, sweeteners, reformulation, structure, miraculin

## P-1.5 SUBSTITUTION OF BAKING POWDERS IN A POUND CAKE BY MIXING UNDER CO<sub>2</sub> PRESSURE

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The baking powders (BP) are usually a mix composed of an acid component such as pyrophosphate (SAPP) and of an alkaline component, usually sodium bicarbonate (SB). The neutralization of the BP occurs partly during mixing and then during baking, resulting in water and CO<sub>2</sub> production in the liquid phase of the batter. CO<sub>2</sub> is first solubilized in the dough and is converted to gas during baking (thanks to the temperature rise) resulting in the aerated cake structure.

Phosphates based ingredients are under scrutiny by the medias and consumers, and in a general context of "clean label" reformulation, the baking industry is looking for the suppression or replacement of phosphate based acids or eventually of the whole BP.

This study aims at a full suppression of the BP by mixing the batter under selected gazes at different pressure in a prototype spiral mixer – VMI-France (Sadot et al., 2017). A comparison was done between air and CO<sub>2</sub>, at atm. Pressure and at 0.3 atm. Several parameters were studied to compare physicochemical and structural properties of the batter and the cake (with and without BP) such as batter aeration, batter pH, specific volume (SV) of cake and cake color.

Mixing under air didn't result in an increase in the SV of the cakes, whereas cakes prepared under CO<sub>2</sub> mixing at 0.3 atm. had a significantly higher SV compared to the control without BP (+16%) and to other commercial cakes (+9%). In addition, cake prepared under CO<sub>2</sub> had a softer texture compared to the cakes prepared without BP, and had a lighter color (increase of lightness by +5-10%). It is assumed that the CO<sub>2</sub> solubilization during mixing was the major reason for obtaining such result. During baking, the solubilized CO<sub>2</sub> was vaporized resulting in the cake expansion and to the obtention of an enhanced cake volume. Indeed, the pH of the batter was lowered in the case of mixing under CO<sub>2</sub>, indicating that the CO<sub>2</sub> gas was effectively solubilized in the batter during mixing (thanks to the presence of H<sup>+</sup> ions present in solubilized H<sub>2</sub>+CO<sub>3</sub><sup>-</sup>). Besides, the pH of all cakes except with BP, was similar (without BP and with pressurized air or CO<sub>2</sub>), indicating that all the CO<sub>2</sub> escaped from the batter during baking.

As a conclusion, the use of mixing of cake batter under CO<sub>2</sub> gas under pressure appeared as a relevant alternative to the use of BP. This finding was revealed in a patent from 1949 (No. 6052150-BAKER PERKINS LIMITED, UK). However, more research is needed to optimize the mode of preparation and the mixing strategy.

### Keywords

Mixing, pressure, carbon dioxide, cake, aeration

## P-1.6 A HEALTHY CHOICE: COLOR WHEAT OVER WHITE WHEAT

**Saloni SHARMA**, Monika GARG, Pragyanshu KHARE, Mahendra BISHNOI, Kanthi K KONDEPUDI

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**Scope and Relevance:** Consumption of cereals as whole grains are well known to play a significant impact on healthy living. Among staple crops, wheat is the cereal that can be consumed easily as whole wheat products in different forms like bread, noodles, cakes, muffins, etc. Health benefits of whole wheat are also reported by several researchers because of the presence of various bioactive components in various layers of whole wheat grain. However, the presence of anthocyanin in color (pigmented) wheat has added up the whole wheat in top of the health-promoting cereals. Anthocyanins are plant pigments recognized as strong antioxidants and known to impart protecting/preventing effects against the development of obesity and other lifestyle disorders. No doubt, dark-colored fruits, and vegetables are rich sources of anthocyanins but they are seasonal, difficult to store for a long period and not easily accessible to common men of developing and underdeveloped countries. Henceforth, the current study was designed to compare an effective response of anthocyanin-rich color and white wheat on a high-fat diet (HFD) induced alterations.

**Methods and Results:** Swiss albino mice were fed with HFD supplemented with isoenergetic white, purple and black whole wheat for 12 weeks. They were evaluated physiologically and biochemically along with gene expression investigation by qRT-PCR. Moreover, with transcriptome analysis in adipose and liver tissue, we tried to gain insight into the molecular mechanism. Black wheat observed to significantly reduce the body weight and fat pad gain. Black and purple wheat also significantly reduced the total cholesterol, triglyceride and free fatty acid levels in serum besides the restoration of blood and insulin resistance. RNA seq analysis revealed the activation of antioxidative enzymes, fatty acid balancing and insulin signalling relevant pathways, which further lead to a surge in fatty acid  $\beta$ -oxidation markers and antioxidation genes providing an insight into the preventive mechanism in adipose tissue. However, RNA seq analysis in the liver revealed that whole white wheat also maintained the fatty acid balance likes that of black and purple wheat. Observed results were also supported by qRT-PCR analysis.

**Conclusion:** Our results provide evidence that incorporating colored wheat (especially black wheat) in our daily diet can protect from obesity and its co-morbidities.

### Keywords

Anthocyanins, whole wheat, obesity, high fat diet (HFD), colour wheat

## P-1.7 CONCENTRATION OF AVENANTHRAMIDES IN VARIOUS OAT FOOD PRODUCTS

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Avenanthramides are nitrogen containing phenolic compounds typical to oats (*Avena sativa*). They have been extensively studied over the years e.g. because of their antioxidative and anti-inflammatory properties.

Avenanthramides withstand various food processing steps relatively well, and thus can be found in food products such as oat drinks, breads and breakfast cereals. In the current study concentrations of the three major avenanthramides, namely 2c, 2p and 2f, in some commercial oat products were analyzed by high performance liquid chromatography with diode array detector (HPLC-DAD).

In soft breads (n=6) the sum of avenanthramides 2c, 2p and 2f was 5.2–24.6 mg/kg in dry weight (DW); in flours and flakes (n=7) 12.7–24.8 mg/kg DW; in crispbreads, crackers and cakes (n=4) 5.0–5.5 mg/kg DW; in breakfast cereals (n=5) 6.8–15.4 mg/kg DW; in oat drinks and yogurt (n=4) 9.0–30.6 mg/kg DW, and in traditional Finnish dish, talkkuna, (n=3) 7.6–15.8 mg/kg DW, respectively. Cooking oat porridge in a microwave oven or in a saucepan did not affect the concentration of avenanthramides. Currently in Finland, more in-depth studies are underway to produce new information on oat-based raw materials for the development of novel oat innovations by means of both research and business development.

### **Keywords**

Oats, avenanthramides, food

## P-1.8 THE GLYCEMIC INDEX OF RICE-PULSES NOODLES

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Rice noodles is widely consumed by ethnic Chinese, the glycemic index of pure rice noodle is slightly lower than cooked rice with similar shortage of lower dietary fiber and protein content. Starchy food replaced by 50% of pulses has been shown to reduce glycemic responses and with more balanced nutrition in terms of higher dietary fiber and protein content. The purpose of this study is to test whether the addition of pulses such as lentil and chickpea can reduce the glycemic index of rice noodle or not. Rice was mixed with lentil or chickpea at a ratio of 10% or 20% to make rice-pulse noodle. Each rice-pulse noodle sample was subjected to equal cooked and grinded treatment. Different samples were in vitro digested in a GI analyzer (NutriScan/RS20) with digestion enzyme and buffer. Digested glucose was determined by a glucose analyzer (Analox GL6). Total starch content is measured by Total Starch Kit (Megazyme Co.). The determined value of available carbohydrate, glucose released, percentage starch digested, area under the curve, hydrolysis index (white toast as reference) were employed to calculate expected-predicted GI with both Grandfelt and Goni equation. The results showed the predicted GI of all rice-pulse noodles compositions did not differ from the 100% rice noodle control. The percentage content of slowly digestible and resistant starch (SDS/RS) is average 4.2/0.3 and 6.0/6.2 in 10% and 20% inclusion of pulses, respectively. The content of SDS is similar in both rice-lentil and rice-chickpea noodles, but RS is higher in lentil-rice noodle sample. The results indication inclusion of 10-20% of pulses was not sufficient to reduce GI of rice-pulse noodle but can increase content of RS.

### Keywords

Glycemic index, slowly digestible starch, resistant starch, rice noodle, pulse

## P-1.9 LOWER STARCH DIGESTIBILITY IN WHITE WHEAT BREAD SUPPLEMENTED WITH MALTOGENIC AMYLASE

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Bread is a staple food worldwide. It has a high glycemic index. In the last decades, significant progress has been made on enzymatic approaches to in situ modify starch during bread making, enhancing breads's sensorial properties and prolonging its shelf life. A characteristic example is maltogenic amylase which has been widely used as an anti-crumb firming agent. However, the potential of maltogenic amylase to reduce starch digestibility in bread has never been explored. Here, in a dose-response approach, breads were supplemented with 0, 1.6, 4.6 and 7.2 enzyme units/g flour and bread crumb firmness and resilience, starch retrogradation and in vitro starch digestibility were studied for fresh and stored breads. Dough manageability was not impaired due to enzyme usage. For fresh breads, bread loaf volume and initial firmness did not change upon enzyme supplementation, while resilience was decreased due to partial amylose degradation. During storage, enzyme supplemented breads presented significantly lower crumb firmness with increasing enzyme concentration. Upon enzymatic activity, the amylopectin chains are shortened and less retrograde during bread storage, as indicated by the decreased amylopectin melting enthalpies studied with differential scanning calorimetry. Consequently, the lower starch retrogradation can be held responsible for the lower crumb firmness. Very interestingly, in an in vitro gastrointestinal digestion assay, the extent of starch digestion gradually declined up to 19% with increasing enzyme dosages for fresh breads, while the digestion rate did not change. Upon storage, the same decrease on the extent of digestion was observed while the digestion rate was moderately reduced due to partial starch retrogradation. Apparently, pancreatic amylase cannot efficiently digest the shortened amylopectin chains due to steric hindrance close to the branching point and/or unsaturation of the active subsites, lowering the extent of starch digestion. In conclusion, supplementation with maltogenic amylase was shown to drastically decrease the extent of starch digestion with a parallel improvement of bread crumb texture. Appropriate dosages of maltogenic amylase can be selected to produce tailor-made breads with softer texture during storage and potentially attenuated glycemic responses, allowing to get the best out of the daily consumed bread.

### **Keywords**

White wheat bread, crumb firmness, in vitro starch digestion, maltogenic amylase

## P-1.10 MARKETED INSECT-BASED-PASTA, WHAT IS THE CURRENT STATE? A NUTRITIONAL AND TECHNOLOGICAL STUDY.

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During the last years the demand for the new alternative sources of proteins has growth. One of the alternatives is represented by the edible insects thanks to their relative low water and energy requirements for the production. For those reasons, lately food market is putting more emphasis in the production of new foodstuffs made by edible insects. Insects based pasta, is becoming increasingly present in the world food market and therefore available for the consumers. The aim of this study was to analyze the commercial insect pasta under the nutritional and cooking performance point of view comparing with the traditional ones made with and without eggs. For this purpose, two wheat durum commercial pasta Control 1 and Control 2 (eggs) and three commercial pasta made by insect flour were chosen. As declared on the package by the manufacturer S1 was composed by wheat durum flour and cricket flour (20%). S2 was made by wheat durum flour, *Alphitobius diaperinus* flour (14%), dehydrated egg white and dehydrated basil (1.5%) while S3 was based on spelt flour, cricket flour, eggs and salt. About the energy value, all the pasta containing insects were characterized by a low caloric density compared to their controls. The same trend was observed in the carbohydrate content although insect pastas were richer in fat and protein content. Cooking quality indicators were evaluated for: optimal cooking time (OCT), water absorption (WA) and swelling index (SI). To get the OCT, insect-based pasta needed less time than the controls. During cooking, pasta with insect flour lost more solids and the control with eggs showed the highest value. S1 with cricket flour and Control 2 (eggs) displayed the lowest and highest WA and SI respectively. Pasta containing insect flour could represent a valid choice for the protein daily intake but from the other hands technologically improvements are required to enhance the cooking quality performances.

### **Keywords**

Pasta, insect pasta, nutritional quality, technological quality

## P-1.11 IMPACT OF ADDITION OF AYOCOTE BEAN (PHASEOLUS COCCINEUS) AND BLACK BEAN (PHASEOLUS VULGARIS) FLOURS IN BREAD MAKING: NUTRITIONAL AND QUALITY EVALUATION

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Bread is consumed worldwide because it is a versatile product; usually, made from wheat flour; however, recent studies have innovated this product to make it healthier and more sustainable. Additionally, legumes are known for their high nutritional value, bioactive components, antioxidants and other phytochemical components, and some of those legumes are underutilized and only consumed locally. Ayocote bean (*Phaseolus coccineus*) is an underutilized legume, and black bean (*Phaseolus vulgaris*) is one of the most popular beans used in traditional cuisine. The objective of this study was to evaluate physicochemical composition, nutritional value, and sensorial quality of bread with substitution of wheat flour with ayocote bean (*Phaseolus coccineus*) or black bean (*Phaseolus vulgaris*) flours, at 10, 20 and 30%. Ayocote and black bean contain 21.06 and 23.94% of protein, and 3.06 and 5.21% of crude fiber, respectively. Those components increased in bread manufactured with ayocote bean and black bean. Protein digestibility was not improved using bean flours in bread formulation, mainly by the higher fiber content. In bread's characterization, black bean and ayocote bean's addition decreased specific volume when replacement percentage was 30% black bean and 20 and 30% for ayocote bean. The color was affected mainly by the beans coat. According to the results, black bean and ayocote bean can replace wheat flour at 10% without altering sensorial aspects. Accordingly the obtained results, wheat bread can be improved in the nutritional and quality characteristics when legumes substitute wheat flour at 10 and 20%; however, in 30%, it affects drastically those characteristics.

### **Keywords**

Bread, ayocote, black bean

## P-1.12 IN VITRO STARCH DIGESTION: CHALLENGES WHEN SETTING UP CONDITIONS

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Starch hydrolysis increases blood glucose levels, which have been correlated with metabolic disorders. Due to this statement, there is great interest in modulating starch digestion. In this context in vitro studies based on enzymatic reactions offer a very good alternative to evaluate starch or starch-based food digestion. In fact, in the last decade, in vitro studies have been continuously used for evaluating the impact of ingredients and processes on starch digestibility. Nevertheless, the range of conditions reported does not always simulate the human body scenario in the most accurate way, bringing difficulties to make comparisons. Enzymes used in the in vitro studies include alpha-amylase (AM) and alpha-glucosidase (AG), but different substrates (type and concentration), enzyme level, reaction conditions, and reagents type have been reported. The aim of this project was to set up an in vitro starch digestibility comparable to human body reactions. Different substrates, enzyme concentrations, and reaction times were tested to design the optimal approach. To set up the reaction condition with AM from porcine pancreas, different gelatinized wheat starch concentrations were tested (0.5 to 5 mg/mL in the reactive medium), as well as different enzyme concentrations (1, 5, and 10 U/mg starch) besides the presence or not of CaCl<sub>2</sub>. Concerning AG from *Saccharomyces cerevisiae*, starch, maltotriose, maltohexose and maltose were tested as substrates, and different AG concentrations (0.125 and 0.25 U/mg maltose) were tested. All results were subjected to statistical analysis. In setting up the optimal conditions, the minimum level of reagents and the shortest reaction time were determinant factors. For AM reaction, 5 mg/mL of gelatinized wheat starch in the reaction medium was the best substrate and level tested, and 10 min of incubation at 37°C was selected. As for enzyme concentration, 1 U/mg starch gave the best results. No significant differences were observed in the presence or absence of CaCl<sub>2</sub> in the reaction medium. To stop the reaction and to quantify released sugars as reaction products, 3,5- dinitrosalicylic acid (DNS) was used. Similar conditions were set up for the AG procedure. Although starch, maltotriose, maltohexose and maltose were tested as reaction substrates, maltose led better results. Therefore, 8 mg/mL of maltose in the reaction medium was used as a substrate, which was hydrolyzed with 0.125 U AG/mg maltose at 37°C for 10 min. After stopping the reaction by boiling in a water bath, the GOD-POD method was employed to quantify the glucose released as the reaction product. Results highlighted the significance of the methodology used in in vitro digestibility by AM and AG. Setting up methodology conditions of the enzymatic reactions results crucial for carrying in vitro digestibility of starch.

### Keywords

Alpha amylase, Alpha glucosidase, In vitro digestibility, Starch, Maltose

## P-1.13 HIGH-QUALITY GLUTEN-FREE SPONGE CAKE WITHOUT SUGAR: THE EFFECT OF NATURAL SWEETENERS ON TECHNOLOGICAL QUALITY AND NUTRITIONAL VALUE

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The coexistence of celiac disease (CD) and diabetes is increasing due to CD recognition in patients with type 1 diabetes, but also due to the development of type 2 diabetes in CD patients resulting from the unbalanced gluten-free diet. Many commercial gluten-free products are characterized by a high glycaemic index (GI), mainly due to high sugar and fat content.

This study aimed to evaluate the effect of total sucrose replacement with the mixture of natural sweeteners on the quality of gluten-free sponge cakes (GFSs) assessed based on selected technological parameters, nutritional value, and sensory descriptors. For this purpose, whole sugar (14 %) in the control recipe was replaced with the equivalent amount of fructooligosaccharides (FOS; Beneo, Belgium). Additionally, one of the polyols was added to the GFS formulation: sorbitol (SRB), xylitol (XLT), maltitol (MLT), erythritol (ETH) or isomaltitol (ISM) (Hortimex PLUS, Poland) in an amount providing half of the sweetness of sugar. Physical parameters, chemical composition, textural profile during storage, sensory quality (QDA), and the *in vitro* GI (Megazyme, Ireland) were analyzed in the GFSs. Compared to control, ETH was characterized by a significantly ( $p < 0.05$ ) higher specific volume and lower bake loss. The crust of all GFSs, regardless of the kind of polyol used in formulations, was significantly ( $p < 0.05$ ) darker ( $L^*$ ), redder ( $a^*$ ), but less yellow ( $b^*$ ) than of the control. According to instrumental texture analysis, fresh SRB and XLT had significantly ( $p < 0.05$ ) softer, more springy, and less gummy and chewy crumb, comparing to the control. The 72 h storage improved the texture profile of SRB, which becomes softer, less gummy and chewy than the fresh crumb, contrary to other GFSs. Among GFSs with sweeteners, ISM showed the lowest overall sensory quality ( $p < 0.05$ ) compared to the control, while SRB received the highest marks and was characterized by the intense sweet taste, although it was also the most pungent. SRB exhibited a 10 % lower GI value than the control. The results obtained allow us to conclude that sucrose in the GFS recipe could be successfully replaced with a mixture of FOS and polyols, and produce a GFS of appropriate technological parameters and high sensory quality, comparable to the control. Among GFSs with sweeteners, SRB could be proposed to patients suffering from CD with concomitant diabetes as a high-quality, palatable product with potential health benefits resulting from low GI.

### Acknowledgment

The research was financed from the statutory funds of the Department of Chemistry and Biodynamics of Food IAR&FR PAS in Olsztyn. EIT Food RIS Fellowships program was the financial support of the scholarship of Aiga Vespere in IAR&FR PAS in Olsztyn.

### Keywords

Sucrose replacement, gluten-free cake, dietary fibre, sensory quality, glycaemic index

## P-1.14 EVALUATION OF PHYSICOCHEMICAL, TEXTURAL AND GLYCAEMIC PROPERTIES OF EXTRUDED CORN SNACKS ENRICHED WITH RICE BRAN

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Cereal-based snack products are ranked as high glycaemic index foods. Dietary fibre addition to these products represents an excellent strategy for developing ready-to-eat snacks with healthy nutritional benefits and good structural characteristics at the same time.

The aim of this work was to investigate changes in physicochemical, textural, and glycaemic properties of ready-to-eat extruded corn snacks enriched with rice bran (RB). Moreover, rheological properties of extrudate doughs were investigated to relate product structure to the glycaemic response after in vitro digestion. Snack products were supplemented with the by-product of rice milling at 10 and 15%. A co-rotating twin-screw extruder was used with a feed moisture content of 16 g 100 g<sup>-1</sup>, a screw speed of 240 rpm, and four heating sections of the barrel (100, 140, 150, and 150 °C). Nutritional profile, starch digestion, physicochemical and textural properties of snack products were evaluated. RB-enriched extrudates showed a lower specific volume and hardness, and higher crispness than control. RB at 15% gave a water holding capacity lower than control. Rheology of extrudate dispersions indicated an increase in elastic interactions and solid-like behaviour with RB supplementation. Differences in rheological properties resulted in attenuation of predictive glycaemic response for RB enriched snacks. RB can be successfully included in ready-to-eat extruded snacks to improve nutritional properties and modulate starch digestion.

