AGF

Arbeitsgemeinschaft Getreideforschung e. V.

in cooperation with

Max Rubner-Institute

Institute of Safety and Quality of Cereal

and the

Institute for Food Technology

- Fermentation Technology- in Hohenheim

72nd Starch Convention
&
17th European Bioethanol and Bioconversion Technology Meeting

April 20th – 22nd 2021
-online-

Tuesday, April 20th 2021

72nd Starch Convention

13^{45} **Opening Remarks** by the President of the Association of Cereal Research, **Götz Kröner**, Ibbenbüren (Germany)

1. Basic research

14^{00} 1.1. **Mario Martinez,** Aarhus (Denmark)
Shear-induced molecular fragmentation decreases the bioaccessibility of fully gelatinized starch and its gelling capacity

14^{30} 1.2. **Hervé Vanderschuren,** KU Leuven (Belgium)
Bringing the CRISPR revolution to the starch community

15^{00} 1.3. **Jens Buller,** Potsdam (Germany)
Hydrophobized starches, their colloidal properties and effect in paper production

15^{30} Communication Break

16^{00} 1.4. **D.C. Saxena,** Punjab (India)
Synthesis of starch nanoparticles from pearl millet by acid hydrolysis coupled with ultrasonication and their subsequent application in reinforcement of pearl millet starch films

16^{30} 1.5. **Roman Bleha**, Prague (Czech Republic)
Fungi, algae and non-traditional fruits are sources of health beneficial polysaccharides

17^{00} 1.6. **Y. Yassaroh**, Groningen (The Netherlands)
Starch modification and its digestibility

17^{30} Communication Break

18^{00} 1.7. **Mario Martinez,** Aarhus (Denmark)
Starch Nutritional Quality: Beyond Intraluminal Digestion in Response to Current Trends

2. Analytics

18^{30} 2.1. **Barry McCleary**, Bray (Ireland)
Digestible starch and available carbohydrates

19^{00} 2.2. **Cynthia Klostermann,** Wageningen (The Netherlands)
Production and characterization of resistant starch type 3

Wednesday, April 21st 2021

3. Technology

14^{00} 3.1. **Markus Eggenmüller**, Augsburg (Germany)
Secrets in the dry fractionation process of pulses

14^{30} 3.2. **Maurice Essers**, Wageningen (The Netherlands)
Thermally inhibition of tuber starches

15^{00} 3.3 **Markus Götz**, Hohenheim (Germany)
Building up modular, regional biorefineries – Starch-rich residues to Hydroxymethylfurfural and coatings

15^{30} Communication Break

16^{00} 3.4. **Marco Ulbrich,** Berlin (Germany)
The supporting effect of ultrasound on the acid hydrolysis of granular potato starch

16^{30} 3.5. **Sajid Alavi,** Kansas (USA)
Starch Extrusion Processing

17^{00} 3.6. **Bart Koops**, Hilversum (The Netherlands)
Improved method for the production of Iso-Malto-Oligosaccharides with higher molecular weight and lower glucose

17^{30} Communication Break

18^{00} 3.7 **Mario Martinez,** Aarhus (Denmark)
Mesoscale structuring of gluten-free bread with starch

18^{30} 3.8. **Lilith Baczynski**, Gent (Belgium)
Improved process control using Oxamine in wet starch separation

19^{00} 3.9. **Ted Slaghek**, Wageningen (The Netherlands)
Starch from the oil palm trunk

Thursday, April 22nd 2021

4. Application

14^{00} 4.1. **Martin Kozich**, Tulln (Austria)
Foamed starch adhesives

14^{30} 4.2. **Laura Roman**, Aarhus (Denmark)
The importance of amylose retrogradation in the textural attributes of starch based foods

15^{00} 4.3. **Francisco Vilaplana**, Stockholm (Sweden)
Compatibilization of corn starch in engineered bioplastic blends for automotive and construction applications – BARBARA Project

15^{30} Communication Break

17th European Bioethanol and Bioconversion Technology Meeting

1. Alternative Feedstocks

16^{00} 1.1. **Arjen van Tuijl,** Hilversum (The Netherlands)
State of the art technology in developing a new and efficient SSF enzyme for high ethanol yield in fuel ethanol production

16^{30} 1.2 **Stefanie Graber,** Völs (Austria)
Flasche statt Tonne - Lebensmittelmüllvermeidung bei Therese Mölk - Use it don't waste it – how the Therese Mölk bakery supports recycling instead of wasting bread

17^{00} Communication Break

2. Process optimization (Bioconversion)

17^{30} 2.1. **Elia Tomás Pejó,** Madrid (Spain)
Biotechnological advances in lactic acid production by lactic acid bacteria: lignocellulose as novel substrate

18^{00} 2.2. **Jovan Nizeyimaana,** Kampala (Uganda)
Effect of thermal pretreatment of East African Highland banana peels on biogas production

3. Future trends & regulation

18^{30} 3.1. **Nelli Elizarov**, Berlin (Germany))
Towards Zero Emissions in Transport: Role of crop-based biofuels

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Effective April 19th, 2021, 11.00 a.m.