### **Keywords**

By-product, Dietary fibre, Extrusion cooking, Rheology, Starch digestion

## P-1.15 EFFECTS OF PROCESSING CONDITIONS ON THE FODMAP CONTENTS OF COMMON WHEAT AND RYE BREADS

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Over the last years, there have been intense discussions about the tolerability of cereals and cereal products. A clear medical diagnosis can prove or exclude celiac disease or wheat allergy (0.5 and 0.1% of the population, respectively). In the latter case, patients suffer from the so-called irritable bowel syndrome (IBS), one of the most common functional and often chronic intestinal dysfunctions. Since the symptoms vary greatly between patients and the discussed causes of IBS are diverse, a clear diagnosis is difficult. For approximately half of the patients, a food intolerance can be identified as the most probable cause. Those affected suffer from bloating, abdominal pain, flatulence and diarrhoea, which impairs their quality of life.

Intolerable in this case, are indigestible, osmotically active carbohydrates in the food that can be fermented by intestinal bacteria, summarized under the acronym "FODMAP". These are fermentable oligo-, di-, monosaccharides and polyols. These carbohydrates occur naturally in various foods, including cereals and cereal products. Since baked goods made from wheat and rye are widely consumed, it is of interest to investigate how changes in baking recipes and processes can reduce the levels of the triggering carbohydrates. From existing literature, it is known that rye contains more fructans (main component of FODMAP) than wheat, and in both cereals the fructans are enriched in the outer layers (bran) of the grain. Laboratory experiments have already shown how prolonged fermentation of bread doughs can reduce FODMAP levels.

In the present study, it was investigated to what extent different baking procedures, established in practice, influence the FODMAP content in the respective baked goods. For this purpose, baked products based on different wheat and rye flours were produced according to standard baking procedures, including the use of sourdough. Both raw materials and products were analysed chromatographically using HPAEC-PAD (high performance anion exchange chromatography with pulsed amperometric detection) for the content of relevant carbohydrates and the fructan contents were determined enzymatically according to AOAC 991.03.

For classic wheat breads, an extension of the fermentation time by 20 min resulted in a reduction of both fructans and total FODMAP content by about 50% each. The use of sourdough also reduced the fructan content, but the fermentation processes of the lactic acid bacteria led to an accumulation of polyols, mainly mannitol. Particularly in rye baked goods, the total FODMAP content was not significantly reduced. This study showed, that the use of standard baking procedures can result in the production of low-FODMAP white wheat bread but requires further optimisation to achieve similar results for wholegrain wheat and rye breads.

### **Keywords**

FODMAP, fermentation time, bread, wheat, rye

## P-1.16 SUBSTITUTION OF SUCROSE BY BRAN IN FINE BAKERY PRODUCTS - POSSIBILITIES AND LIMITS

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In fine bakery products, sugar (sucrose) is not only used to create sweetness. Rather, sucrose is also an important component of recipes from a technological point of view.

Sucrose is a bulking agent in doughs and binds water due to its hygroscopicity. The result is an increased gelatinization and denaturation temperature of starch and proteins, respectively. This gives the pore structure and texture of fine bakery products their characteristic properties. Sucrose also influences the browning of the crust and the shelf life of the products.

However, it should not be ignored that excessive consumption of so-called free sugar is partly responsible for civilization diseases (overweight/obesity with consequences, caries). It is therefore of interest to reduce the sucrose content also in fine bakery products.

Only a few studies have dealt with the use of plant fibres or bran as a substitute for sucrose. Changes in the viscosity of the doughs, a lower pastry volume or a changed breaking strength, as well as changes in the colour of the crust and crumb have been observed.

A WHO-sponsored study concluded that even a small reduction in the intake of free sugars has positive long-term effects on the health of the population. The project presented here therefore investigated the effect of partial substitution of sucrose by various brans on the properties of dough and baked goods.

As model pastries, sponge cakes were produced according to a standardized process. The amount of sucrose was reduced by 10%, 20% and 30% and replaced by bran from wheat and durum, each ground with different mills. The brans had different particle size distributions and different water binding capacities.

The density and the consistency of the dough, the volume yield of the pastry, the texture of the crumb, and changes in the colour of the crust and the crumb by L\*a\*b\*-colour value measurements were investigated. Furthermore, all baked goods were evaluated by a sensory panel for shape/appearance, browning, crumb colour, pores, odour, taste, and texture.

### **Conclusion**

Durum bran frequently showed a lower influence on the respective measured variables compared to wheat bran. The differences in crumb colour were particularly noticeable. In the sensory evaluation, the baked goods with durum bran performed better than the corresponding baked goods with wheat bran. Substitution of up to 20% of sucrose with durum bran is possible without noticeable quality deterioration of the final products.

### **Keywords**

Bran, fine bakery products, sugar reduction, reformulation

## P-1.17 EVALUATION OF SOURDOUGH-RELATED LACTIC ACID BACTERIA TO DEGRADE AMYLASE-TRYPSIN INHIBITORS AND GLUTEN

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Wheat-based bakery products are one of the main sources of nutrients in Western diets. However, in predisposed individuals the consumption of wheat can lead to inflammatory immune reactions, such as non-celiac wheat sensitivity (NCWS). To date, the causative factors for NCWS are assumed to include  $\alpha$ -amylase-trypsin-inhibitors (ATIs) as well as gluten proteins. To determine the effect of sourdough processing on the degradation capacity of these triggers, sourdough-related lactic acid bacteria were evaluated for their break-down capacity. Therefore, the potential of 87 LAB strains associated with sourdough to grow on a gluten-based medium was evaluated, and best performing strains were selected for further experiments. These strains were further tested for their growth potential with ATIs as sole protein source. MALDI-TOF MS measurements were performed to qualitatively evaluate the degradation of gluten (gliadine) and ATIs. Furthermore, ATI-degradation capacity of the selected strains was determined by means of acidification, and HPLC after an incubation of 72 h. Results showed the capacity of all tested isolates to degrade ATIs to a high degree. However, the gluten-degradation capacity varied greater among the tested isolates. The gliadin pattern was strongly altered by *Lacticaseibacillus paracasei* Lpa4 followed by *Lactiplantibacillus plantarum* Lp5. The ATI degradation capacity ranged from 85% to 52% by HPLC measurements. Overall, *Lacticaseibacillus paracasei* Lpa4 reached superior results. The outcomes obtained by this study might help in developing starter cultures for the production of better tolerated wheat-based products for people suffering from NCWS.

### Keywords

Sourdough, lactic acid bacteria, gluten, ATIs, NCWS

## P-1.18 VARIATION ON WHEAT GLUTEN FRACTIONS AND ON THE EXPRESSION OF TOXIC SEQUENCES FOR GLUTEN DISORDERS, IN TRITORDEUM IN COMPARISON WITH DIFFERENT WHEAT VARIETIES

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Wheat is an ingredient for the preparation of several bakery products. Furthermore, some gluten proteins as primary cause of the celiac disease (CD) and other gluten-related diseases.

The consumers and food supply chain are requiring more clear information on factors that could exert an effect on peptides potentially responsible of gluten disorders. In addition to the environmental conditions, the wheat genotypes and the nitrogen (N) fertilization are key field factors that are able to modulate qualitatively and quantitatively the flour protein profile. In particular, some early scientific evidence suggests a low content of gluten immunogenic peptides in tritordeum, a hybrid of wild barley (*H. chilense*) and a durum wheat (*T. turgidum* L. subsp. *durum*), compared to wheat.

The effect of the N fertilization rate (80 vs 160 kg N/ha) was evaluated by a full factorial experimental design, considering two soft wheat (landrace and modern) and one tritordeum cvs, cultivated in the same experimental field in North West Italy.

Protein of refined flours of all samples (cultivar X N rate) was characterized through advanced proteomic approaches including chromatography (RP-HPLC) and electrophoresis. Flour samples were subjected to in vitro simulated human digestion using the static model system. A quantification of CD-toxic epitopes using a ELISA-R5 test was made on in vitro digested flours. The peptides of digestome were examined by mass spectrometry and through in silico approach, investigating celiac and allergenic sequences.

Landrace variety has shown higher values for gluten content (17,65%), followed by tritordeum (16,55%) and modern wheat (14,85%). N fertilization rate increase significantly grain protein content of all cultivars, while did not impact on gluten composition.

Tritordeum flour had the lowest level of immunoreactivity of gliadins measured through ELISA R5 compared with landrace (-51%) and modern (-58%) cvs, while no significant difference was accounted for each genotype between the N rates.

Through in silico analysis it was observed that tritordeum has 50% fewer CD epitopes belonging to the  $\omega$  gliadins and the 23% and 44% lower numbers of LMW-GS class compared to landrace and modern cv. The biggest difference for allergenic epitopes was for  $\omega$  gliadin where modern cv stands out with 50% fewer sequences than landrace and tritordeum.

Although N rate had a marked impact on total protein content, the effect of fertilization on gluten composition and occurrence of toxic/allergenic epitopes was limited. On the other hand, these parameters varied strongly according to the genotypes. In particular, tritordeum, probably as a consequence of the absence of D genome, had lower presence of highly celiac epitopes compared to an ancient and modern wheat.

## Keywords

Soft wheat, tritordeum, N rate, toxic epitopes, allergens

## P-1.19 MEETING CLEAN LABEL CHALLENGE IN GLUTEN-FREE BAKING

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The commonly used term of "clean label" is not regulated by the provisions of European regulations yet. Clean label definition is linked mainly with such expressions like "natural" or "free from" and ingredients that are easily recognisable and considered safe by consumers. Product formulations are becoming simplified, less ingredients are becoming more acceptable. Shorter ingredient lists are achieved by re-formulating products to make them closer to a "home-made" or "traditionally-made" style.

However, a few important issues need to be remembered. Ingredients can be made from entirely natural source materials, but this does not automatically qualify them to clean label. Many ingredients of natural origin are on European food additives list and have E numbers.

In many countries health issues are one of the main aspects influencing consumer behaviour when purchasing foodstuffs. While there is not always scientific reason to believe that "as a rule" an additive-free product or unprocessed food is healthier, many consumers perceive this as a strong link.

In the manufacturing of gluten-free baked goods responding to clean label demand is extremely difficult as gluten-free raw materials demonstrate poor baking properties. It is essential to use technological additives that simulate texturing properties of gluten, however there are not many of them that fulfill clean label concept.

The aim of the research was to develop new technological solutions for the manufacturing of a gluten-free bread with clean label due to the use of texturants of natural origin (classified as food ingredients without E-number).

The possibility of replacing guar gum, one of the most commonly used hydrocolloids, using  $\beta$ -glucan and psyllium in various dosages was checked in the model gluten-free bread. Apart from baking properties of bakery mixes containing only natural ingredients, technological parameters and sensory characteristics results were compared.

The addition of psyllium had a positive effect on the reduction of a bake loss but at the same time adversely affected the appearance of the bread (cracked crust). The best results in guar gum elimination were obtained for baked goods containing  $\beta$ -glucan. Products with this additive were characterized by a proper specific volume, crumb moisture and structure, as well as acceptable taste and flavour comparable to the control sample (with guar gum). Also a farinograph study revealed few options with potential for further development. Quinoa &  $\beta$ -glucan blend achieves a consistency value identical to that of wheat flour. However, stability of such batter is really low. The opposite effect is noticeable for the blend of quinoa and psyllium. This findings support researchers to carry out studies in this field. Further investigations are required to clarify whether a synergistic effect is observed when a combination of these texturants of natural origin is being used.

### Keywords

Bakery, gluten free diet, gluten free bread, natural ingredients, clean label

## P-1.20 INFLUENCE OF TEMPERATURE IN THE PHYSICAL MODIFICATION OF RICE FLOUR ACHIEVED BY LOW-FREQUENCY ULTRASOUND TREATMENT

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Gluten-free market has been continuously growing as consequence of an increasing number of consumers due to celiac disease diagnosed patients, and an influenced trend to eliminate gluten from diet for being perceived as a healthy improvement. Rice flour is an interesting cereal grain in gluten-free market because it can replace wheat in an easier way than other cereals, mainly because of characteristics such as having a bland taste, white color, digestibility and low allergenicity. Flours and starches have been modified by different techniques to improve their properties and increase their industrial range of applicability. Ultrasonication (US) is a novel technique with proved results on the physical modification of flours by the effect of cavitation on the treated particles that leads to alterations on their structural and functional properties. US treatments are associated to high temperatures since collapsing bubbles from cavitation generate very high shear forces that cause local rises of temperature that lead to rise of the suspension's temperature. The objective of this work was to physically modify rice flour by low frequency US and to determine the influence that the treatment temperature (40, 50 and 60 °C) has on the physical properties of the modified flours. The rest of the treatment variables were set constant, with flour dispersion concentration of 10% (w/w) and treatment time of 60 min at 80% on-off pulse. Treatments were carried out using a Hielscher UP400St sonicator (Hielscher Ultrasonics, Germany) at a frequency of 24 kHz and maximum output power of 180W. Temperature was kept constant during treatment using a LAUDA RA12 water bath (Lauda-Königshofen, Germany). The degree of modification was measured by changes in the flours' structural, hydration and pasting properties, as well as rheological properties of gels made with them.

Results showed that temperature is a key variable defining the degree of modification achieved by treatment, having a synergistic effect with ultrasonication. US led to the generation of smaller size particles. A marked increase of water absorption index (WAI) and swelling power (SP) was quantified after US with higher results for lower temperature, while starch damage presented higher values at 60°C. Ultrasounds caused a delay of pasting temperatures and pasting profiles were significantly reduced, particularly remarkable at higher temperatures. Rheology indicated a more solid-like behavior after US.

The authors thank the financial support of Ministerio de Economía y Competitividad and the European Regional Development Fund (FEDER) (AGL2015-63849-C2-2-R), the Ministerio de Ciencia e Innovación (PID2019-110809RB-I00) and the Junta de Castilla y León/FEDER VA195P20. Antonio J. Vela thanks the Junta de Castilla y León for the doctorate grant and Marina Villanueva thanks the Alfonso Martín Escudero Foundation for the post-doctoral grant.

### Keywords

Ultrasound treatment, rice flour, hydration properties, pasting properties, rheology

## P-1.21 CANADIAN HULLESS BARLEY VARIETIES ARE A SOURCE OF BIOACCESSIBLE PHENOLIC COMPOUNDS

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Barley contains phenolic acids which are partially responsible for the health benefits of whole-grains. The bioaccessibility of phenolic acids has been examined in wheat, millet, oats, and other grains; however, there are no studies on the bioaccessibility of phenolic acids in food-grade barley. Therefore, the objective of this study was to measure the bioaccessibility of phenolic acids in four, cooked, whole-grain, hulless barley varieties as well as determine the effect of cooking on their phenolic acid profiles. An *in vitro* digestion model was used to mimic human upper gastrointestinal digestion. The bioaccessible portion collected after digestion contained a variety of phenolic acids, including vanillic, p-coumaric, ferulic and sinapic acids. The most bioaccessible phenolic acids were ferulic and p-coumaric acids with their bioaccessibility ranging from 131-173% and 51-135%, respectively. The variety Peru-35 had significantly greater bioaccessibility of ferulic acid compared to the other varieties examined. Cooking increased the extractable bound phenolic content, possibly through loosening of the food matrix, and breakage of the bonds between phenolic acids and the cell wall carbohydrates. A hydroxycinnamic acid amide not reported in barley before, N1, N8- dicaffeoyl spermidine, was identified in the free phenolic extracts with a relatively high abundance compared to the phenolic acids and may provide additional anti-inflammatory and antioxidant functions. These cooked, whole-grain, hulless barley varieties are sources of bioaccessible phenolic compounds.

### **Keywords**

Hulless, whole-grain barley, bioaccessibility, cooking, phenolic compounds

## P-1.22 IMPACT OF COOKING DURATION ON CAROTENOID ISOMER CONTENT IN PASTA PREPARED FROM THREE DURUM WHEAT CULTIVARS

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Background: Pasta has become a popular staple in most countries and is a good source of both macro and micronutrients. Durum wheat is the preferred grain cereal for its production due to its carotenoid and protein-rich content. Aside its nutritional significance, carotenoids are associated with the attenuation of some chronic diseases through its antioxidant activities. To be able to have any biological value however, pasta must be cooked before consumption. Food processing including cooking duration has been shown to affect carotenoid content in food. Increases or decreases may depend on the influence of factors such as food matrix, food type and chemical nature of the compound. Assessing the effect of cooking duration will contribute to the understanding of the factors affecting carotenoid isomer content and stability post-extrusion which may subsequently affect their availability upon digestion.

Objectives: The aim of this study was to determine the impact of three cooking durations (al dente, fully cooked and overcooked) on refined semolina and whole wheat pasta carotenoid content prepared from three durum wheat cultivars.

Materials and methods: Ten grams of 5 cm refined semolina (RS) and whole wheat (WW) pasta of AAC Spitfire, CDC Precision and Transcend cultivars was cooked in 300 ml boiling distilled water to reach al dente ( 8 and 7 mins for RS and WW respectively), fully cooked ( until central white core gelatinized) or overcooked (cooked 6 mins above the fully cooked time). Carotenoid isomers were identified and quantified using HPLC. Further, carotenoid cooking stability was calculated relative to uncooked dry pasta.

Results: Apart from all-trans lutein, the main effect of cooking duration significantly influenced the content of all-trans zeaxanthin, 9- , 13- and 13'-cis lutein in cooked pasta ( $P < 0.05$ ). Overcooked and fully cooked pasta significantly increased 9-cis lutein content regardless of flour type or wheat cultivar by 8% and 3% respectively ( $P < 0.05$ ) from al dente cooked samples. In addition, all-trans zeaxanthin was significantly affected by the flour type and wheat cultivar ( $P < 0.05$ ) while all-trans lutein was only affected by the wheat cultivar. Indeed, as cooking duration increased, the content of trans isomers also increased.

Conclusion: Our study demonstrated that cooking duration and flour type were not significant main effects for all-trans lutein establishing its homogenous distribution across the wheat grain. However, increasing cooking duration increased the content and stability of all-trans zeaxanthin and cis-lutein isomers regardless of flour type or wheat cultivar possibly due to better extractability. Fully cooked or overcooked pasta may be important for an increased release of carotenoid upon digestion.

### Keywords

Carotenoids, Durum wheat, Al dente, Overcooked, Fully cooked

## P-1.23 HYDROXYCINNAMIC ACID AMIDES PRESENT IN BROA, A TRADITIONAL ETHNIC MAIZE BREAD

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Maize can be used to produce different food products and, in Portugal, it is the main ingredient of *broa*, a traditional ethnic maize bread. Maize-based foods are important sources of phenolic compounds, specially hydroxycinnamic acids, including ferulic and *p*-coumaric acids, which are widely known for their health benefits. However, in cereals, these compounds present a very low bioaccessibility, since they are mostly conjugated to polysaccharides, and are often referred as “insoluble phenolics”. Hydroxycinnamic acids can also be conjugated to smaller molecules (soluble phenolics), showing a higher bioaccessibility. On the other hand, different food processing techniques may also influence phenolic compounds bioaccessibility.

Hydroxycinnamic acid amides (HCAAs) are known to be present in maize. This work aimed at identifying the major HCAAs present in maize and *broas*. The soluble phenolic compounds of maize flours and corresponding *broas* (n = 6) were extracted with 50% ethanol. The residue obtained after this extraction was submitted to hydrolysis (NaOH 40 M) in order to study the insoluble phenolics. Soluble and insoluble phenolic fractions were analysed by HPLC-DAD-MS/MS (high-performance liquid chromatography coupled with diode array detector and tandem mass spectrometry).

The major soluble phenolic compounds identified in maize and *broas* were HCAAs, namely *p*-coumaroyl feruloyl putrescine, diferuloyl putrescine and dicoumaroyl spermidine. Some of these compounds were also detected in the insoluble fraction. Additionally, several novel isomeric forms of dehydrodiferuloyl and dehydrotriferuloyl putrescines were identified in the insoluble fraction. The obtained results suggest that HCAAs are bound to maize polysaccharides but, since they were also detected in the soluble fraction, some of them are only loosely bound to the matrix and can be available for absorption. Insoluble HCAAs can eventually exhibit their action directly in the GI system. Since HCAAs were not only identified in maize flours, but also in *broas*, they can contribute to the beneficial health effects of maize-based foods.