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Summaries

1. Basic research

1.1. **Mario Martinez,** Aarhus (Denmark)
Shear-induced molecular fragmentation decreases the bioaccessibility of fully gelatinized starch and its gelling capacity

Mario M. Martinez[1], Laura Roman[1], Osvaldo Campanella[2]

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[2]Department of Food Science and Technology, The Ohio State University, Columbus, OH, USA

Consumers are increasingly more aware about the importance of healthy eating. Cereals, tubers, legumes and some starchy fruits are important plant-based food crops in the human diet; they are a good source of macronutrients such as protein, carbohydrates and dietary fibers, as well as micronutrients such as vitamins and minerals. However, processed starchy foods, owing to the amorphous stage of the starch molecules, are characterized for having high glycemic index and consequently considered of low nutritional value. Interestingly, the digestion rate of fully gelatinized starch, and, therefore, its bioaccessibility, is reduced during storage due to retrogradation, with an extent that depends on the main constituents involved in the reassociation. Amylose (AM) forming double helical structures (retrograded amylose) is known to be enzymatically resistant and yield resistant starch (RS), whereas retrograded amylopectin (AP) has been associated with the formation of slowly digestible starch (SDS).

This presentation will cover the selection and manipulation of the starch structure at the molecular level to result in targeted self-assemblies that are slowly digested. For the first-time, this work provides a mechanistic evidence about the feasibility of extrusion technology to create structurally-
driven slowly digestible starch (SSDS) through retrogradation. Here, it is shown that the nature of the formed SSDS is mostly consisting of molecular assemblies involving amylopectin and their fragments that do not necessarily bring deleterious effects on the food mechanical properties that may affect its texture quality. It is demonstrated that interactions promoting those molecular assemblies can be further increased by shear-induced reduction of the hydrodynamic radius (R_h) and molecular weight (M_w) of amylopectin molecules in a range between 54.3 and 58.9 nm and 9.9×10^6 and 17.1×10^6 g/mol, respectively. This presentation will also show a successful application of this phenomenon, where the digestion rate of the fully gelatinized starch present in bread was decreased by the manipulation of the starch molecular structure.

Mario M. Martinez *obtained his PhD in Chemistry from the University of Valladolid (Spain) and worked as a Postdoctoral Research Fellow at Purdue University´s Department of Food Science (USA). In August 2017, he became Tenure Track Assistant Professor at the College of Engineering and Physical Science (CEPS), University of Guelph (Canada), where was awarded the CEPS Assistant Professor Research Excellence Award for his outstanding research productivity in the fields of Food Engineering and Health-Promoting Compounds. In April 2020, he joined the Department of Food Science at Aarhus University (Denmark) as Tenure Track Assistant Professor, from where he was awarded the Young Scientist Research Award by the Cereals & Grains Association (USA). Mario is also Adjunct Assistant Professor at the Whistler Center for Carbohydrate Research (Purdue University, IN, USA) since September 2019. M. Martinez' research group is centered on understanding dietary carbohydrates and associated metabolites as well as the mesoscale structuring and processing of food and bio-based food packaging materials. His research also aims at providing refinery approaches of starchy and lignocellulosic biomass into functional polymeric streams.*

1.2. **Hervé Vanderschuren,** KU Leuven (Belgium)
Bringing the CRISPR revolution to the starch community

The emergence of molecular tools enabling precise genome manipulation has opened tremendous potential to bring novel improved traits to crop species. Genome editing by CRISPR/Cas offers several advantages as compared to approaches involving Zinc Finger Nucleases (ZFNs) and Transcription activator-like effector nucleases (TALENs) technologies. The CRISPR/Cas revolution drives numerous applications ranging from gene knockout to targeted epigenetic changes in plant genomes. Those CRISPR/Cas applications and our increasing knowledge about starch biosynthesis in plants offer opportunities to tailor starch for industrial needs. CRISPR/Cas genome modifications can also be combined with conventional breeding strategies to generate crop varieties with multiple improved traits. Importantly, strategies are being implemented to produce a new generation of transgene-free edited plants. As a consequence, biosafety requirements need to be reconsidered in the light of those new transgene-free techniques used to produce edited crop varieties. Several examples will be used to illustrate the abovementioned concepts.

Prof. Hervé Vanderschuren *holds a* ***BSc in Bioengineering*** *from the University of Liège (Belgium), a* ***MSc in Plant Genetics and Breeding*** *from AgroParisTech (France). He obtained his* ***PhD in Plant Biotechnology*** *from ETH Zurich (Switzerland).*
Prof. Vanderschuren started his academic career as group leader in crop biotechnology at ETH Zurich and he has been appointed Professor of Plant Genetics at University of Liège (Belgium) in 2014 and Professor of Tropical Horticulture at KU Leuven in 2019. Over the last 15 years, his research activities have been focused on the study of crop responses to biotic and abiotic stresses as well as on the implementation of tools to select and develop tropical and temperate crops (i.e. cassava, banana, rice, potato, wheat, chicory) with improved traits. Several cassava and rice accessions with increased disease resistance, improved nutritional quality and prolonged shelf life traits have been developed by his team. He has collaborated with several national and international research institutions in developing and emerging countries through joint research programmes. Prof. Vanderschuren's team is also actively involved in technology transfer to laboratories in Africa, Asia and South America.