### Keywords

Maize, *broas*, phenolic compounds, hydroxycinnamic acid amides

## P-1.24 EFFECT OF BREADS ELABORATED WITH HEALTHY FORMULATIONS (WHOLE MEAL AND REDUCED SODIUM) ON THE BREADMAKING QUALITY

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Bread is arguably the most consumed wheat-derived product across the world, constituting the major staple food in several countries. Nevertheless, bread is also a major contributor of sodium intake and a sodium overconsumption is also associated with a series of health conditions. For these reasons, in the past years several countries worldwide have implemented different bread salt reduction initiatives which are aimed at a gradual reduction of sodium intake. Nevertheless, the reduction or elimination of salt from bread often comes at the expenses of quality.

Currently, white bread is on average the most consumed type of bread, especially in developed countries. In the past decade however, there has been an increasing trend towards the consumption of whole grain products and their sales drastically increased. Compared to whole meal flour, refined flour has a much lower content of important nutrients such as vitamins, minerals, fibers and antioxidants. Nevertheless, bread obtained using whole meal flour is often associated to attributes such as low loaf volume, increased crumb hardness, coarse texture, darker color, and unappealing flavor and aroma which may limit its consumer acceptance.

Increasing fiber intake and reducing salt represent the most crucial objectives for public health worldwide to combat diet-related non-communicable diseases. The objective of this study was to evaluate the suitability of the current breadmaking quality tests, for the selection of wheat lines intended for high-quality healthier breads.

The study was conducted using 14 common wheat lines whose breadmaking quality was tested using three different pan bread formulations: 1) classic (refined flour and 1% salt, RF), 2) low-sodium (refined flour and no added salt, RNa) and 3) whole meal (reconstituted flour and 1% salt, WM). In general, the average bread loaf volumes obtained using the RF formulation exhibited higher values (714 mL) compared to the bread obtained with lower sodium (661 mL) and with the reconstituted flour (518 mL). However, the average bread volume penalty observed for the RNa formulation was relatively low (average loaf volume reduction of ~ 50 mL) compared to the average loaf volume reduction observed for the WM formulation which was of almost 200 mL. The RNa bread loaf volume values could be accurately predicted using the RF formulation ( $r > 0.90$ ). Differently, the WM breadmaking quality was less predictable using the RF formulation ( $r = 0.64$ ). These results suggest that the current methods used for evaluating wheat breadmaking quality are effective to predict low-sodium bread quality but not whole meal bread quality. Adjustments in the analysis methods of whole meal breadmaking quality might be needed.

### Keywords

Breadmaking quality; Healthy formulations; Whole meal breads; Reduced sodium breads.

## 2. Analytical Methods for Quality Determination

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## P-2.1 STUDY OF CEREAL DOUGH AERATION DURING MIXING WITH A TOUCHLESS AIR-JET LASER SYSTEM

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The aeration of bread dough during mixing is crucial, as the production and retention of gas is the key aspect that will influence all the following steps in a bread-making process and the final quality of the bread. Indeed, the air entrapped in the dough are the “nucleation” sites that will affect the final alveolar structure of the dough after fermentation and then the crumb structure of the bread.

In this study, an innovative system, the FPD (Food Puff Device), has been assessed with the objective of measuring the aeration and eventually the rheological properties of a bread dough. Indeed, this system allows the user to characterize the rheological behavior of food materials by creating deformation over the sample surface using an air jet and monitoring the relaxation with laser triangulation in function of time. This device has been proven effective in various food product from fruits to meat but has not been used, as far as we know, in the field of cereal dough.

A specific FPD prototype has been developed and tested. As a result based on a campaign of measurements, the maximum depth deformation was correlated to the dough porosity. Furthermore, the recovery-step has been modelled with a Kelvin-Voigt model to obtain quantitative information on dough rheology, more precisely deformation, deformation rate, time scales, order of magnitude of apparent viscosity and compliance. The performance of the FPD for monitoring the dough aeration and rheology at different stage of the kneading has been tested with different dough recipes.

Showing a good sensitivity to the air content, such system seems a relevant, fast and non-destructive method that could be used to supervise the mixing process or the degree of fermentation in a baking line.

Acknowledgments: This project took place within the MIXI-LAB project funded by the National Agency for Research (ANR – agreement ANR- 15-LCV3-0006-01).

### **Keywords**

Bread dough aeration, rheological properties, touchless system

## P-2.2 PROFILING ANALYSIS OF TRIACYLGLYCEROLS AND PHYTOSTEROLS IN RICE BY LIQUID CHROMATOGRAPHY-TANDEM MASS SPECTROMETRY

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Consuming brown rice, a whole grain, has many health benefits. Lipids are one of the major nutrients and bioactive components in brown rice, in addition to proteins, carbohydrates and fibers. The information on the distribution pattern of fatty acids on triacylglycerol and conjugated phytosterols of rice is limited, although the fatty acid composition of rice bran oil has been intensively studied. Brown rice samples of *Indica* and *Japonica* varieties were selected as testing materials and for comparative study. An ultra-performance liquid chromatography-electrospray tandem mass spectrometry (UPLC-ESI-MS/MS) was developed for the fatty acid distribution patterns of triacylglycerols. Triacylglycerols were separated and grouped according their equivalent carbon number (ECN). The MS data recorded for ammonium adducts ( $[M + NH_4]^+$ ) of triacylglycerols and the signals of onium ion of diacylglycerol in MS<sup>2</sup> were used to differentiate the fatty acid on the sn-2 position of original triacylglycerols. The develop method could distinguish more than 70 types of triacylglycerols and the distribution pattern can be served as a fingerprint recognition tool. Another analytical method was also developed for the phytosterols and their conjugated forms in rice. Ferulate esters of sterols,  $\gamma$ -oryzanols, and free sterols were the major components of rice phytosterols. Steryl glycosides and acylated steryl glycosides were also detected with less abundance. The analytical methods developed in this study can be a powerful tool for studying lipid metabolism and composition of cereals.

### Keywords

Rice, lipid, triacylglycerol, phytosterol, gamma-oryzanol

## P-2.3 NEW TEXTURE ANALYSIS SYSTEM TO MEASURE DOUGH EXTENSIBILITY

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Flour quality information is important to the milling and baking industry, in order to produce end products of consistent quality at reasonable cost. Fit-for-purpose bread flour requires a balance of viscoelastic properties to ensure good dough moulding and oven spring. Mixing and extension properties of the flour are monitored by bakers, and their formulations and processes are adjusted, to ensure batch-to-batch consistency of their products. The Brabender Extensograph is the widely used standard (ICC Std No. 114, AACC Method 54-10.01, AGSA Method 06-01) to measure dough extensibility. However, this method requires large dough pieces (150 g), and significant variability in results between instruments has been reported. The Stable Micro Systems Kieffer dough and gluten extensibility rig is a non-standardised method, performing small-scale extension tests on ~0.4-g dough pieces, but is prone to variability due to poor temperature control and ill-defined dough resting conditions. Perten Instruments has prototyped a new Dough Extension System (DES), consisting of a moulding apparatus for rolling 8-g dough pieces, proofing chamber and uniaxial extension rig fitted to a TVT texture analyser. Extension tests of doughs with diverse properties were performed on DES and compared to the Extensograph. DES results showed acceptable correlations to Extensograph maximum resistance, extensibility and ratio of resistance to extensibility, with  $R^2$  values of 0.79, 0.66 and 0.54, respectively. Correlations for extension parameters over the entire test were generally superior to those at maximum resistance. Within-instrument repeatability of the TVT was similar to or better than the Extensograph. The DES provides a suitable solution for bakers to measure the extension properties of dough and ensure quality and consistency in their products.

### **Keywords**

Dough, extensibility, resistance, consistency, baking

## P-2.4 USING THE GLUTOPEAK® TO BENCHMARK ONTARIO WINTER WHEAT

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The Brabender® GlutoPeak® has been used to establish insight to fundamental aspects of gluten quality and aggregation behaviour in previous studies and on-going research has shown potential in relating agronomic management practices to flour quality. This information was used to provide a framework to benchmark the quality of 34 Ontario-grown soft and hard winter wheat lines and varieties. Principal component analysis was used to identify relationships among GlutoPeak® parameters, gluten properties (secondary structure, thiols), and other flour quality testing methods (protein content, Farinograph® parameters, SRC values, and bake tests).

The full data set displayed a significant correlation between bread volume and GlutoPeak® torque ( $r = 0.612$ ;  $p < 0.01$ ). This relationship was still significant at the  $p < 0.05$  level for the individual hard wheat ( $r = 0.579$ ) and the  $p < 0.01$  level for soft wheat ( $r = 0.655$ ) subsets, respectively. Secondary structures identified in the GlutoPeak® slurry including  $\alpha$ -helices,  $\beta$ -sheets, and  $\beta$ -turns showed significant relationships with both GlutoPeak® torque and bread volume, indicating that gluten protein structure may be an important driver of both GlutoPeak® rheological parameters and bread making potential.

Breaking the data set down into hard and soft winter wheat subsets revealed a correlation with GlutoPeak® time ( $r = -0.646$ ;  $p < 0.01$ ) in the soft subset. Interestingly, a clear separation of hard and soft winter wheat varieties was never achieved in various iterations of PCA plots, although the strong relationship between GlutoPeak® parameters and gluten secondary structures was further defined. Closer evaluation revealed that a subset of soft winter wheat lines had comparable or better bread making performance compared to certain hard winter wheat lines. This is likely related to efforts in Ontario to breed for soft winter wheats with stronger gluten profiles over the past decade.

The overall patterns from the study demonstrate that hard winter wheat quality improvements have lagged in the Ontario wheat breeding pool compared to soft winter wheat; the GlutoPeak® has potential as a broad stroke tool in categorizing experimental lines and varieties in breeding programs; and that further exploration of the role of gluten protein secondary structure in dough rheology and cereal products is necessary.

### Keywords

Quality, glutopeak, gluten, winter wheat

## P-2.5 THE RELATIONSHIP OF GRAIN AND MILLING CHARACTERISTICS WITH SOLVENT RETENTION CAPACITY AND SWELLING INDEX OF GLUTENIN

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Bread wheat breeders can only conduct quality analysis on breeding material when sufficient amounts of seed are available, usually later in the breeding process. Selection for quality at a later stage in the breeding cycle means that lines with inferior quality characteristics cannot be discarded. This increases the magnitude of the breeding program, with reduced efficiency and higher cost to release an adapted, high yielding cultivar with acceptable quality. In this study five solvent retention capacity parameters and one swelling index of glutenin parameter were correlated with five grain and milling characteristics (hectolitre mass, breakflour yield, flour yield, flour protein content and falling number) to determine their relationships using hard red spring and hard red winter wheat germplasm. Highly significant differences were observed for all measured characteristics across the dryland and irrigated summer rainfall regions and the winter rainfall region in South Africa. Genotype effect was high and significant for most measured quality parameters. Correlations between solvent retention capacity, swelling index of glutenin, grain and milling parameters were highly significant but inconsistent across regions, with only lactic acid solvent retention capacity and lactic acid swelling index of glutenin parameters showing consistently significant ( $p \leq 0.001$ ) correlations with protein content. Stepwise multiple linear regressions indicated that most solvent retention capacity and swelling index of glutenin parameters are poor predictors of grain and milling parameters and that regression coefficients across localities were higher for flour protein content with lactic acid solvent retention capacity and lactic acid swelling index of glutenin, explaining most of the variation.

### **Keywords**

Glutenin swelling index, solvent retention capacity, protein content

## P-2.6 EFFECTS OF COLD TEMPERATURE ON STARCH MOLECULAR STRUCTURE AND GELATINIZATION OF LATE-MATURITY ALPHA-AMYLASE AFFECTED WHEAT

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Late maturity alpha-amylase (LMA) is a serious problem if it occurs in wheat, as it is supposed to affect quality and hence price. The synthesis of LMA occurs when wheat experiences a cold-temperature 'shock' during the post-anthesis, grain-filling period. This markedly increases the amount of high isoelectric point (pI) alpha-amylase in wheat grains in susceptible varieties. These affected grains have low Falling Number (FN) and are rejected at receival points of downgraded to feed grade, as low FN is associated with inferior end-product qualities. However, several studies have reported little if any correlation between FN-LMA and bread quality. In addition, the presence of LMA unexpectedly improves baking properties such as loaf volume increment and Maillard reaction enhancement. There is considerable controversy surrounding any association between low FN and end-product quality. Furthermore, there is limited information on the starch molecular structure in LMA affected grains; its structure has significant influence on flour functionality and end-product quality. The present study has three aims: (1) to characterize the starch molecular structure of LMA- affected wheat grains, (2) to determine the starch gelatinization properties of LMA-induced wheat flour to assess the impact of cold temperature and LMA on the thermodynamic performance of LMA flours, and (3) to relate (1) and (2) to each other. The basic starch structure analysis was carried out using size-exclusion chromatography (SEC) and fluorophore-assisted carbohydrate electrophoresis (FACE). Wide-angle X-ray diffraction (XRD) and differential scanning calorimetry (DSC) were employed to examine the intermediate starch structure and its thermal properties respectively. Results show that the cold-treatment during post-anthesis has minimal effect on starch molecular structure. However, there was a small decrease in the gelatinization temperature from cold-treated wheat grains; not due to the presence of LMA, but this reduction is empirically trivial and inadequate to cause any undesirable effect on end-product as demonstrated by previous relevant work. The present findings suggest that the supposition that LMA is a major contributor to inferior end-product quality should be reconsider.

### Keywords

Late maturity alpha-amylase, molecular starch structure, starch gelatinization properties, size exclusion chromatograph

## P-2.7 RHEOLOGY OF FORMULATED GLUTEN FREE BLENDS: USEFUL PARAMETERS TO PREDICT BREAD QUALITY

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Gluten free foods are still attracting the attention of bakeries because of the increasing consumption of those products, particularly bread. There are many marketed formulated blends that allow obtaining homemade gluten free breads. The features of the breads are greatly dependent on the dough or batter performance, but in the case of gluten free there is still no consensus about real indicators for predicting the fresh bread quality. The objective of this study was to define rheology parameters that could foresee the gluten free formulated blends quality. For that purpose, the rheology of nine commercial gluten free blends were evaluated using the Mixolab, Amylab and selected parameters were correlated with the breads characteristics (2D-volume, crumb structure and texture, moisture content). Dough/batters were prepared following supplier recommendations in order to evaluate the real systems proposed for obtaining better breads. Mixolab settings for gluten free dough/batters, and adapted method for Amylab (400 s) allowed recording rheological behavior and from the plots different parameters were identified. Breadmaking was carried out following supplier instructions and the technological parameters of the loaves and crumb characteristics were compiled. Results were subjected to statistical analysis and principal components analysis (PCA) was selected to correlated dough/batter behavior with bread characteristics. PCA discriminated among blends indicating that rheology parameters from Mixolab and Amylab were appropriate to evaluate them. Particularly, slice area and dough density could be predicted with C1 and C2 Mixolab parameters, maximum Amylab viscosities and the speed to reach them were correlated with the crumb texture characteristics (springiness, cohesiveness and resilience), whereas time to reach maximum viscosity and viscosity stability from Amylab and gelatinization parameters (C3, C4, C5) from Mixolab were directly correlated with crumb hardness. Overall results indicate that Amylab and Mixolab are useful tools for evaluating dough/batter performance of gluten free blends and also to predict their breadmaking behavior.

### Keywords

Gluten free, mixolab, amylab, batter, bread

## P-2.8 MULTISPECTRAL IMAGING TO EVALUATE WHEAT GRAIN TISSUE DISSOCIATION IN PROCESSED-BRAN FRACTIONS

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In the cereal milling industry, wheat grains are fractionated at a histological scale for recovering the starchy endosperm into flour or semolina and collecting the peripheral tissues in bran fractions. Bran could be seen as a composite material with multilayered structure (peripheral tissues from pericarp, testa, hyaline and aleurone layer), and adherent starchy endosperm. Bran fractions could be further processed to extract compounds of interest such as dietary fiber or vitamins and minerals. Tracking the tissue composition of bran fractions could help to infer their composition and then their nutritional quality or their end-use properties, but is also useful for monitoring fractionation processes. Different methods have been proposed based on tissue-specific molecules or tissue-specific spectral responses. The specific autofluorescence properties of the aleurone layer and pericarp under UV and blue light have been exploited to quantify the contamination of the flour by the whole bran particles. Using the difference spectral response between the different constitutive bran tissues could be used to follow the bran dissociation. The objective of this work was to develop a method based on multispectral images to evaluate the ratio between the aleurone layer and the other peripheral tissues in bran fractions. In this study, a multi-zoom microscope AZ100M (Nikon, Japan) has been equipped with 4 filter blocks to acquire images under UV, blue and green excitation light. Emission light was recovered through long pass filters and, taking advantage of the RGB channels of the color camera, each image was split in three channels and stack all together to obtain a 12 channels multispectral image. In such images, the intensities measured for each pixel are not spectra, but are spectral profiles relevant to identify tissues (Baldwin et al., 1997). To synthesize the information observed on each image, the average spectral profile was calculated on each field of view and used to compare samples with different tissue composition. In order to facilitate sample handling and avoid high segregation between particles, pellets were prepared and 2 to 4 images were acquired on each face. The number of images to give a stable mean spectral profile for powder was determined in relation to median particle size, and specific attention was paid on the effect of sample preparation (pellets thickness, density, face) on spectral profiles measured. An experimental procedure was then optimized and applied to bran fractions issued from a fractionation diagram including electrostatic separation process. Based on differences in autofluorescence properties under both UV and visible excitation light, this method discriminated the different bran fractions, in relation to bran tissue composition.

### Keywords

Multispectral imaging, bran, wheat

## P.2-9 RAPID FORCE ANALYZER FOR DISCRIMINATING STARCH TYPES

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Starch characterization is of great interest for food manufacturers considering its extensive use as food ingredient in many different types of foods. The objective of this study was to set up a rapid method for characterizing starches and to define discriminating parameters. For that purpose, starches from different origin (wheat, rice, corn, potato and cassava) were selected and a rapid thermal treatment (90 s) was carried out using the Chopin Amylab in its testogram mode. This equipment allows to record the force of starch suspension along heating. The results showed significantly different plots for the viscosity forces recorded for each type of starch. Plots exhibited a lag period without any change in the strength of the paste, followed by an increase of the force associated to starch gelatinization. From the recorded plots, the following parameters were defined: the onset time for increasing the strength, the initial and maximum force, between these forces the  $\alpha$ -slope, force at the end of the 90 s, paste stability during heating and starch breakdown. Significant differences among starches were observed in all the parameters defined. Potato starch exhibited the largest force and higher  $\alpha$ -slope indicating faster gelatinization, whereas cassava starch showed low paste strength that gradually increase during the time of analysis. In conclusion, a 90 seconds method is presented for detecting starch differences using a rapid force analyzer, which could be very useful for food manufacturers that are working with different starch batches.

### **Keywords**

Amylab, viscosity, gelatinization, quality control

## P.2-10 EFFECT OF FERMENTATION OF OAT FLOUR BY SELECTED LACTOBACILLUS STRAINS ON PROFILE OF VOLATILE COMPOUNDS

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Fermented products are produced and consumed since the development of human civilization. Nowadays the fermentation process is not used only for preservation but also for obtaining a new type of food with unique flavors, aromas, or texture. Cereals are the reservoirs of polysaccharides, which could be used as a source of carbon and energy by microorganisms during fermentation. Lactic acid bacteria are a group of microorganisms that have traditionally been associated with food fermentation. A little information connecting the fermentation process time and changes in volatile compounds in cereals is available in the literature.

The aim of this study was to examine the changes in volatile compounds during 24-hour fermentation of 5% oat flour suspension using selected *Lactobacillus* strains.

Commercial Polish oat flour (*Avena sativa* L.) was purchased from a local producer (Melvit S.A., Kruki, Poland). Based on the preliminary studies three strains were selected for fermentation: *L. plantarum* IB, *L. plantarum* W42, and *L. casei* LcY. Analysis of volatile compounds was done according to Starowicz et al. (Molecules, 2019, 24(5), 982). Briefly, samples were mixed with sodium chloride solution (25%), then volatiles was extracted to SPME fiber, separated, and determined using GC-MS method. The relative quantitative analysis of volatile compounds in fermented samples was performed using the internal standard of pyrazine-d4 and the results were expressed as mg/ml.

Compared to the non-fermented flour in the samples fermented with selected bacterial strains, many new aromatic compounds appeared, which were characteristic of each analysed strain. Forty-four volatile compounds were detected in all analysed samples. The largest group were aldehydes, followed by alcohols, ketones, and acids. The highest sum of analysed compounds appeared after 12 hours of fermentation by *L. plantarum* W42, while for the other two strains after 20 hours. The main compound detected were: hexanal and acetic acid, followed by 1-hexanol, 2-pentylfuran, and hexanoic acid.

### Acknowledgment

The project was financed from the statutory funds of the Department of Chemistry and Biodynamics of Food IAR&FR PAS in Olsztyn. The part of this research was an MSc thesis of Edyta Kurantowicz. EIT Food Fellowship program was the financial support of the scholarship of T. Georgieva Yaneva in IAR&FR PAS in Olsztyn.

### Keywords

Oat, fermentation, volatile compounds

## P-2.11 LOW FIELD NMR TO DESCRIBE INTERACTIONS BETWEEN STARCH, GLUTEN AND WATER IN WHEAT-BASED PRODUCTS

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Starch and gluten are key constituents involved in structuring mechanisms of wheat-based based foods. Studying their interactions with water molecules during manufacturing process steps is essential to understand resulting structuring mechanisms. Low-field NMR is commonly used for measuring interaction states of water molecules protons with hydrophilic constituents. The study objective is to investigate starch and gluten interactions with water molecules by low field NMR. Pure or mixed constituents were analyzed by NMR under different conditions of water content and heat treatment. NMR signal was acquired with a laboratory spectrometer (20 MHz - 0.5 T) by a combined FID-CPMG excitation sequence. The results allowed the identification of 5 proton populations, with hydrothermal treatments dependent proportions. The least mobile population, characterized by a 0,01-0,03 ms relaxation time, is associated with rigid protons from starch or rigid protons of protein strands in gluten sheets without contact with water. The most mobile proton population, characterized by a 24-80 ms relaxation time, is associated with free water in interaction with starch protons on the surface of granules or with gluten protons. The assignation of proton populations is discussed in relation to destructureation states of wheat constituents.

### Keywords

Low field NMR, relaxometry, wheat products, starch, gluten

## P-2.12 THE PREDICTION OF MOISTURE SORPTION ISOTHERMS FOR FREEZE-DRIED EMULSIONS STABILIZED WITH HYDROPHOBICALLY MODIFIED STARCH

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Octenyl succinic anhydride-modified starch has been successfully used as an emulsifier, e.g., as an encapsulating agent for fish oils, fat-soluble vitamins and flavours, in making bread, cake and cookies. Enriched dried emulsions stabilised with modified starches can also be used as an ingredient in cereal products to play a functional role and fortify.

In general, redispersible dry emulsions stabilized with biopolymers have a tendency to cake and agglomerate particularly during storage under humid conditions. Moisture uptake may therefore play a key role in the functional properties of these powders such as flow behaviour, bulk density, dissolution rate and caking during storage or transport to the customer if the environmental relative humidity is not controlled. In this work, a model oil-in-water emulsion containing 2.0 wt% octenyl succinic anhydride-modified starch acting as an emulsifier was produced using a jet homogenizer and was subsequently freeze-dried. The water sorption characteristics of freeze-dried oil-in-water emulsions were then studied using a dynamic vapour sorption (DVS) apparatus. The water sorption isotherms showed a noticeable increase in equilibrium moisture content (EMC) values above 65% RH, suggesting a change in the mechanism of water sorption by starch molecules. The experimental water sorption isotherms were fitted to three mathematical models: Brunauer-Emmett-Teller (BET), Guggenheim-Anderson-de Boer (GAB) and Oswin. Comparison of predicted values of EMC with experimental values using E (Mean percentage deviation modulus) and R<sup>2</sup> (coefficient of determination) value showed that all three models were satisfactory for predicting the isotherms of oil-in-water emulsions. Also, it was shown that the GAB model provides the best fit for describing both sorption and desorption isotherm of freeze-dried emulsion.

### **Keywords**

Sorption isotherm, modified starch, emulsion, freeze drying

## P-2.13 SOLVENT RETENTION CAPACITY UTILIZING SUPPLEMENTARY SOLVENTS FOR HARD RED SPRING WHEAT QUALITY EVALUATION

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The solvent retention capacity (SRC) test (AACCI Method 56-11.01) has been widely used to evaluate flour functionality. This test can be used for all wheat classes but has been used largely for soft wheat flours. Hard wheat and strong gluten flours require a better determination of glutenin and gliadin contributions since end products made from these flours are highly dependent on gluten functionality. The SRC test was conducted using the traditional shaking method according to AACCI method 56-11.01 utilizing the following supplementary solvents: 55% aqueous ethanol, 0.75% sodium dodecyl sulfate (SDS), 0.006% sodium metabisulfite (MBS), and 0.75% SDS + 0.006% MBS. The ethanol solvent is related to gliadin content, MBS promotes the thiol-disulfide exchange for glutenins, and the SDS with or without MBS is relevant to the alignment of glutenin macropolymers. Hard red spring (HRS) wheat flours (18) from wheat samples grown in the HRS wheat-growing region from the 2020 and 2019 crop years were evaluated for quality and SRC (traditional and supplementary solvents) according to standard methods. Water, sodium carbonate, lactic acid, and sucrose SRC values ranged from 66-81%, 92-120%, 128-162%, and 109-134%, respectively. The GPI ranged from 0.59 to 0.69. The ethanol SRC values ranged from 52-62%. The SDS SRC ranged from 122-144%, and the MBS SRC values ranged from 62-74%. The MBS+SDS values ranged from 104-137%. Samples with higher protein content had higher ethanol SRC and higher MBS SRC. The SDS SRC showed a decreasing trend for samples with higher protein content. There were significant ( $p < .05$ ) differences among samples for the supplementary solvent SRC values. The supplementary solvents were able to provide additional information about the quality of HRS wheat flours. The flour samples had a wide range of quality attributes that could be evaluated and selected based on the use of the supplementary SRC solvents. Often, HRS flour will have similar protein contents, but the quality of the protein will be critical to the end-use quality of the flour. Utilizing the supplementary SRC solvents, a more detailed evaluation of protein quality can determine end-use applications for HRS wheat flours.

### **Keywords**

Protein quality, Supplementary Solvents, Hard Red Spring Wheat, Solvent retention capacity

## P-2.14 PHYSICOCHEMICAL, THERMAL AND AMYLOPECTIN STRUCTURAL ANALYSIS OF WHEAT STARCHES FROM WAXY, NORMAL, AND HIGH AMYLOSE WHEAT

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High amylose wheat by conventional breeding was recently developed as a health-promoting ingredient by its resistant starch and dietary fiber function. The wheat flour has commercialized, and the primary benefit of the flour related to processing functionality would be less deterioration in gluten functionality because of being able to use as refined flour. As a fundamental study on its starch characteristics, the present study investigates the physicochemical, thermal, and amylopectin structural properties of wheat starches with high, medium, and low amylose contents. Three starches (W, N, H) were isolated from waxy, normal and high amylose wheat flours (amylose content in flour: 0, 28.9, and 57.6%, respectively). Morphology, crystallinity, and thermal property of the starches were measured by scanning electron microscope (SEM), x-ray diffractometer (XRD), and differential scanning calorimetry (DSC), and rapid visco-analyzer (RVA). HPAEC determined the amylopectin chain length distribution of them. All starches appeared small (B-type<10um) and large (10um<sup>2</sup>) of amylopectin for H starch than W and N starches. Overall data confirmed the effect of amylose content and chain length of amylopectin of wheat starches on the morphology of starch granules, crystallinity, and starch pasting, and gelatinization characteristics.

### **Keywords**

High amylose wheat, Wheat starch, Amylose content, Physicochemical and thermal property, Amylopectin structural property

## P-2.15 HYDROLYSIS KINETICS MONITORING OF CEREAL STARCH GELS BY RHEOLOGICAL MEASUREMENTS

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Rheology is a widely used technique to determine the starch transformations during processes. In fact, several well-known apparatus employed in industry or research labs measure some rheological (or at least related to) properties to establish adequate operational conditions or parameters quality.

The monitoring of starch digestion is usually carried out by biochemical methods measuring the glucose released during time. The objective of this work is to monitor the gelatinized starch hydrolysis through the measurement of the viscosity decay of the samples. Three different (corn, wheat and rice) starches were used to carry out this study. Starch gels contain the same ratio of starch/water (1:4) in all samples and were formed after heating (at 95°C during 20 min) and further cooling up to 37°C. In first place, hydrolysis of starch gels was determined following a proposed method [1]. Briefly, gel sample (0.2 g) was suspended in 4 mL of 0.1 M sodium maleate buffer with porcine pancreatic  $\alpha$ -amylase (0.9 U/mL) and incubated in a shaker at 37°C under constant stirring at 200 rpm during 3 h. Ethanol was used to stop the enzymatic reaction. Glucose released was quantified using the Megazyme kit (GOPOD). Viscosity of hydrolyzed starch gels at 37°C was measured with a controlled stress rheometer (Anton Paar 301) with plate-plate geometry (50 mm) and a gap of 0.5 mm. After preliminary tests employing different shear rates (from 1 to 600 s<sup>-1</sup>), a constant shear rate of 10 s<sup>-1</sup> was selected to simulate the stirring obtained in the thermostatic shaker. Samples containing 0.2 g of starch gel, 4 mL of maleate buffer and porcine pancreatic enzyme were placed in the rheometer after 2 min of homogenization.

Apparent viscosity,  $\eta$ , dramatically decreased during starch hydrolysis, in all cases. Normalized viscosity,  $n$ , values were evaluated by means of the equation:  $n = (\eta_t - \eta_\infty) / (\eta_0 - \eta_\infty)$  where initial (0), final ( $\infty$ ) and at hydrolysis time  $t$  viscosities are involved. A very good agreement between the starch digestion curves obtained by biochemical method and normalized viscosity curves was verified. In conclusion, starch hydrolysis could be monitored using the rheological determinations after establishing the adequate shear rate. Rheological method for assessing starch hydrolysis would be cheaper and less time consuming.

[1] Benavent-Gil, Y., Rosell, C. M. (2017). Performance of Granular Starch with Controlled Pore Size during Hydrolysis with Digestive Enzymes. *Plant Foods for Human Nutrition*, 72(4), 353-359.

### Keywords

Corn, rheology, rice, viscosity, wheat

## P-2.16 SOLVENT RETENTION CAPACITY: SUPPLEMENTAL SOLVENTS FOR EVALUATION GLUTEN QUALITY

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Solvent retention capacity (SRC) is a solvation test for wheat flour in which functional contributions of different polymeric components are predicted based on their swelling behavior with different diagnostic solvents. To assess the functionality of individual gluten components, four solvents have been proposed: 1) 55% aqueous ethanol for gliadins; 2) 0.75% sodium dodecyl sulfate (SDS) for glutenin macropolymer; 3) 0.006% sodium metabisulfite (MBS) for gluten strength; and 4) 0.75% SDS + 0.006% MBS for glutenin macropolymer without disulfide network. This research aimed to predict the gluten functionality of commercial wheat flour samples by the four proposed supplemental diagnostic solvents. Commercial wheat samples were purchased in 2020 at a grocery store in Fargo, North Dakota. Four different brands from three flour types (bread flour, all-purpose flour, and cake flour) were analyzed. These flour types represent wheat flour from three different U.S. wheat classes, hard spring wheat, hard winter wheat, and soft wheat. Moisture content was determined with the AACC-approved methods 44-15.02. SRC was measured according to the AACC-approved method 56-11.02 with modifications. The supplementary solvents 55% aqueous ethanol, 0.75% SDS, 0.006% MBS, and 0.75% SDS + 0.006% MBS were used instead of the traditional SRC solvents. For bread flour samples, the ethanol SRC values ranged from 53-59%; the SDS SRC ranged from 126-140%; the MBS SRC values ranged from 64-70%; and the SDS+MBS values ranged from 109-126%. For all-purpose flour samples, the ethanol SRC values ranged from 49-58%; the SDS SRC ranged from 120-133%; the MBS SRC values ranged from 65-68%; and the SDS+MBS values ranged from 111-118%. For cake flour samples, the ethanol SRC values ranged from 48-62%; the SDS SRC ranged from 65-134%; the MBS SRC values ranged from 56-63%; and the SDS+MBS values ranged from 63-123%. Significant ( $p < 0.05$ ) differences were detected between flour types. Overall, significantly ( $p < 0.05$ ) higher ethanol and MBS SRC values are seen in bread flour samples, thus a stronger gluten network is predicted from them. Within bread flour samples, Brand 4 had significantly ( $p < 0.05$ ) higher ethanol, MBS and SDS+MBS SRC values (59%, 70% & 122%, respectively). For all-purpose flour samples, Brand 2 had a significantly ( $p < 0.05$ ) higher ethanol, MBS and SDS+MBS SRC values (58%, 67% & 111%, respectively). For cake flour, the sample predicted with the weakest gluten network is Brand 4 due to its significantly ( $p < 0.05$ ) lower SDS, MBS, and SDS+MBS SRC values (65%, 56% & 63%, respectively). The four proposed supplemental diagnostic solvents have shown the differences to predict commercial wheat flour samples' gluten functionality among each flour type. These results highlight the importance of assessing specific flour polymers' functional contributions to predict each flour type end-use potential.

### Keywords

SRC, Solvent Retention Capacity, Wheat quality, SDS, MBS

## P-2.17 GLUTOPEAK TEST FOR PREDICTION OF WHEAT TECHNOLOGICAL QUALITY AND BAKING PERFORMANCE OF BRAZILIAN TROPICAL WHEAT SAMPLES

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The GlutoPeak is a quick and on a small-scale method, and has been proposed as an alternative to evaluate wheat and as a tool to predict the baking quality of flour. It performs a shear test to measure the aggregation of gluten. The traditional rheological tests, alveography and farinography, need more sample amount and are time-consuming. To know the end-use of wheat samples it is necessary to perform a great number of analyses, including, besides the rheological, the physicochemical and baking tests. The wheat cultivated in the central Brazil region, also known as Brazilian Tropical wheat, where the Cerrado biome (Brazilian savanna) is predominant, is characterized by its good performance for baking (high gluten strength and stability). In the last years, the Embrapa cultivar BRS 264 has been the most used for bread production, although more recent genotypes as BRS 394 and BRS 404 are also used, and new lines are tested every year within Embrapa Breeding Program. As commercial samples are a mixture of more than one cultivar, in this assay six samples were tested: BRS 264, BRS 394, BRS 404, PF 100368 line, two mixtures, BRS 264 with 30%PF 100368, and BRS 264 with 50% PF100368. The objective of this study was to investigate the relationship between GlutoPeak and traditional analyses used to evaluate technological quality (physicochemical and rheological) and baking test in Brazilian tropical wheat samples. These six samples were characterized by different methods of analyses and the data obtained were submitted to Pearson's correlation analysis ( $p < 0.05$ ). GlutoPeak parameters showed high and significant correlations with some important parameters of wheat technological quality evaluation. The main correlations were from GlutoPeak parameters with gluten index, wet and dry gluten; with elasticity index (alveography); and water absorption (farinography). Also, this study showed promising results, suggesting that "expanded" profile (GlutoPeak rheometer) can be very useful for differentiation of wheat genotypes, showing the contrast in gluten aggregation behavior of Brazilian wheat genotypes samples.

### Keywords

T. aestivum, gluten aggregation, rheology, wheat quality, baking test.

### 3. Alternative Grain Crops

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## P-3.1 MILLET AS ALTERNATIVE CEREAL FOR DEVELOPING FOOD PRODUCTS IN THE BRAZILIAN DIET

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*Pennisetum glaucum* (L.) R. Br also known as pearl millet is a gluten-free millet cereal mainly cultivated in the Brazilian Savannah covering an estimated area of 4.5 million hectares. The main purpose of this crop is for soil management or green soil incorporation between rotational crop systems. Pearl millet grains can be watery cooked and flours can be obtained after grinding. Millet flours can be used in formulations of different products such as: baked products, porridges, cookies, ready-to-eat snacks, non-dairy fermented beverages, biscuits, pastes and kibbeh (Taylor et al., 2014). On the other hand, there has been an increase of gluten-free products, the food industry has been seeking new ingredients for the development of gluten-free processed foods for celiacs, people with non-celiac gluten sensitivity (GNCS) and food-style adherents. Thus, in this study was investigate the potential nutritional and technological of pearl millet (*Pennisetum glaucum* (L.) R. Br.) whole grain flours obtained from different cereal processing: decortication, extrusion and germination. Proximate composition of raw flour showed an average (wb) of 62.5% carbohydrate, 12.0% protein, 5.6% lipid, 8.2% dietary fiber and 1.7% minerals (mainly K, P and Mg). The decortication, as expected, reduced nutrient contents. Decorticated flour had a reduction of 5% of proteins, 67% of lipids, 41% of fiber and of Fe, Mn, Ca, Zn and Cu content, when compared to raw flour. However, decorticated flour have advantages over the raw flour because it would suit for porridge preparation because have larger paste viscosity, larger luminosity (L\*) and, lower lipid, content that may have helped to increase its shelf life. The extruded pearl millet flour, unlike decorticated flour, the nutrient content, except lipid, did not differ from the raw flour, but presented great potential as ingredient for improving the nutritional value of powdered cereal beverages and soaps, because of its great solubility (high shear extrusion) and water absorption. The germinated flour did not differ from raw flour. However, germinated flour showed reduction in phytate content, also as expected, thus it may be suggested that germinated flour is the most nutritive because of its low phytate content that may promote better mineral absorption and protein digestibility. In addition, the germinated flour reported interesting technological characteristics such as higher lightness (L\*), higher WAI and WSI, low paste viscosity and setback, also suitable as nutritive ingredient for preparing vegetable beverage, frozen food formulations and baking products. It can be concluded that by applying varied cereal processing on pearl millet, it would allow food alternatives for encouraging its use in the Brazilian diet, particularly in gluten free products.

### Keywords

Extrusion cooking, germination, pearl millet, cereal processing

## P-3.2 DEVELOPMENT OF GLUTEN-FREE BREAD WITH RED QUINOA FLOUR USING THE MIXTURE DESIGN APPROACH

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Quinoa Pasankalla is a variety of red quinoa with a high protein and fiber content, 14.4% and 7.2%, respectively. It is very appropriate for celiac persons due to the absence of gluten. Currently, there is a growing demand for gluten-free bakery products in the Latin American market, however, the vast majority of these products present low sensory and nutritional quality. The aim of this research was to develop gluten-free bread with red quinoa flour using the mixture design approach. The D-optimal design was used in order to optimize the content of quinoa flour (10-50%), water (70-110%) and the blend of tara gum and xanthan (1: 1) (0.5-2%) in a formulation based on potato starch; the content of sugar, yeast, salt and oil remaining constant. The aim was to determine the formulation that could mimic the textural properties of a control dough, which was composed of potato starch (100%) because, in previous work, with this dough, it was possible to obtain breads with high specific volume ( $2.77 \pm 0.1$  mL/g), good crumb structure ( $83.5 \pm 8.5$  cells/cm<sup>2</sup>), but with disadvantage of fast retrograding crumbs. The textural properties of the doughs (firmness, consistency, cohesiveness and viscosity index) were measured using the Back Extrusion accessory of the UTM INSTRON® (model 3365, USA), while to determine the quality characteristics of the bread, the specific volume was measured using topographic scanner (BVM 6630, Perten), the crumb structure was measured using the ImageJ 1.51 software and the crumb firmness was measured using the Texture Profile Analysis methodology. The textural properties of the control dough were:  $3.69 \pm 0.2$  N firmness;  $56.46 \pm 3.7$  N.s of consistency;  $2.70 \pm 0.2$  N of cohesivity and  $36.18 \pm 2.1$  N.s of viscosity index. The optimal formulation that could mimic the textural properties of the control dough was composed of 12.6% quinoa flour, 108.3% water and 1.1% mixture of tara gum and xanthan gum. With this dough, it was possible to develop gluten-free bread with similar specific volume (2.49 mL/g) and crumb structure (84 cells/cm<sup>2</sup>) than the control bread, but with softer crumbs (5.4 N crumb hardness).

### Keywords

Puinoa, gluten-free bread, dough textural properties

## P-3.3 ANALYTICAL CHARACTERIZATION OF GLUTEN & GLUTEN FREE RAW MATERIALS

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Dried gluten is added to various bakery products and mixtures to maintain or to improve the quality. Nevertheless, there are only limited opportunities to analyze the quality of dried gluten powder. Hence, the gluten is processed and incorporated into bakery products or ready-mixes without knowing its specific quality. This causes variations in the quality of the final bakery products. As there was a need for a method to analyze the dried gluten quality, a working group consisting of a gluten-processor, a gluten-producer, a research institute and a equipment manufacturer started working on a method development. Finally, a quick method has been developed to analyze the gluten's quality. On the other hand, the growing importance of alternative protein sources and the trend of gluten-free nutrition have been increasing. These developments arouse the demand for new analytical methods to analyze the raw materials used for gluten free products manufacturing. The broad range of materials comprises different pulses, cereals and pseudo-cereals. As the water absorption is different to the one of flour, and the dough properties differ from the ones of wheat based doughs, the existing methods need to be adapted. Methods are shown how current instruments can be used to analyze gluten free raw materials in terms of their water absorption, dough forming properties and mixing characteristics. The methods can be used at the stages of raw material reception and within the product development of gluten free formulations.

### **Keywords**

Gluten free, pseudo cereals, rheology, Farinograph, quality control

## P-3.4 ANCIENT GRAINS: INTRODUCING THE KABOG MILLET FROM THE PHILIPPINES AS A RICE ALTERNATIVE

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Cultivating ancient crops improves food security by diversifying our staple foods. An example of ancient Philippine crops is the kabog millet, an ecotype of *Panicum miliaceum*. Little is known about its nutritional quality; hence, the nutritional value of kabog millet was analysed in comparison to rice (white, brown, red, and black rice) and to a reference millet sourced from local supermarkets in Switzerland. We found that whole grain kabog millet has dietary fibre and ash content almost three times of black rice, protein levels almost double of white rice and 1.5 times higher than black rice, total phenolic acid content more than double than black rice and more than five times higher than the reference millet, and total carotenoid content that is almost 2.5 times higher than the reference millet and almost five times higher than black rice. To assess the antioxidant activity, DPPH, ABTS, and ORAC were used. The antioxidant activities of the whole kabog millet were significantly higher than the white rice samples and the reference millet in all three assays. By giving attention to underutilised, ancient crops, we are not only saving biodiversity and our planet, but we are also breathing new life into these forgotten ancient treasures.

### **Keywords**

*Panicum miliaceum*; ancient grains; nutritional quality; dietary fibre; protein; essential amino acids; phenolic acids; carotenoids; antioxidant properties; rice; kabog millet

## P-3.5 HEMP (CANNABIS SATIVA L) FLOUR OBTAINED FROM SEEDS OF INDUSTRIAL VARIETIES GROWN IN SPAIN: A STUDY OF ITS POTENTIAL AS A HIGH NUTRITIONAL VALUE FOOD INGREDIENT

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The current global market is characterized by a growing demand for products of high nutritional value from sustainable sources. Cannabis sativa L, known as hemp, is a promising product for food and other industrial uses. The interesting chemical composition of this product, especially its high lipid and protein content, makes it a raw material of great interest for application in different foods in order to enrich their nutritional value. Most of the studies found in the literature on the application of hemp are focused on hemp oil and hemp grain as ingredients in many certified organic foods, which have been gaining in popularity in recent years.

The aim of this study was to evaluate the functional, thermal and pasting properties of defatted hemp flour extracted from hulled seeds of hemp cultivars (USO 31, Henola and Ferimon) approved for production in Spain, cultivated in the same climatic and geographic conditions. Cultivars were agronomically evaluated by determining their yield and thousand seed weight. Once the dehulled seed was obtained, the oil was extracted by cold pressing and the hempseed residue was ground by a blade mill to obtain the hemp flour. The flour was then sieved on a 250-micron sieve. The flour was kept at refrigeration temperatures and used for analysis. The thermal properties of hemp flour were investigated using a DSC3 calorimeter (Mettler Toledo, Spain). The functional properties measured were Water absorption capacity (WAC), Water absorption index (WAI), water solubility index (WSI) and swelling power (SP).

The results revealed that hemp seed yield and properties varied greatly between varieties, depending mainly on the genetics of each cultivar and its adaptation to agro-climatic, geographical and cultivation system conditions. The USO 31 variety had the lowest yield and the highest seeds weight, significantly different than those of the other varieties. The results obtained showed defatted hemp flour (regardless of hemp variety) is a very important protein source to improve the nutritional value of protein-poor products. DSC measurements confirmed the presence of globulin 11S and 7S types which denaturation temperatures are above 92°C. This assures the by-product obtained from oil extraction, even if the temperature reached by flour is above room temperature, will keep the protein biological value, as to be applied in protein food enrichment.

Authors thank the financial support of Ministerio de Economía y Competitividad and the European Regional Development Fund (FEDER) (AGL2015-63849-C2-2-R), the Ministerio de Ciencia e Innovación (PID2019-110809RB-I00) and the Junta de Castilla y León/FEDER VA195P20. Rito J. Mendoza thanks the Junta de Castilla y León for the doctorate grant and Marina Villanueva thanks the Alfonso Martín Escudero Foundation for the post-doctoral grant.

## Keywords

Hemp flour, hempseed, techno-functional properties, DSC

## P-3.6 QUINOA GERM, PERISPERM & BRAN FRACTIONS: FUNCTIONAL AND RHEOLOGICAL PROPERTIES

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Quinoa, a pseudo-cereal, is popular for its nutritional composition. Nutrient content of quinoa grain is reported to be unevenly distributed in various seed components such as germ, bran and perisperm. In the present study, quinoa grain was fractionated by physical process to produce germ, bran and perisperm. To ascertain the application of these fractions for food product formulation, their physical, nutritional, functional and rheological properties were studied. Fractionation process resulted in production of germ (23%), bran (18%), perisperm (54%) with 5% mixed fraction. Nutritional analysis revealed that germ contained more protein and fat; bran was rich in dietary fibre and minerals. Brightness value (L - 81.23) of flour portrays its purity; higher yellowness of germ confirms separation efficiency. Highest bulk density was observed for germ (0.66 g/ml) & highest WHC was observed for the bran fraction. Foaming and emulsion properties varied among the quinoa fractions. Samples were evaluated for flow behavior properties; viscosity of all samples decreased with increase in shear rate and exhibited non-Newtonian, shear thinning (pseudoplastic) behaviour. Power law model and Hershel-Bulkley model were used to predict flow properties of samples. Results of study conclude that quinoa fractions have the potential to be exploited for various food formulations and product development.

### **Keywords**

Quinoa, Fractions, Physical property, Functional property, Rheology

## P-3.7 DEPENDENCE OF WATER REMOVAL METHOD IN THE FINAL PROPERTIES OF TEF FLOURS MODIFIED BY ULTRASONICATION

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Tef (*Eragrostis tef* (Zucc.) Trotter) is a gluten-free grain with rich nutritional value, offering an excellent balance among the essential amino acids, which makes it an interesting research subject. Physical modifications of gluten-free flours have been conducted in the food industry to alter the physicochemical properties of the native flours to improve their industrial range of use. Among the available techniques, ultrasound (US) treatments have received an increasing interest for being a green technology and a non-thermal processing method for modifying the flours' properties. These treatments require an aqueous medium to generate a homogenous modification, resulting in excess water that has to be removed to retrieve the modified flour. The magnitude of modification achieved by US treatments depends on variables such as sonication time, flour concentration in the treated suspension, temperature during treatment and power and frequency of the US, but also on processing variables related to the drying method. The aim of this work was to study the effect of US treatment on 2 varieties of tef (white and brown), and contrasts their final physicochemical properties depending on the drying method (freeze drying and sedimentation by centrifugation followed by air drying at 40°C). US treatments were performed at a flour concentration of 25% (w/w) for 10 min at a constant temperature of 20°C and a frequency of 24 kHz using a Hielscher UP400St sonicator (Hielscher Ultrasonics, Germany) equipped with a S24d22D titanium tip. After treatment samples were dried and sieved to a size < 250 µm.

US treatment has proved its potential in modifying the tef flour's structural, hydration, thermal and pasting properties, and the rheological properties of gels made with them. Results indicated high dependence of the flours final characteristics to the drying method, mainly derived from the soluble fraction that is lost in the centrifugation method, since their presence influences the way all flour compounds interact with water. US led to particle size reduction, while X-ray diffraction data indicated no significant crystallinity degree differences after sonication. Pasting profiles decreased when freeze-drying, but increased when drying by the centrifugation method. In all cases peak viscosity was achieved at longer time, indicative of a thermodynamically more stable arrangement in starch structure. Gels presented a more solid-like behavior after sonication.

Authors thank the financial support of Ministerio de Economía y Competitividad and the European Regional Development Fund (FEDER) (AGL2015-63849-C2-2-R), the Ministerio de Ciencia e Innovación (PID2019-110809RB-I00) and the Junta de Castilla y León/FEDER VA195P20. Antonio J. Vela thanks the Junta de Castilla y León for the doctorate grant and Marina Villanueva thanks the Alfonso Martín Escudero Foundation for the post-doctoral grant.

### Keywords

Ultrasound treatment, tef flour, pasting properties, hydration properties

## P-3.8 MODIFICATION OF THE TECHNO-FUNCTIONAL AND PASTING PROPERTIES OF BUCKWHEAT FLOUR BY MICROWAVE RADIATION

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Physical methods of modification open new processing possibilities to change the functional properties of different native flours. Among them, hydrothermal treatments, especially heat-moisture treatment (HMT), are techniques of great potential. HMT is usually carried out in relatively low moisture (<35°C) and high temperature (90-120°C) for a specified length of time (1-24 h). In HMT the heat transfer is based on convection phenomena but the utilization of another efficient method as microwave radiation (MW) can significantly improve the process. Therefore MW assisted HMT can provide more pronounced effects than conventional heating in typical HMT.

Common buckwheat has more recently received a great deal of attention due to gluten-free raw material and its nutritional profile. It is a rich source of starch, proteins, antioxidant compounds, trace elements and dietary fiber. However, because of lacking gluten, common buckwheat flour cannot be used to produce breads, cakes, and noodles like other flours.

Buckwheat flour from Kora variety (with 20 or 30% initial moisture content, IMC) was modified by MW radiation of 2450 MHz frequency and a power of 900 W. 4 and 8 min of MW treatment time was applied to 100 g of flour in cycles of 20 s of exposure and 40 s of rest. The functional properties of hydration, foaming and emulsifying characteristics of flours, as well as pasting properties and colour characteristics, were evaluated.

Initial moisture of treated flours showed to have an important effect on pasting properties, as 20% moisture samples evidenced pasting curves above the untreated sample. However, 30% IMC evidenced lower peak and final viscosity than untreated flour. The microwave treatment also had a significant effect on the functional and technological properties of flours. Higher effects on WAC, WAI and WSI at 30% initial moisture and longer treatment times (8 min) were observed. However, these flours showed lower emulsifying activity and lower foam stability in foaming tests.

MW treatments are an alternative technology for significant improvement of techno-functional properties of buckwheat flour and hence, will be a possibility to modify the gels or dough consistency and therefore, the physical properties of the resulted products.

The authors thank the financial support of the National Science Centre (NCN Poland) and Norway Grants (UMO-2020/37/K/ST5/03602), Ministerio de Economía y Competitividad and the European Regional Development Fund (FEDER) (AGL2015-63849-C2-2-R), the Ministerio de Ciencia e Innovación (PID2019-110809RB-I00) and the Junta de Castilla y León/FEDER VA195P20. Marina Villanueva thanks the Alfonso Martín Escudero Foundation for the post-doctoral grant and Antonio J. Vela thanks the Junta de Castilla y León for the doctoral grant.

## Keywords

Buckwehat flour, microwave treatment, techno-functional properties, pasting properties

## P-3.9 MICROWAVE TREATMENT OF BUCKWHEAT GRAINS AT DIFFERENT MOISTURE CONTENT AND ITS EFFECT ON TECHNO-FUNCTIONAL AND RHEOLOGICAL PROPERTIES OF OBTAINED FLOURS

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The use of heat moisture treatments (HMT) assisted by microwave (MWT) for physical modification of buckwheat grains was carried out in this study. Buckwheat is a pseudocereal without gluten and with high nutritional value, therefore, its use for food product development could improve variety and quality of gluten-free diets. MWT was chosen as a quick and effective technology alternative to conventional HMT. Buckwheat grains at 13%, 20%, 25% and 30% initial moisture content (IMC) were microwaved for 8 min at 18 W/g in a non-hermetic container, which allowed variable moisture evolution of the sample during MWT. The techno-functional and rheological properties and x-ray diffraction pattern of the flours obtained after milling treated grains were measured. The water absorption capacity increased up to 16% in the samples treated at 25 and 30% IMC while the swelling power decreased 12,5% in the MWT-30% sample and slightly increased (+6,5%) in MWT-20% sample. The emulsifying capacity and emulsion stability were reduced with MWT up to near zero in the MWT-30% sample. A significant impact of MWT on buckwheat flour pasting properties when the grain was treated at 30% IMC was observed: the pasting temperature increased +1°C and the peak, setback and final viscosities decreased 12%, 18% and 15% respectively with respect to the native flour (obtained from untreated grains). The rheological test applied to gels made from the flours obtained after treatment, showed a significant increment in the gel structure stability and tolerance to stress. The A type pattern obtained by X-Ray diffraction did not change with treatment, though an increase in the intensity of the diffraction peaks was observed denoting an increase in starch crystallinity. At the same time, an increase in the V-type crystallinity was observed, which is usually related to the formation of amylose-lipid complexes. Based on these results, MWT of buckwheat grains seems to be a viable and effective alternative to modify techno-functional and rheological properties of buckwheat flour to meet the needs of gluten-free food production.

### Acknowledgments

The authors thank the financial support of Ministerio de Economía y Competitividad and the European Regional Development Fund (FEDER) (AGL2015-63849-C2-2-R), the Ministerio de Ciencia e Innovación (PID2019-110809RB-I00) and the Junta de Castilla y León/FEDER VA195P20. Ainhoa Vicente thanks the Ministerio de Ciencia, Innovación y Universidades for her doctorate grant. Marina Villanueva thanks the Alfonso Martín Escudero Foundation for the post-doctoral grant.

### Keywords

Buckwheat, microwave treatment, techno-functional properties, rheological properties

## P-3.10 THE INFLUENCE OF LACTIC ACID BACTERIA ON QUINOA SOURDOUGH FERMENTATION AND WHEAT BREAD FORTIFICATION

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Quinoa (*Chenopodium quinoa* Willd.) is a well-known industrially valuable pseudocereal due to its potential application as an important source of nutrients, fibres, and bioactive compounds in particular. Recently, the application of quinoa in bread and sourdough production using selected LAB strains has attracted much interest. LAB play a significant role in food fermentations, where they contribute to the development of the wanted technological properties, sensory characteristics and microbiological safety in the food products. The application of selected LAB as starters permits the quality of bread products and their nutritional value to be improved through metabolic activity and the release of peptides with antioxidant activity. The application of selected starter cultures with specific properties for fermentation may determine steady LAB variety and the characteristics of fermented products that influence nutritional value, the composition of biologically active compounds and quality. The aim of this research was to evaluate the influence of different LAB on the biochemical characteristics. The aim of this research was to evaluate the influence of three starter cultures, *Lactobacillus acidophilus* DSM 20079, *Lactobacillus plantarum* MR24, and *Lactobacillus brevis* R26, on the biochemical features of fermented quinoa as pH, total titratable acidity (TTA), volatile acidity, D/L-lactic acid, LAB count and enzyme activities (protease, amylase, phytase and cellulase), and its effect on the quality and acceptability of quinoa-wheat composite bread.

The results confirmed that *L. plantarum*, *L. brevis*, and *L. acidophilus* were well adapted in quinoa medium, confirming its suitability for fermentation. LAB strains influenced the acidity, L/D-lactic acid content, enzyme activity of fermented quinoa. *L. brevis* produced the highest phytase activity in quinoa medium therefore, quinoa fermented with these LAB could be recommended for bread production to make nutritionally fortified bread with good sensorial properties and acceptability. The addition of 5 and 10% of quinoa fermented with *L. brevis* did not affect the total titratable acidity of wheat bread, while 10% of fermented quinoa with *L. brevis* resulted in a higher specific volume. Fermented quinoa additives increased the overall acceptability of bread compared with unfermented seed additives. The application of fermented quinoa flour with *L. brevis* might be considered relevant for novel applications as a functional dietary supplement.

### **Keywords**

Quinoa; *Lactobacillus*; fermentation; quinoa-wheat composite bread; quality; acceptability

## 4. Milling and Bread Making Technology

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## P-4.1 CHARACTERIZATION OF DOUGH MIXERS PERFORMANCES FOR DESIGN AND SCALE UP

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The kneading stage achieved in dough mixers have a decisive impact on the baked bread quality. Actually, mixing acts at different scales. Firstly the mixing at the bowl scale aims at the dispersion and homogenization of the ingredients, especially the water, and is also responsible for the heat removal. This macromixing is ensured by the rotation of the bowl that allows the tool to sweep the entire volume thanks to planetary motion. At the local scale, especially in the vicinity of the rotating tool, the micromixing promotes different physicochemical reactions that contribute to the dough stiffness development. This region is also the seat of heat production due to high viscous stresses, and concurrently air is incorporated by the tool suction, then dispersed in the dough in the form of small bubbles that will later be essential for the fermentation. The global kneader performances results of the combination of these two scales.

The purpose of the present study is to propose a methodology to characterize the performances of the dough mixers by adapting the multicriteria chemical engineering approaches.

The set of kneaders used for this study are standard equipments of the VMI™ company, two SPI™ with capacities of respectively 11L and 400L equipped with a spiral tool in a rounded bottom vessel, and two “Kneadster”™ (here and after named KN) of respectively 25L and 250L, in a cylindrical flat bottom vessel. The designs of SPI™ and KN™ kneaders differ by many aspects, and each design is available at two different sizes. The SPI11 is conceived to tune the vertical location of the tool (thus the nip between the tool and the wall), and the KN25 is equipped with a double tool with adjustable centers distance, in order to carry out a refined study of the influence of the tool/bowl geometry.

The characteristic parameters that were investigated are at first the global power and strain rate coefficients, namely  $K_p$  and  $K_s$ , determined experimentally by the Metzner-Otto analysis with power law fluids. Mixing numbers  $K_{MF}$  and  $K_{MP}$  were also determined on the criteria of temperature homogenization and the power peak time, both obtained with a sandwich bread dough. A global heat transfer coefficient was fitted in various conditions to assess the thermal exchange capacity. The micromixing performance was characterized by an evaluation of the local shear rate through the  $KL$  coefficient, and the air intake.

These parameters provide a profile of the kneading devices, as well as relevant combinations of them ; for instance the power factor versus the mixing time factor, as proposed by Delaplace et Guérin (2006) allows a global energetic performance, ranking of the four devices studied here as follows :  $SPI400 < KN250 < SPI11 < KN25$ .

These characterizations of the kneading devices provide some highlight about the most adequate design for given dough manufacturing applications.

## Keywords

Dough mixers, kneading, mixer design, dough mixer performance

## P-4.2 TAGUCHI DESIGN, A NEW APPROACH TO FORMULATE MIXED FLOUR BREAD

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A simple bread formulation includes four elements (wheat flour, leaven, water and salt). But when it comes to improving the bread or using combinations of flours, finding the suitable ingredients and portions can be difficult. This research used seven different flours as the ingredients for making bread. White wheat flour, durum flour, whole wheat flour, white sorghum flour, soybean flour, waxy rice flour, and green banana flour were combined with the goal to make high nutritive, lower gluten and lower glycemic index bread. To reach the goal, a Taguchi model (L18) was used as the statistical model algorithm. By the help of Mixolab instrument, the hydration of each flour combination was obtained. The formulations were shaped and baked by a professional baker. The control samples were breads made by white wheat flour and whole wheat flour. The textural properties, aromatic compounds, and physical properties like density, porosity and colour were collected from all samples. The optimisation carried on the results and based on the controls, the optimised formulated bread was obtained using the Taguchi model. The model desirability was 95%.

### **Keywords**

Taguchi design, bread formulation, texture, aromatic compounds, sour dough

## P-4.3 DEVELOPMENTS IN HUMAN UTILIZATION OF OAT AND RYE IN TERMS OF PROCESSING TECHNOLOGY AND NUTRITIONAL VALUE

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Rye and oat are good source of nutrients, including dietary fibers, such as arabinoxylans and beta-glucans. However, their breeding for human utilization has been neglected in the recent decades in Hungary, in spite of the increasing demand on the market for products based on rye and oat. Besides, oat can be also a part of gluten-free diet by selecting appropriate varieties and by ensuring strict gluten-free processing conditions. However genetic and environmental variability can affect the amount of valuable and technologically relevant components and behaviour of the grains and their flours. The aims of this work were the experimental cultivation of oat and rye varieties and the selection of promising cultivars in terms of stability of technological properties and nutritional value. In the field studies, Hungarian oat and rye varieties from two harvest years were investigated. The chemical composition (i.e. protein, ash, fat, dietary fiber, beta-glucan) was determined according to standardized methods. Investigation of protein composition was performed by HPLC. The rheological properties of the flours were characterized by Zeleny sedimentation test, Falling number method, as well as Farinograph, micro-doughLAB, Rapid Visco Analyser and Mixolab tests. In baking trials, the experimental loaves were characterized by the determination of specific volume, baking loss, crumb hardness and crumb structure properties. Oat varieties showed differences in chemical composition especially in fat, dietary fiber and beta-glucan content, while protein content of the varieties was similar. Protein composition was also comparable but some protein peaks could be identified that have a difference between varieties and could cause diverse technological properties. Wholemeal flours of dehulled oat varieties differed in mixing and pasting properties, while in case of falling number no significant difference was found. Test baking method was developed successfully to measure baking quality of oat. Rye varieties had slight differences in protein and dietary fiber content while fat content showed higher diversity. Wholemeal and white rye flours differed mainly in pasting behaviour, which was also in accordance with amylolytic status. The continuation of our research work includes the characterisation and selection of valuable milling fractions for rye. This requires chromatographic characterization of protein and carbohydrate composition, thus helping to determine the relationship between the technological properties and the components that play a role in this. Our work also focuses the selection of varieties/fractions with health-promoting components (i.e. mainly arabinoxylans) and low FODMAP content.

This work was supported by the BME-Biotechnology FIKP grant of EMMI (BME FIKP-BIO), GalgaGabona project (2017-1.3.1-VKE-2017-00004) and the COST Action 18101 SOURDOMICS.

### Keywords

Genetic variability, oat, rye, technological properties

## P-4.4 SOURDOUGH BIOTECHNOLOGY NETWORK TOWARDS NOVEL, HEALTHIER AND SUSTAINABLE FOOD AND BIOPROCESSES

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Traditional sourdough bread resorts to spontaneous fermentations leading to natural selections of microorganisms, mainly yeasts and lactic acid bacteria. Such microorganisms are essentially beneficial to humans and inhibits propagation of undesirable microbiota. Sourdough fermentation was probably one of the first microbial processes employed by Man for food production and preservation. Sourdough bread stills widely manufactured at farm level across Europe and worldwide and is highly appreciated by consumers for its distinct flavour, texture and healthy attributes. Through a bottom-up approach, this COST Action network brings together a multidisciplinary group of scientists and SMEs/LEs dedicated for many decades to study cereals and sourdough technologies. SOURDOMICS will exploit sourdough technology through entire value chain: from sustainable cereals' production, through fermentation processes' exploitation, to by-products' valorisation in circular economy. In (1)-upstream, it aims at (1.1)-exploitation autochthonous (pseudo)cereals with good baking, nutritional and healthy attributes, while (1.2)-promoting a sustainable agriculture and preserving genetic diversity. Simultaneously, aims at contributing to develop new business opportunities to local farmers through their engagement into food processing with shared small-scale breadmaking facilities, and the integration into industrial and trade chains. Such features are in agreement with European Agenda for Food and Environment. In (2)-downstream, the biotechnological sourdough fermentation exploitation comprises several objectives: (2.1)-Design starter cultures with a wide range of biotechnological applications; (2.2)-Production of healthy and tasty varieties of bread, thus catalysing changes in consumers' diets and market orientations; (2.3)-Production of high-added value metabolites resorting to sourdough microbiota; and (2.4)-Valorisation of by-products from cereal production and sourdough technologies. The poster will demonstrate the structure of the programme, the possible connection points and the first results of the project.

### Keywords

Food biotechnology, fermentation, breadmaking technology, proteomics

## P-4.5 EVALUATION OF GLUTEN-FREE BREAD MADE FROM QUINUA AND BANANA FLOUR, CASSAVA STARCH, LUPINE FLOUR OR WHEY PROTEIN, WITH HIDROXYPROPILO METHYLCELLULOSE (HPMC) AND TRANSGLUTAMINASE, AS IMPROVERS

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Gluten free-bread (GFB) quality is a challenge because of their rheological, physical and sensorial properties are lower than wheat. In addition, the materials to make GFB are very expensive. Thus, the incorporation of foods that have overproduction and by-products both with low cost as well as hydrocolloids and enzymes as improvers, could be an alternative to produce GFB with high quality, competitive in the market and accessible for the population that has sensibility to gluten and other population that consume GFB as life style. In this study, rheological and physical properties of gluten-free bread formulations were evaluated from quinoa (HQ) and banana (HB) flours, cassava starch (CS), lupine flour (HC) or whey protein (PL) with hydroxypropylmethylcellulose (HPMC) and transglutaminase (TG), as enhancers. The effect of TG at different concentrations (0.0; 0.5; 1.0 and 1.5 %) on proteins (HC or PL) was evaluated, through the quantification of free amino groups and thiols, analysis of apparent viscosity and electrophoresis SDS-Page. For the rheological and structural analysis, a 22 factorial design with 4 axial points and a central point was performed. The contents of HPMC (0.5 - 2.5 %) and HC or PL (3.0 - 9.0 %) varied, while the levels of HQ, HB, AY and TG were remained constant (% higher protein cross-linking). Thus, 10 formulations were obtained, they were characterized by mass characterization (Mixolab 2), pasting properties (rheometer coupled with a pasting cell), breadmaking ability (loaf volume), firmness (texturometer) and crumb structure (ImageJ®). Cross-linking analyzes showed the best result with 1 % of TG. The addition of HPMC and PL or HC modified the properties of the bakery dough in various ways. However, the synergy between 1.50 to 2.21 % HPMC with 6 to 9 % HC or PL, provided good characteristics in the rheological and physical properties of the gluten-free bread. The correlations found in HC or PL indicate a greater fragmentability of the starch granule, the more it swells. Furthermore, the lower denaturation of the HC protein improves the gelatinization of the starch. Finally, through of the Response Surface Method, the baking formulas that presented the best rheological and physical characteristics were determined with 1.80 % HPMC and 8.30 HC or 8.33 % PL. The progress reached in this gluten-free breadmaking contribute to better understanding this kind of matrix as well as to maximize their properties.

### **Keywords**

Gluten-free bread, hydroxypropylmethylcellulose, transglutaminase, overproduction foods, by-products

## P-4.6 IMPACT OF TEMPERING PROCESS ON THE YIELD AND COMPOSITION OF QUINOA FLOUR

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Quinoa kernels are generally whole-milled due to their small kernel size. However, roller milling allows the separation of the starchy perisperm from the protein- and fat-rich bran fraction. Both fractions can be used for specific food applications. Studies have focused on roller milling of quinoa but information on tempering is rather limited. This study investigates the impact of different tempering conditions on roller milling of quinoa. Three types of commercially available quinoa seeds were roller-milled on small scale by a Brabender Quadrumat Junior. Two levels of tempering time (8 and 20 h) were combined with three levels of tempered moisture (13, 15 and 17 %). Flour yield was recorded and the obtained flour was characterised by ash and protein content, and particle size distribution (PSD). An increase in tempered moisture reduced the flour yield, while a change in tempering time had no effect on two out of three samples. Flour composition depended on the combination of tempering conditions but increasing tempered moisture generally resulted in a better bran-perisperm separation. Differences in kernel properties were reflected in the PSD: small kernels created a coarser flour with higher ash and protein content.

### **Keywords**

Tempering, roller milling, flour yield, quinoa flour

## P-4.7 DURUM AND COMMON WHEAT IN BREADMAKING: STRUCTURAL, BIOCHEMICAL, AND RHEOLOGICAL RELATIONSHIPS TO QUALITY

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The current work investigates the biochemical differences between durum wheat flour (DWF) and common wheat flour (CWF), and it studies doughs and breads made from mixtures of the two flours. The most significant differences in DWF compared to CWF appear to be an increase in the concentration of triacylglycerols ( $21.65 \pm 2.43$  vs.  $15.12 \pm 1.14$   $\mu\text{mol fatty acid.g}^{-1}$  flour db) and a decrease in the level of insoluble proteins ( $10.69 \pm 0.01$  vs.  $18.41 \pm 0.01$  mg.g<sup>-1</sup> flour db). These changes may underlie the observed differences in dough rheology, where doughs with higher proportions of DWF are stiffer (consistograph maximum pressure of  $2279.3 \pm 74.4$  mb for 100% DWF and  $2026.0 \pm 122.1$  mb for 100% CWF). This study also confirmed the expected quality differences observed in bread made from DWF and CWF, where bread made from DWF is inferior in both loaf volume ( $1433 \pm 17$  cm<sup>3</sup> vs.  $1701 \pm 16$  cm<sup>3</sup>) and crumb fineness as analyzed by digital image analysis. Further work is necessary to investigate the biochemistry of doughs made with mixed flours to draw conclusions about how the differences between the flours manifests in the changes to bread quality.

### Keywords

Common wheat, durum wheat, biochemistry, rheology

## P-4.8 ANDEAN CROPS: KAÑIWA AND TARWI FLOURS APPLIED TO THE DEVELOPMENT OF GLUTEN-FREE MUFFINS

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Tarwi (*Lupinus mutabilis*) and kañiwa (*Chenopodium pallidicaule*) are Andean crops that have taken importance due to their nutritional properties. Tarwi is leguminous with exceptionally high protein and fat content. The proteins are rich in lysine and the oil is an excellent source of unsaturated fatty acids. Kañiwa has a balanced essential amino acid profile. On the other hand, gluten-free products are usually rich in carbohydrates and fats but poor in good quality proteins, dietary fiber, and micronutrients. Thus, the use of ingredients of high nutritional value could transform gluten-free food matrices into healthier ones. The objective of this research was to evaluate the effect of tarwi and kañiwa flours in a gluten-free muffin formulation. Control muffin (C) formulation consisted in: potato starch (100%), sugar (40%), butter (8%), dry yeast (3%), xanthan gum (1%), salt 1% and water 110%. Potato starch was substituted at 50% by a) kañiwa flour (K50), b) tarwi flour (T50), and c) a blend form by 50 % of both flours (K25T25). The proximal composition and water (WA) and oil absorption (OA) of flours were determined. Besides, the pasting behavior of formulations were performed in a rapid viscoanalyzer (RVA 4500). Muffin quality was measured by moisture content, specific volume, and crumb porosity using the ImageJ 1.52a software. The crumb parameters determined were crumb density, air fraction, and the fractal dimension (D). The tarwi flour had a very high protein (51.51%) and lipid content (20.67%) and 11.3% and 3.25% of insoluble and soluble fiber, respectively. The content of carbohydrates, proteins, insoluble and soluble fiber in kañiwa was 50.74%, 21.76%, and 11.58 and 2.59%, respectively. Concerning WA and OA, tarwi presented the highest values (WA: 276%; OA:149%), followed by kañiwa flour (WA:174%; OA:136%) and finally, starch (WA:74%; OA:93%). These compositional and absorption characteristics lead to considerable modifications in the RVA profile by adding tarwi and kañiwa flours, leading to lower viscosity values during the whole run. The value of breakdown decreased with Andean flours showing a higher pasting stability. In the same sense, a decrease in the setback (tendency to retrograde) in these samples was observed. Concerning muffin quality, K50 presented similar specific volume to control (2.39 cm<sup>3</sup>/gr), while the lowest value was obtained by T50 (1.64 cm<sup>3</sup>/gr). With respect to crumb porosity, K50 exhibited the highest crumb density (45.57 alveoli/cm<sup>2</sup>) and the control sample the lowest one (29.82 alveoli/cm<sup>2</sup>). Finally, D ranged from 1.66 to 1.77 for T50 and control sample, showing a higher matrix complexity in the control sample. Results show the aptitude of these Andean flours to be used in high levels in the development of gluten-free muffins. Remarkably, the addition of kañiwa flour at 50% led to products with improved nutritional profile, maintaining the technological quality.

### Keywords

*Chenopodium pallidicaule*, *Lupinus mutabilis*, gluten-free muffin, pasting properties

## P-4.9 DETERMINATION OF TECHNOLOGICAL PARAMETERS OF THE SPONTANEOUS SOURDOUGH FERMENTATION OF HULL-LES BARLEY

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The spontaneous sourdough fermentation process is considered an important type of sourdough. The development of microorganisms of sourdough can be influenced by changing the parameters of the technological process such as the ratio of flour and added water, the fermentation temperature and time. The aim of the study was to determine the optimal parameters for the three phase spontaneous fermentation process of hull-les barley sourdough, as well as to describe the dynamics of community of microorganisms. Sourdough was prepared under laboratory conditions in the Latvia University of Life Sciences and Technologies. To start the fermentation, hull-les barley variety "Kornelija" wholegrain flour and water in ratio of 1:1 were mixed. Three phase spontaneous backslopping method was applied to barley sourdough fermentation. Box-Behnken design statistical method was used with 15 runs of the experiment for data acquisition and to model the response surface. An experiment involves three factors in three levels: temperature, fermentation time, amount of added water. For each sample, the number of Lactic acid bacteria, yeast and of Mesophilic aerobic and facultative anaerobic microorganisms (MAFAM) CFU per gram was determined. The microbiological tests were done using standard methods. The goal of the first phase is to reduce the development of MAFAM. Solutions for the criteria of minimum MAFAM includes the following parameters : flour and water ratio 1:1.13, temperature 30 °C , time 24 h. The tasks of the second phase is the maximum development of Lactic acid bacteria. The modelled parameters of maximum Lactic acid bacteria: inoculate, flour and water ratio 1:1:1.3, temperature 31 °C , time 14 h. The goal of the third phase is to strengthen the development of Lactic acid bacteria and yeast. Solutions for such criteria are as follows for: inoculate, flour and water ratio 1:1:1.5, temperature 28.5 °C , time 12 h. In the spontaneous fermentation process during this study the number of Lactic bacteria increased from 3.0 log CFU g<sup>-1</sup> at the start of fermentation to 8.2 log CFU g<sup>-1</sup> at the end of the third phase. The colony counts of yeast developed from 4.9 to 7.3 log CFU g<sup>-1</sup>. The change of pH of the sourdough from 5.8 to 3.8 shows metabolic activity of Lactic acid bacteria. The developed spontaneous hull-les barley sourdough is consistent with the number of Lactic bacteria and yeasts in line with those seen by the active sourdough. In the final sourdough there is a significant number of yeast cells which allows it to be used as leavening agent.

### Keywords

Sourdough, fermentation, hull-les barley

## P-4.10 CHARACTERIZATION OF GLUTEN FREE CAKE BATTER WITH WALNUT FLOUR: WATER MOBILITY AND TEXTURAL BEHAVIOR

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Walnut flour (WF) is a by-product of the oil industry, obtained from the press cake milling. The compositional characteristics (high lipid, protein, and fiber contents) made WF attractive for improving the nutritional and technological quality of gluten-free products. This work aimed to characterize WF and evaluate the effect of WF addition on the water mobility and textural behavior of gluten-free batters. The proximate composition, water activity ( $a_w$ ), organic molecule absorption (OMAC), and water (WHC) and oil (OHC) holding capacities of WF were obtained. Besides, particle size distribution and microstructure by low vacuum scanning electron microscopy (LVSEM) of WF were evaluated. The control batter formulation contained rice flour and corn and cassava starches, and two levels of WF were used: 15% (WF15) and 20% (WF20). The water mobility and texture of batters were determined by low-resolution  $^1\text{H-NMR}$  and back-extrusion, respectively. WF presented a  $a_w$  value ( $0.565 \pm 0.02$ ), high lipid (55.7%), protein (24.6%), and dietary fiber content (9.4%). Regarding interaction with other ingredients, the value of WHC for WF was  $2.58 \pm 0.1$  mL/g WF. Also, the OHC and OMAC were  $0.72 \pm 0.05$  and  $0.77 \pm 0.09$  g oil/g WF, respectively. With respect to WF particle size, WF exhibited only one peak centered at  $264.8 \mu\text{m}$  ( $D(0.5)$ ) but when WF was submitted to sonication particles deagglomerated, and a shift to smaller particle sizes were observed ( $D(0.5) = 13.4 \mu\text{m}$ ). Besides, in this case, one defined peak was observed together with two overlapped and broad peaks. The micrographs showed that WF has not intact cells and is composed primarily of thin layers of cell walls and agglomerated protein bodies. The small particle size and the absence of intact cells could contribute to the bioaccessibility of WF lipids. Otherwise, relaxation times describe the mobility of water protons in the batter matrix. The relaxation spectra were fitted with an exponential decay equation and the spin-spin relaxation times ( $T_2$ ) and proton fraction ( $I_i$ ) were obtained. The fraction of protons ( $I_i$ ) affected by magnetic field increased with the addition of WF. Also, the amount of free water decreased with WF level as the decrease of  $T_2$  showed. The relaxation time decreased from 18.73 ms for the control to 14.33 ms for WF20. This effect could be related to the protein and fiber content of WF that bound the water in the batter. Concerning the textural properties, the increase of WF concentration in the batters increased their firmness, consistency index, viscosity index, and cohesiveness. Particularly, the addition of 20% WF almost doubled the batter firmness and cohesiveness. Likewise, the higher consistency and viscosity indexes of WF20 batter were probably the reason that pouring that batter into the beaker was easier. These results showed that besides improving the nutrition value of batters. WF addition makes the batters easier to handle during its manufacture.

### Keywords

*Juglans regia* L.,  $^1\text{H-NMR}$ , backextrusion, physicochemical properties, microstructure

## 5. Food Safety and Security

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## P-5.1 THE EFFECT OF HEAT STRESS ON THE NUTRITIONAL COMPONENTS OF WINTER BARLEY (HORDEUM VULGARE L.)

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Although winter barley (*Hordeum vulgare* L.) is able to survive various environmental stresses, it is seriously threatened by global climate change. Heat stress is one of the major constraints that can negatively affect the crop growth, and the quantity and quality of the grain. Protein and  $\beta$ -glucan content, of the seeds is of primary importance due to their effects on nutrition and on the processing quality. Thus, identifying genotypes with higher adaptability and stable compositional traits under heat stress condition is a primary goal for researchers and breeders.

The tolerance of 28 different winter barley genotypes to high temperature (ZD31: 30°C (5days), ZD49: 35°C (10 days)) was studied under controlled environment. The genotypes were treated with single (ZD49) and double heat stress (ZD31+ZD49) at the first node appearance (ZD31) and at booting stage (ZD49), to determine their response profiles to high temperature. Compositional properties of the grain were characterised by analysing the thousand kernel weight (TKW), the total protein (TP) and the  $\beta$ -glucan (BG) contents of the wholemeal.

The genotype, the heat stress and their interactions were all determined high portion of the total phenotypic variance. Genotype had the strongest effect on BG (66.2% of the total variance), which was followed by TKW (42.8%) and TP (30.5%). The average TKW did not differ significantly under control and single heat stress environments, but was reduced by 11% due to double heat stress. Both TP and BG increased under both heat treatments, but this increase was moderate for BG (8.0 % in single and 14.7 % in double stresses), and significantly high for TP (26.3% and 31.6%, respectively). No significant correlations was found between the three studied traits under control conditions, but TKW showed a strong negative correlation with TP ( $r = -0.67^{***}$ ) and a medium positive correlation with BG ( $r = 0.36^*$ ) under double heat stress. Due to the large genotypic variance found in the BG and TP contents of the studied lines, it is possible to identify barley genotypes (e.g. Lonni, Lambada, Canberra) which can preserve their compositional traits even under heat stress conditions.

This research was funded by national research grant from the Hungarian Scientific Research Fund (GINOP-2.3.2-15-2016-00029)

### Keywords

Winter barley, heat stress, protein, glucan, TKW

## P-5.2 EFFECT OF DROUGHT STRESS ON BARLEY GRAIN QUALITY (HORDEUM VULGARE L.)

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Drought is one of the main abiotic stress factors which have serious effects on crops. It has strong effects on the physiological processes of the plants which also impacts on the morphological, biochemical and molecular traits. When water deficit occurs in critical periods of the plant or seed development, the grain number and size would be reduced, and grain composition could drastically change. The general finding is that the protein content increases, while the dominant component of the dietary fibres in barley, the  $\beta$ -glucan content, decreases due to drought stress. Thus, it is very important to test the stability of the grain yield and quality under drought conditions, in order to identify barley genetic resources for breeding purposes.

Twenty-eight barley varieties were studied under drought stress conditions. Two drought stress treatments were applied in controlled chambers. Single stress treatment was applied at first awns visible (DEV49) stage, while double treatment also included the first node detectable (DEV31+DEV49) stage. Drought stress was applied by withholding water and maintaining the average daily volumetric soil moisture content (VSMC) at 15% for 1 week. This VSMC value represented a non-lethal, but severe drought stress during this period. The control plants were irrigated to keep the VSMC at 21%. The thousand kernel weight (TKW), the total protein content (TP) and the  $\beta$ -glucan (BG) content were measured in barley wholemeal. The average TP content was significantly affected by the genotype (G) (38.0%), and the interaction between the genotype and the treatment (GxE) (36.7%). The G determined 49.2% of the total variance of the BG content, while the TKW was influenced by the E (41.1%) to the largest extent. The TP increased by 10% under the single stress treatment and by 8% under double stress. The BG content decreased by 20% both under single and double stress. The largest reduction was observed for TKW, which was 30% lower compared to the control. Negative correlation was found between the TP content and the TKW under control conditions, while all parameters correlated significantly when double stress was applied. Both TKW and BG had negative correlation with TP. Results showed that there was a large variation in the compositional traits of the barley cultivars and in their response profiles to drought. Thus it is possible to identify genotypes which could keep their stability in their compositional traits even under drought stress conditions.

This research was funded by national research grant from the Hungarian Scientific Research Fund (GINOP-2.3.2-15-2016-00029)

### Keywords

Drought stress, barley, protein, glucan, TKW

## P-5.3 IMPACT OF WAITING TIME BEFORE BAKING AND AMOUNT OF BAKING POWDER ON AERATION DURING KNEADING, OVEN RISE AND FINAL POROSITY OF POUND CAKE

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Baking powder used in bakery products is composed of an alkaline substance and a blend of acidic substances. These acidic substances known as leavening acids are composed of minerals such as phosphate, potassium, sodium, aluminum and others. Recent changes in European legislation (EC Regulation 380/2012) resulted in a restriction of the dose of aluminum in food additives. Since that date sodium aluminum phosphate (SALP), used as acid agent in baking powder, is affected by this regulatory change. SALP is largely used in baking powder mixes due to its ability to provide expected specific volume of cake, a homogeneous cohesive and resilient crumb, beside the neutral taste.

This study aims at assessing alternatives to SALP in order to reduce the overall aluminum content in cake while keeping a comparable quality. A screening of 11 different phosphates was carried out for this purpose and compared to the performance of the SALP. A sponge cake matrix was chosen as a food model for this study. The performance of baking acids was measured thanks to several parameters related to CO<sub>2</sub> released during mixing and baking, the evolution of the height during baking and cooling, the final volume and the texture of sponge cake. The influence of selected leavening acids was evaluated in three series. During batter preparation and sponge cake baking, CO<sub>2</sub> released and height evolution were monitored. These parameters were related to the final textural characteristics. Principal component analysis (PCA) was used to combine all the results. It showed that two acids are appropriate substitutes thanks to their performance similar to SALP during the baking process and comparable quality of the final sponge cake. Further investigations need to be performed in order to relate the chemical and physical properties of leavening acids to the baking performance.

### **Keywords**

Leavening acids, mixing, baking, texture, sponge cake, batter, carbon dioxide release

## P-5.4 EFFECT OF DEGREE OF FLOUR WHOLENESS AND NITROGEN FERTILIZATION DOSE AND TIMING OF APPLICATION ON ASPARAGINE CONCENTRATION, AS THE MAIN INDICATOR OF ACRYLAMIDE-FORMING POTENTIAL IN WHEAT

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Free asparagine (Asn) is the main precursor for acrylamide (AA) in food. Both sugar and free Asn react during the Maillard reaction to form AA. As a consequence of the carcinogenic potential of AA formed by heating carbohydrate-rich food materials such as cereals, the European Commission in 2017 has announced a regulation aiming to reduce the level of AA in food products.

Fertilization is a key factor in crop production to increase yield and quality but can affect Asn levels as well. Moreover, the degree of flour wholeness can also impact on Asn content.

The aim of the present study was to evaluate the effect of the flour wholeness and nitrogen (N) fertilization amount and timing of application on Asn content in wheat.

For this purpose, during the 2018-2020 period the effect of the flour wholeness (refined flour vs wholegrain flour) and of 5 doses of N fertilization (from 0 to 198 kg N/ha) was evaluated on a variety of bread-making wheat (Aubusson). The timing of application consisted of a first N rate application at the end of tillering of 33 or 66 kg N/ha and for each of this initial N dose a supplementary N amount at the beginning of stem elongation stage of 0, 33, 66, 99 and 132 kg N/ha was applied. A total of 10 treatments for each typology of flour were compared in each year, adopting a randomized block scheme with 4 repetitions and elementary plots of 12 m<sup>2</sup>.

The determination of the free Asn content was carried out for all samples through the use of an enzymatic spectrophotometric assay (KIT K-ASNAM, Megazyme) based on NADPH consumption that is measured by the decrease in absorbance at 340 nm, after extraction of the flour samples with HClO<sub>4</sub> 1 M. For a selection of treatment in 2020 trial, biscuits were made following a protocol recipe and were analyzed to determine the AA content with a LC-MS/MS QUECHERS method.

The results underlined that the ASN content was positively correlated to the N rate, with a stronger relationship with the application at stem elongation. As far as the timing of application was concerned the N rate at the end of tillering of 66 kg/ha increased the Asn content on average of +19% respect to the amount of 33 kg/ha. Moreover, the application of a N rate at the beginning of stem elongation of +132 kg/ha increased on average the Asn content of +135%.

There was a very strong relationship ( $R^2 = 0.93$ ) between the Asn content in wholegrain and refined flour. The wholegrain flour showed on average an increased Asn content equal to +164% in comparison to the refined flour.

The acrylamide content in wholegrain flour was approximately three times higher than the content of refined flour. There was positive relationship ( $R^2 = 0.72$ ) between AA and Asn contents.

In conclusion, the flour wholeness and the amount of N fertilization, particularly at stem elongation, heavily impact on the Asn content, which, being the main precursor in the AA formation, determines a direct increase in AA content in the finished wheat-based bakery products.

**Keywords**

Refined flour, whole grain flour, nitrogen fertilization, asparagine, acrylamide

## 6. Wholegrains, their definition and utilisation in foods

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## P-6.1 CONSUMER'S PERCEPTION OF SORGHUM FOR THE DEVELOPMENT OF A WHOLE GRAIN BEVERAGE

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Sorghum is often used in animal feed, therefore sorghum whole grains have high bioactive compounds and fiber content. Its use in the human diet requires the development of products that attend the consumer's needs and preferences. The aim was to interpret the consumers' perception of sorghum, as well as to evaluate the potential of extrusion and different sorghum genotypes for a soluble beverage. Taking into account that sorghum is not used in most countries, the consumer perception of this seed was investigated using word association method, applying online questionnaire. In parallel, six sorghum genotypes were investigated. In whole grains, chemical composition, condensed tannins (CT), total phenolic compound (TPC), antioxidant capacity (AC) and resistant starch (RS) were analyzed. They were ground and processed by thermoplastic extrusion to develop soluble beverage and their wettability, dispersibility and the sensory characterization of the beverages were evaluated. The answers obtained in word association were divided into two groups: No food restriction people (NFR) and food restriction people (FR). The category "unknown" presented highest percentage of mention to both groups. FR associated sorghum as an alternative. Among the categories most mentioned by the NFR group is the animal feeding. Regarding the six sorghum genotypes brown sorghum presented the highest CT, TPC, AC and RS. Powder from red sorghum presented highest wettability and sensory acceptance, whereas, powder from white sorghum had the lowest absolute density, wettability, dispersibility and sensory acceptance. Additionally, sensory acceptance presented positive Pearson's correlation with good rehydration characteristics. The residual bitter taste was directly correlated with AC. Sorghum is not known as food in Brazil and this may affect its sensory acceptance. Chemical properties and solubility properties affected the sensory acceptance. Genotypes with higher antioxidant capacity and resistant starch do not presented highest sensory acceptance. A mixture of 2 or more genotypes could give the product a good technological and functional characteristic which results in greater sensory acceptance.

### Keywords

Wholemeal, extrusion cooking, word association

## P-6.2 STUDY OF DIFFERENT PRESOAKING TEMPERATURES OF BUCKWHEAT WHOLE GRAINS TREATED WITH HIGH HYDROSTATIC PRESSURE: EFFECTS ON FUNCTIONAL, TECHNOLOGICAL AND NUTRITIONAL PROPERTIES OF FLOURS

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Nowadays, food manufacturers have an increasing interest in emerging and non-thermal technologies as they allow to achieve additive-free food products with great acceptance by health-concerned consumers. While high-pressure processing (HPP) has a deep background in the field of food preservation, this technology is not well-known as a tool for modifying the functional and nutritional properties of ingredients used in food processing. Up-to-date, information regarding HPP use to treat cereals or pseudocereals is still scarce and limited to flours and slurries. For this reason, the application of HPP treatment on a highly dense nutrient-packed food as buckwheat whole grains is an interesting strategy to modulate the functional and nutritional properties of resulting flours. In this work, HPP treatment at 600 MPa and 30 min of holding time along with a soaking pretreatment at two different temperatures (20 and 40°C for 4h) were applied to buckwheat wholegrains. The effect on functional, technological and nutritional properties was studied on the resulting flours. Functional tests carried out showed a significant ( $p < 0.05$ ) increase in water absorption capacity of HPP treated flours, while a significant ( $p < 0.05$ ) loss on emulsifying and foaming capacity of these flours was also noted compared to the control. Analyzed pasting properties revealed lower peak viscosity and higher trough viscosity for treated samples, indicating higher gel stability in the hot paste phase especially for HPP treated samples with presoaking. The cold paste phase exhibited lower setback values for treated samples, with the 40°C presoaked sample exhibiting the lowest value. This sample also presented the lowest value of complex shear stress modulus in the oscillatory rheology test performed. The antioxidant activity (DPPH test) of the 40°C pre-soaked sample was preserved after HPP treatment. Moreover, phenol content determination (Folin-Ciocolteau test) revealed increased values in HPP samples in comparison to the control. Similar mineral content regarding Bo, Ca, Fe, Mn and Zn were found in 40°C presoaked HPP treated sample compared to the control.

### Acknowledgments

Authors thank the financial support of Ministerio de Economía y Competitividad and the European Regional Development Fund (FEDER) (AGL2015-63849-C2-2-R), the Ministerio de Ciencia e Innovación (PID2019-110809RB-I00) and the Junta de Castilla y León/FEDER VA195P20 and VA165G18, and UVa/FUNGUVa-ITACyL 2018 grant (flour sector). Marina Villanueva thanks the Alfonso Martín Escudero Foundation for the post-doctoral grant.

**Keywords**

Wholegrains, Buckwheat, High Pressure processing, Nutritional, technological and pasting properties, Gel rheology

## P-6.3 NUTRITIONAL PROFILE OF ANCESTRAL WHEAT VARIETIES (TRITICUMSPELTA) AND BAKERY PRODUCTS OBTAINED UNDER ORGANIC AGRICULTURE IN ARGENTINA

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Nowadays, the consumer appreciates nutritional quality by opting for a healthy diet and paying attention to agroecological and or organic production. The preference in the consumption of foods made with whole grains would help improve insulin sensitivity by reducing the glycemic index of the diet and increasing the fiber and mineral content.

Spelt wheat is a hexaploid cereal made up of 3 genomes with 7 chromosomes each, belonging to the genus *Triticum* in the Gramineae family. It is characterized by being called “dressed or hulled wheat”, unlike bread wheat (*Triticum aestivum* L.). The hulled grains has the advantage of resistance to attack by pathogens whose presence can have harmful consequences for health. The physical barrier of the hulled grain would provide protection against some pathogens, making it possible to obtain whole meal flours with nutritional potential, guaranteeing its food safety and adaptability for organic agriculture in Argentina.

The definition of *Triticum spelta* L. was incorporated into the Argentine Food Code (CAA) in 2017. However, organic food production information in Argentina, needs to be addressed through workshops, publications and networking between all actors across agro-value chain with the aim to increase the impact of the support provided.

The objective of this work was to evaluate the nutritional profile of only two organic whole spelt flours available at the market in Argentina, comparing their performance with a whole wheat bread flour (*Triticum aestivum*) of high industrial quality.

Spelt wheat “Dinkel ECOFAUNO” (DK) and “Oberkulmer ROTKORN” (OR) varieties were cultivated and certified under the organic farming conditions between 2018-2019 years in the Wheat Subregion IV Argentina. The samples of two spelt with different granulometry and whole wheat varieties were analysed: moisture, protein, Crude fat, minerals, ash, Crude Fiber, Falling Number, rheological parameters as well as bakery products.

Statistically significant differences were observed among the three flours in gluten quality, baking strength, tenacity and extensibility ratio and farinographic characteristics (development time, stability and quality number).

In DK, the wet and dry gluten content were the highest and showed significant differences with respect to the other flours. DK presented statistically different values of Crude Fat and Crude fiber compared to OR. The analyzed minerals showed similar concentrations, with higher Phosphorus and Sodium content in DK. Spelt flours presented higher amylasic activity compared to whole wheat flour. These results suggested that spelt whole flours were being more suitable for making cookies and other bakery

products providing carbohydrates, high protein quality, and minerals. To consolidate this investigation more studies need to be performed.

**Keywords**

Argentine organic whole spelt flour, bakery products

## 7. Noodle Quality and Acceptability

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## P-7.1 DPP-IV INHIBITORY POTENTIALS OF POLYPHENOLS ISOLATED FROM QINGKE BARLEY FRESH NOODLES: IN VITRO AND MOLECULAR DOCKING ANALYSES COMPOUNDS CONTENT

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Type 2 diabetes (T2D) is characterized by excessive blood glucose and decreasing insulin secretion or occur insulin resistance in the organs of the body. According to the report of WHO, more than 90% of diabetic patients are diagnosed as T2D and around 366 million or more people will be suffered by diabetes by the year 2030. Hence, controlling postprandial glucose level of blood and promoting insulin secretion have been emerged as promising approaches for the treatment of type 2 diabetes.

Glucagon like peptide-1 (GLP-1) and glucose-dependent insulintropic polypeptide (GIP) are incretin hormones secreted from intestinal L and K cells after food intake, and exist at fairly high level in the postprandial state. They can promote insulin secretion, maintaining glucose homeostasis without inducing hypoglycemia. Unfortunately, GLP-1 and GIP are rapidly degraded and in-activated by the dipeptidyl peptidase-IV (DPP-IV, EC 3.4.14.5) after secretion. Accordingly, inhibiting the DPP-IV enzyme activity becoming one of the important targets to increase the half-life of GLP-1 and GIP, and to control or relief T2D through glucose-dependent insulin release.

Qingke barley fresh noodles are rich in bioactive compounds, and some of the bioactive compounds with the phenolic structure have the potential to inhibit the activity of the DPP-IV. Hence, the purpose of the study is; (1) to identify the individual phenolic compounds existed in Qingke barley fresh noodles, (2) to evaluate the DPP-IV inhibition activity of the phenolic compounds in vitro and in silico.

Materials and methods: Qingke barley fresh noodles were prepared according to the methods published in our early research (DOI: 10.1002/fsn3.1151). Phenolic profiles existed in the Qingke barley fresh noodles were identified by HPLC according to the methods described by Rosanna De Paula et al., (DOI: 10.1016/j.foodres.2017.09.088). DPP-IV inhibitory activity of the phenolic compounds were evaluated according to the method described by Poonam Kalhotra et al., (DOI:10.3390/molecules23061368). Molecular docking and dynamics studies were performed according to the methods described by Pan et al., (10.1111/jfbc.13570).

Results: Fifteen phenolic compounds were identified in the Qingke barley fresh noodles, including gallic acid, phloroglucinol, protocatechuic acid, chlorogenic acid, vanillic acid, syringic acid, p-coumaric acid, rutin, ferulic acid, naringin, epicatechin, o-coumaric acid, quercetin, naringenin and kaempferol, which were existed in bound and free forms. The IC<sub>50</sub> of the sitagliptin was 0.11 μM, while it ranged from 124 μM to 1198 μM for the phenolic compounds. Among of them chlorogenic acid and quercetin have lower IC<sub>50</sub> value.

The molecular docking study indicated that chlorogenic acid and quercetin, existed in Qingke barley fresh noodle, bonded with amino acid residues in the active pockets of the DPP-IV, and formed hydrogen and hydrophobic bonds. The molecular dynamics study indicated that chlorogenic acid and quercetin changed the protein structure of DPP-IV, the size of the three active pockets and the distances of the amino acid residues. Besides, the amino acid residues in the three active pockets were fluctuated in the different degrees, and the secondary structure of the DPP-IV, including helix, sheet

and loop, were changed during the molecular dynamics, indicating that chlorogenic acid and quercetin affect the corresponding secondary structure of DPP-IV, destroy the original secondary structure and that inhibit its activity.

Conclusion: All of the phenolic compounds from Qingke barley have the inhibitory effect on the DPP-IV in the different degrees. Chlorogenic acid and quercetin have the best inhibition activity on DPP-IV.

### **Keywords**

Fresh Qingke barley noodles, cooked Qingke barley noodles, phenolic compounds content, antioxidant ability

## P-7.2 DURUM WHEAT SEMOLINA CHARACTERIZATION BY MEANS OF A RAPID SHEAR-BASED METHOD

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Glutopeak test (GPT) is a rapid shear-based method, recently introduced by Brabender GmbH & Co. (Duisburg, Germany), for discriminating gluten quality. The instrument records the time to reach peak torque during the formation of gluten network. It has been successfully proposed for flour characterization, while no information is available for durum wheat products.

Twenty-height durum wheat semolina samples were considered and characterized in terms of protein content, gluten index, and alveographic indices. Semolina (9 g) and distilled water (10 ml) were weighted into the sample cup of the GPT. Temperature was maintained at 35°C and the paddle was set to rotate at 2,750 rpm. Each test ran for 5 min and maximum torque, peak maximum time and the area under the peak were recorded.

A significant correlation between the protein content and the peak ( $r = 0.70$ ,  $p < 0.01$ ) was observed, indicating strong aggregation properties. As for the quality of gluten, the statistical analysis showed a significant correlation between the area under the peak and the gluten index ( $r = 0.76$ ,  $p < 0.01$ ) and W alveographic index ( $r = 0.70$ ,  $p < 0.01$ ). In other words, the greater the energy required to form the gluten, the higher the gluten and W indices. On the basis of the conventional alveographic test, semolina samples were divided into three classes of quality: poor ( $W < 180 \cdot 10^{-4}$  J), medium ( $180 \leq W < 250 \cdot 10^{-4}$  J) quality. The test was able to distinguish the samples of high quality (area  $> 2400$  AU) from those of low quality (area  $< 2400$  UA). As expected, medium quality semolina exhibited an intermediate behavior. For this class, the time of maximum peak was the parameter significantly correlated to the quality of gluten ( $r = 0.73$ ,  $p < 0.05$ ). These preliminary results are encouraging to propose GPT as a rapid and reliable approach for semolina characterisation.

### Keywords

Semolina, gluten, rheology, durum wheat, glutopeak

## 8. Consumer Perception

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## P-8.1 REVIEW OF THE SENSORY AND PHYSICOCHEMICAL PROPERTIES OF RED AND WHITE WHEAT: WHICH MAKES THE BEST WHOLE GRAIN?

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Establishing sensory and physicochemical differences between products made with red and white wheat may help guide the choice of wheat for use in whole grain and high fibre products. As sensory acceptance is key to consumption, this scoping review aimed to document sensory and physicochemical research demonstrating quantitative differences in red and white wheat and the associated bran. Of 18 studies, 13 were sensory studies with 737 participants (six studies also performed quantitative analysis) and five additional quantitative studies. Overall, 12 studies were positive for white wheat, including seven sensory studies (two included quantitative analysis) and five quantitative studies. Studies examined whole grain bread, pita bread, crackers, noodles and tortillas. Aside from the seed coat colour, levels of bound versus free phenolic compounds and polyphenol oxidase activity appeared most responsible for the differences in red and white wheat. Ensuring the sample size for sensory studies are large enough to detect between-group preferences and linking with physicochemical analysis are recommended. Attention to blinding techniques in sensory testing and use of food products realistically and consistently prepared with commercial potential are also suggested. This scoping review provides confidence in preference for white wheat for whole grain products, particularly breads, tortillas and in refined grain noodle products suitable for the Asian market.

### **Keywords**

White wheat, red wheat, whole grain, sensory, bread

## P-8.2 MAIN VOLATILE COMPOUNDS OF BROA, A PORTUGUESE ETHNIC MAIZE BREAD

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In Portugal, maize has been used for a long time, to prepare *broa*, an ethnic maize bread. *Broa* was considered a hearty peasant bread and one of the 50 world's best breads by CNN Travel, in October 2019. Different maize varieties origin *broas* with different sensory characteristics, and sensory evaluation results have demonstrated a preference for traditional in detriment of hybrid maize varieties for *broa* production. However, little is known about *broas'* volatile compounds which can be related to their sensorial characteristics.

In this work, SPME and GC-MS conditions were optimized and implemented in order to evaluate the volatile composition of maize flours (n=12) and corresponding *broas*. Different volatile compounds, belonging to different families, such as alcohols, ketones, esters, acids, pyrazines, and furans, were detected. The majority of the volatiles present in maize flours were most likely derived from lipid and carotenoids oxidation (e.g., aldehydes, alcohols, geranylacetone). The main volatile compounds identified in *broas* were not only derived from lipid oxidation, but also from *Maillard* reactions that occur during baking (e.g., furans, furfurals, pyrroles).

A multivariate analysis (principal component analysis) was performed and results showed that the commercial hybrid maize flour and corresponding *broa* presented a higher concentration of aldehydes, alcohols, and alkanes, which suggest that more lipid oxidation reactions were occurring in this sample. Most of these compounds are known to negatively contribute for breads aroma. Results showed that the differences in the volatiles composition among *broas* contribute to the odour and flavour perceived by a sensory panel.

### Keywords

Maize, broa, volatile compounds

## 9. Molecular Approaches

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## P-9.1 EXTRA SOFT WHEAT GERMPLASMS WITH ADDITIONAL PUROINDOLINE GENES ON CHROMOSOME 5A AND THEIR QUALITY CHARACTERISTICS

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Kernel hardness is a primary determinant of milling and end use quality of wheat and is largely controlled by puroindoline genes on chromosome 5D (Pin5D genes). Wheat varieties carrying Pin5D genes tend to have soft endosperm texture and kernel hardness (KH) lower than 45, with consequent higher break flour yield (BFY), finer flour particle size, lower damaged starch content and lower sodium carbonate solvent retention capacity (SRC) than wheat varieties with high KH. We developed extra soft wheat genotypes by the introgression of Pin genes on chromosome 5A (Pin5A genes) from a Chinese Spring substitution line (CS(5Am)RCE#85) carrying both Pin5A and Pin5D genes to two soft red winter wheat varieties (OH04-264-58 and USG 3555), and determined the influence of the Pin5A gene introgression on grain and flour characteristics and cookie-baking quality. Four to six near-isogenic lines (NILs) of each background were selected from backcross-two (BC<sub>2</sub>) derivatives carrying both Pin5A and Pin5D genes and those carrying only Pin5D genes using marker-assisted selection and SDS-PAGE. BC<sub>2</sub>F<sub>3</sub>-derived seeds of NILs were grown in four environments. The KH of genotypes with and without Pin5A genes ranged from -1.4 to 5.7 and 15.3 to 30.2 for the OH04-264-58 background and from 0.7 to 4.1 and 12.1 to 17.4 for the USG 3555 background, respectively. The BFY of genotypes with and without Pin5A genes ranged from 39.3 to 41.7% and 36.1 to 39.3% for the OH04-264-58 background, and from 37.5 to 39.4% and 36.1 to 36.2% for the USG 3555 background, respectively. Higher test weight by 2.6 kg/hl, higher flour yield by 1.7% and greater lactic acid SRC by 16% were observed for the genotypes with Pin5A genes compared to those lacking Pin5A genes for the OH04-264-58 background. The genotypes with Pin5A genes tended to produce cookies of larger diameter than those without Pin5A genes, with diameters of the former ranging from 18.9 to 19.5 cm and of the latter from 18.7 to 18.9 cm for the USG 3555 background, and with diameters of the former ranging from 18.3 to 19.0 cm and of the latter from 18.2 to 18.7 cm for the OH04-264-58 background. The introgressed Pin5A genes exhibited no apparent influences on grain and flour protein contents and sodium carbonate, sucrose and water SRCs. Introgressed Pin5A genes produce extra soft wheat kernels and subsequently increase BFY, providing wheat breeders with an effective tool to improve the milling and cookie-baking quality of soft wheat.

### Keywords

Extra soft wheat, puroindoline genes, kernel hardness, break flour yield, cookie-baking quality

## P-9.2 ANALYSIS OF THE WHEAT ARABINOXYLAN GENETIC CONTROL AND THEIR EFFECT ON WHEAT QUALITY

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Arabinoxylans (AX) are the major components of dietary fibers (DF) in wheat grain and their consumption has been associated with multiple health benefits. However, most people are currently consuming less than the minimum DF amount recommended by most health organizations. The selection of wheat varieties with higher AX content could be an efficient approach to improve the daily consumption of DF. Nevertheless, knowing the genetic control of this trait and understanding how much the AX content in grain affects the flour technological properties, is of fundamental importance to efficiently select varieties with higher AX. For these reasons, in the present study, we first analyzed the AX content in a set of refined flour samples derived from 193 different common wheat lines. The same lines were then analyzed for a series of quality traits, including grain physical quality, protein content, SDS-sedimentation volume, flour mixing properties, dough rheological quality, and breadmaking quality. In general, wide variation in both the total arabinoxylan (TOT-AX) (10.8-16.5 mg/g) and water-extractable arabinoxylan (WE-AX) (3.2-7.6 mg/g) was identified and, in both cases, the genotype had the greatest impact on the observed phenotypes. Variation in the AX fractions appeared to have a moderate effect on wheat quality. The WE-AX, specifically, were positively correlated with gluten strength ( $r = 0.11$  to  $0.32$ ) and bread loaf volume ( $r = 0.16$ ), whereas the TOT-AX were negatively correlated with dough extensibility ( $r = -0.11$ ) and breadmaking quality ( $r = -0.11$ ). A subset of the same samples (175 lines) was then genotyped and used to perform a genome-wide association study (GWAS) to identify the potential genomic regions associated with the observed TOT- and WE-AX content variations. This analysis revealed the association of five single nucleotide polymorphisms (SNPs) on chromosomes 1BL and 5BS with TOT-AX, and of 13 SNPs on chromosomes 1BL, 2BS, 6BS, 7A, and 7BL with WE-AX. Markers on chromosome 1BL were coincident for both the AX fractions and explained the greatest percentage of phenotypic variation (13.29-17.22% for TOT-AX; 11.56-19.37% for WE-AX). In silico analysis of the genomic region delimited by the most significant 1BL markers (~8 Mb) identified a predicted gene encoding for a glycosyltransferase (GT) of the GT61 family which is likely a candidate gene associated with the observed AX variation. Lastly, the four most significant 1BL GBS markers identified through the GWAS analysis were translated into Kompetitive allele-specific PCR (KASP) markers. Overall, the results of this study constitute an important contribution to the improvement of grain DF in wheat breeding programs, showing that the AX present in refined flour does not dramatically alter the wheat quality and that genetic improvement of grain AX is feasible and could be facilitated using molecular markers.

### Keywords

Wheat, wheat quality, arabinoxylans, GWAS, molecular markers

## P-9.3 WHEAT RESISTANCE TO RUST DISEASES IN CZECH REPUBLIC NEGATIVELY CORRELATES WITH BAKING QUALITY AND MOSTLY RELIES ON LR37/YR17/SR38 GENE CLUSTER

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Leaf rust and stem rust are diseases of wheat caused by fungal pathogens *Puccinia triticina* Eriks (*Pt*) and *Puccinia graminis* f. sp. *tritici* (*Pgt*). The most effective way to prevent yield losses is to grow cultivars with resistance genes. New pathogen races with changed virulence profiles can emerge which render resistance genes in grown cultivars ineffective. It is crucial to monitor virulence of current pathogen populations to commonly used genes and introduce new genes. Resistance genes introduced from wild related species can have negative impact on yield and other characteristics such as baking quality. Field resistance tests were carried in years 2014 - 2020 on a selection of 58 wheat cultivars registered in Czech Republic using a mixture of *Pt* races and a mixture of *Pgt* races, separately. Severity of disease was evaluated on a field scale 1-9 (1 susceptible, 9 resistant). DNA was isolated from the same 58 wheat cultivars and PCR was carried out using molecular markers for individual rust resistance genes. Genes that were tested were *Lr37/Yr17/Sr38*, *Lr24/Sr24*, *Lr26/Sr31*, and *Sr6*. Genetic markers detected *Lr37/Yr17/Sr38* in 64 of the varieties tested which is the highest frequency of any of the resistance genes tested by our laboratory. Comparison with the field trials from years 2014 to 2020 shows that this gene cluster is still effective against stem rust infection but not leaf rust. Both *Lr24/Sr24* and *Lr26/Sr31* appear in approximately 10% of cultivars. Out of those only *Lr26* has lost its efficacy against current pathogen populations. Grouping of field trials results based on cultivar baking quality of flour confirms that cultivars with lower flour quality (B and C) have higher average resistance to both leaf and stem rust.

### Keywords

Fungal pathogens, wheat rusts, PCR, resistance genes

## 10. Novel Processing Techniques for Extrusion and Biscuit Making

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## P-10.1 THE EFFECTS OF INCORPORATING MUSHROOM POWDER INTO SORGHUM BISCUITS ON THEIR NUTRITION AND QUALITY CHARACTERISTICS

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The rising demand for functional foods has encouraged the food industry to produce products enriched by fibre and polyphenols. Mushrooms are a good source for health food due to their rich in fibre and protein with biological value and phenolic compounds. The purpose of this study is to incorporate mushroom powder (MP) into sorghum flour for the biscuits production and evaluate their effects on the nutritional values, functional and pasting properties, thermal properties, physicochemical characteristics, antioxidant activity and *in vitro* starch digestibility of biscuits. Addition of MP improved the nutritional properties of biscuits with higher protein, dietary fibre, amino acids and minerals. The biscuits formulations improved functional properties and melting enthalpy ( $\Delta H$ ) values and decreased the viscosity property and the degree of starch granule gelatinisation. In addition, the physical properties were affected by the supplementation of MP, with an increase in thickness and a darker surface colour. The biscuits formulated with MP exhibited lower fracture strength and hardness compared to the blank group. Furthermore, the addition of MP increased the total phenolic content, which improved the reducing powder with higher DPPH and ABTS radical scavenging activity, while these formulations also significantly decreased the extent of starch degradation and the release of reducing sugars during *in vitro* starch digestion. These results suggested that mushroom powder could be added into sorghum biscuits with improved nutrition and antioxidant activity. We are also looking forward to the study for the anti-inflammatory activity of mushroom biscuits through gastrointestinal digestion and the prevention and remission effects on inflammatory bowel disease *in vivo* study.

### Keywords

Biscuit, mushroom powder, nutritional profile, physical activity, antioxidant

## P-10.2 TIGER NUT (CYPERUS ESCULENTUS) AS A FUNCTIONAL INGREDIENT IN GLUTEN FREE EXTRUDED SNACKS

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Tiger nut (TN) is a nutritious source of gluten-free flour, used generally in healthy beverages, but its incorporation in gluten-free extruded snacks has not been explored. TN flour was blended at different concentrations (up to 70%) with rice flour and soluble fiber, for the development of gluten-free snacks on a twin-screw extruder. The effect of TN inclusion in the formulations was evaluated on relevant physiochemical characteristics of the snacks. Viscoamylograph of the raw formulations showed that TN addition increased ( $p < 0.01$ ) onset temperature and delayed peak viscosity. In the extruded flours, TN contributed to limit the starch degradation during extrusion. Diameter, expansion ratio, true density, and total pore volume of the extrudates were reduced ( $p < 0.01$ ) by the increased TN content in the formulations, while bulk density rose. The surfaces of the extruded snacks were modified by the increasing inclusion of TN in substitution of rice in the formulations. Extrudates containing 10% TN showed the best overall texture profile. Moreover, TN addition enhanced the ash and protein content of the snacks and increased their total antioxidant activity. This study demonstrated that incorporation of 10% TN flour into rice-based formulation was suitable for making gluten-free snacks with acceptable physical properties.

### **Keywords**

Tiger nut, rice flour, gluten free, extrusion, snacks

## P-10.3 EFFECT OF WHEAT BRAN PRE-PROCESSING ON PHYSICAL PROPERTIES OF 3D-PRINTED SNACKS

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Novel techniques such as 3D printing, enable the creation of snack foods with a tailored nutritional value and structure. The addition of bran for the enrichment of cereal foods with dietary fibre and bioactive compounds is frequently suggested. However, wheat bran contains a high level of polyphenol oxidase (PPO) which is associated with undesirable browning and reduction in antioxidant activity. This study aimed to investigate the influence of high-intensity ultrasound (HIU) (W=400 W, A=100%, t=2 min), vacuum microwave cooking (MW) (W=350 W, t=20 s) and pulsed light field (PL) (t=125 s, 3 pulses/s) processing of wheat bran, on its PPO activity, total phenolic content (TPC) and antioxidant activity (AO), the colour of 3D-printed dough, as well as on the precision and accuracy of 3D printing, and physical properties (colour, height, width, diameter) of baked snacks. TPC (Folin-Ciocalteu Method), AO (FRAP and DPPH), and PPO activity (AACC 22-85) were determined spectrophotometrically. The snack recipe consisted of oat flour, wheat bran (20% at flour basis), pea proteins, sunflower oil, salt, baking soda and water. Ten dough samples were 3D-extruded in the shape of a heart (20 layers) in duplicate using Createbot S3 printer. The 3D-printed shape accuracy and precision of baked samples were determined by digital image analysis, using ImageJ software, as a proportion of white pixels, and calculating the deviation of printed samples from the desired shape. Dough colour difference ( $\Delta E^*$ ) between the first and the last printed sample (after 1 h) was determined by measuring lightness, redness, and yellowness using a spectrophotometer. Snacks were baked in a deck oven for 18 min with the lower heater at 140°C and the upper heater at 160°C. Height, line width and diameter of baked snacks, were determined using a calliper. Bran processing with HIU, MW and PL significantly reduced the PPO activity (by 75%, 73% and 65%, respectively), but also TPC and AO compared to unprocessed bran. Among all treatments, HIU processed bran showed highest values for TPC ( $0.74 \pm 0.02$  mg GAE/g d.w.) while PL resulted in lowest TPC values ( $0.59 \pm 0.01$  mg GAE/g d.w.) but the highest DPPH and FRAP values ( $1.17 \pm 0.01$  and  $3.63 \pm 0.08$   $\mu\text{mol Trolox Eq/g d.w.}$ , respectively). Dough  $\Delta E^*$  after 1 h was very distinct (3.25). Compared to unprocessed bran, the addition of pre-processed bran resulted in significantly lighter and yellower 3D printed dough, which was darkening slower. In addition, bran pre-processing resulted in higher shape accuracy, while the top and bottom snack diameter were significantly larger when compared with unprocessed bran. Overall, dough with added HIU processed bran was printed with the highest precision (96%), while showing the lowest  $\Delta E^*$  (1.99), whereas PL resulted in the highest shape accuracy (96%) and the lightest snack. We can conclude that wheat bran pre-processing contributes to the physical properties of 3D-printed snack.

### Keywords

High-intensity ultrasound, vacuum microwave cooking, pulsed light, 3D printing precision, dough enzymatic browning

## 10.4 EFFECT OF EXTRUSION PROCESSING ON ANTIOXIDANT AND GLYCEMIC PROPERTIES OF COWPEA AND WHEY PROTEIN CONCENTRATE FORTIFIED RICE BASED EXTRUDED SNACK

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Increased consumer awareness and demand for snack foods has driven the snack industry to combine nutritionally rich ingredients in formulations. Ready-to-eat snacks products are made from refined cereal flours, which contain a considerable amount of calories, salts, saturated fats, and relatively small amounts of dietary fibre and other health-promoting compounds compared to whole-grain raw materials. Further, these ready-to-eat snacks are associated with a high glycaemic index with low nutritional value. Nutritionally, cereals are low in protein, fat, and dietary fibre, but high in starch. Legumes are rich in protein and fibre, low fat and help in the slow assimilation of carbohydrates during digestion. Cereals and legumes are complementary in amino acid profile. Expanded snacks with high protein and fibre were developed with rice, cowpea, and whey protein concentrate (WPC). A Clextral twin-screw extruder with co-rotating and intermeshing screws and a run capacity of 7.9 kg of feed /h was used in extrusion. The effect of extrusion on the antioxidant and glycaemic properties was analysed in the gluten-free formulations of rice, cowpea and WPC. Extrusion reduced the antioxidant and glycaemic properties of cowpea-WPC fortified rice-based extruded snack. However, the fortified snack products were significantly higher in phenolic and antioxidant compounds compared to the rice control and showed a reduced glycaemic response.

### Keywords

Extrusion, Snacks, gluten-free, glycaemic response, antioxidant

## P-10.5 EFFECT OF DEFATTED PEANUT AND SOY FLOUR OBTAINED BY NEW AQUEOUS METHOD ON QUALITY OF GLUTEN-FREE COOKIES

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Gluten-free cookies are promoted because of increase in celiac disease prevalence. Rice is a cereal which is good for making gluten free cookies, but it contains inadequate amounts of proteins and lysine. The effect of defatted peanut and soy flours produced by new aqueous method on quality of gluten free cookie made of rice flour was investigated. Partly substituting rice flour by defatted peanut flour, defatted soy flour and their mixture (1+1) significantly increased the content of proteins and lysine of gluten free cookies. Defatted soy flour was more powerful to increase lysine content. Proper amount of defatted peanut flour, defatted soy flour and their mixture significantly improved the hardness and hedonic score of gluten free cookies. Although the proportion of defatted peanut flour, defatted soy flour and their mixture for substituting rice flour above 15% tended to slightly decrease sensory quality, overall hedonic scores of all cookies studied were in the range of very like scale. Addition of defatted peanut flour, defatted soy flour or their mixture appeared to produce gluten free cookies with deeper or darker color while defatted soy flour had greater effect. Defatted peanut flour, defatted soy flour or their mixture had dosage-dependent effect of increasing the antioxidant capacity of gluten free cookies while defatted soy flour had greater effect. These results indicate that new aqueous method can produce defatted peanut or soy flour with good quality which is suitable for fortification of gluten free cookies.

### **Keywords**

Nutritional quality; anti-oxidant capacity; defatted flour

## 11. Sustainable Agricultural Technology Systems

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## P-11.1 ESTIMATION OF QUALITY TRAITS IN SOME PAKISTANI WHEAT (TRITICUM AESTIVUM L.) UNDER TERMINAL HEAT STRESS CONDITION

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Climate change plays a key role in wheat production. High temperature stress is one of the major causes of yield loss in wheat all over the world including Pakistan. The objective of this study was estimation and selection of efficient parental and cross combinations on the basis of combining ability under heat stress conditions. To study heat stress, 50 crosses and 15 parents were evaluated under stressed condition. Fifty crosses were generated from crossing 15 parents by using Line × Tester mating design in 2014-15. These genotypes were sown in randomized complete block design (RCBD) under normal and heat stressed conditions. Parameters like protein, moisture contents, starch, ash percentage, gluten and test weight were investigated. Highly significant differences were observed among genotypes for all traits. Dominance type of gene action was observed that played a predominant role in the inheritance of all traits in this study. General combining ability (GCA) effects, showed only 3 parents, MISR1, Faisalabad-08, and V-13241 proved to be good general combiners for protein, starch, gluten, test weight and ash in both normal and heat stress conditions. From crosses, AARI-11 × V-12082, V-13241 × Millat-11 and V-13013 × ND64 revealed the best specific combining ability (SCA) under both environments for different quality traits like protein and moisture contents. The parents and crosses which exhibited excellent results in terms of higher GCA and SCA estimates may be exploited in improving quality traits under terminal heat stress conditions of Pakistan.

### **Keywords**

heat stress, Gene action, Specific combining ability, General combining ability