1.3. **Jens Buller,** Potsdam (Germany)
Hydrophobized starches, their colloidal properties and effect in paper production

In the wet-end of paper production cationic starch derivatives are often used to increase the dry strength of the paper. It is generally assumed that the cationic starch must be completely dissolved in order to enable optimum electrostatic interaction with the anionic cellulose fibers and the binding of starch polysaccharides, which is often achieved by jet-cooking the granular cationic starches in the paper mill. Due to the increasing closure of the water cycles in paper mills, the process water contains a high electrolyte load, which leads to a weakening of the electrostatic interactions and a reduction of starch adsorption. Unadsorbed starch remains in the filtrate and increases the biochemical oxygen demand (BOD) of the process water. To optimize the starch input it is necessary to investigate the influence of the degree of substitution (DS) of the starch derivatives, different electrolyte environments and different starch concentrations in the suspension on the adsorption behavior. However, if the salt content of the process water is very high, a lower efficiency cannot be compensated by a higher degree of substitution.
Thus, in an alternative approach, additional hydrophobic interactions between starch and fibre should be exploited. For this purpose, cationic-hydrophobic starch ethers were prepared with Quab® reagents from quaternary ammonium compounds with alkyl chains of different lengths. Derivatives from native corn, wheat and potato starches and dextrins with molar masses in the range of 10^6 g/mol were chemically modified with high yields, mainly in the slurry.
In terms of gelatinisation, products with different chain lengths revealed clearly different behaviour. The pastes of the products with shorter C12 alkyl chains had higher viscosities than those with longer C18 alkyl chains. After pressure cooking diluted dispersions of the products were stable and showed no sedimentation for high molecular products up to a degree of substitution of 0.2 and to a degree of substitution of 0.7 for the products with lower molar mass.

All products showed surface-active effect, whereby this primarily depended on the level of substitution.
However, depending on the degree of substitution and molar mass, particle formation in the nanometer and micrometer range was also observed. The soluble and particulate fractions were investigated using a combination of different methods, including chromatographic methods such as size exclusion chromatography and hydrodynamic chromatography and light scattering and diffraction methods. Compared to ordinary cationic starches the solubility and particle formation was much more dependent on the salt content of the water.
For application tests the hand sheet formation was performed with waste paper pulp in a model water with a conductivity of 6000 µS/cm. The retention of the starch derivatives was increased to over 100% - which means that starch from the waste paper is also re-fixed in the fibre tissue. Despite significantly higher ash values in the laboratory sheets produced with the developed starches, the strength did not decrease compared to the use of a reference starch. In addition, the cationic hydrophobic starches significantly improved the dewatering of the fiber web and hydrophobized the paper even at low derivatization levels of 0.04 with 2% addition. However, the experiments show that, in addition to hydrophobic interactions, also the particle formation of the starches appears to play a role in their high effectiveness as wet-end starches

***Dr. Jens Buller**, head of the Starch Modification / Molecular Properties department at the Fraunhofer Institute for Applied Polymer Research, is a chemist and received his PhD in polymer chemistry from the University of Potsdam in 2013. In his role, he leads several industrial, but also publicly funded national or international research projects. His research focuses on the modification and molecular and physical characterization of starch, especially for technical applications such as paper, adhesives and plastics.*

1.4. **D.C. Saxena**, Punjab (India)
Synthesis of starch nanoparticles from pearl millet by acid hydrolysis coupled with ultrasonication and their subsequent application in reinforcement of pearl millet starch films

Mamta Bhardwaj and D.C. Saxena
Department of Food Engineering and Technology
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In the present study, starch nanoparticles were prepared from pearl millet by acid hydrolysis coupled with ultrasonication at amplitude of 40% and thereafter were used as filler in starch films. The particle size of starch granules was reduced by 50% dual treatment as compared to that by acid hydrolysis alone. The size of starch nanoparticles lied in the range of 30-40 nm after hydrolysis of 2 days and ultrasonication of 4 min. The starch nanoparticles were found to have an A-type crystalline pattern. The crystallinity of starch nanoparticles was higher than native starch. The crystallinity decreased after sonication by but the yield of starch nanoparticles increased. Pasting properties were not obtained for the nanoparticles. Further, influence of starch nanoparticles as fillers (2-20%) on mechanical, barrier properties of pearl millet starch was investigated. Tensile strength of the obtained films increased with increase in starch nanoparticles up to 15% concentration and thereafter it decreased. Elongation at break of films decreased from 50.21% (2% nanoparticles) to 13.45% (20% nanoparticles) with increase in nanoparticle content. The water vapour permeability of starch films was greater than that of one containing starch nanoparticles by 66.34%.

***Dr. D.C. Saxena**, presently Professor in the Department of Food Engineering & Technology, Dean (Students Welfare) and Former Dean (Planning & Development) of Sant Longowal Institute of Engg. & Technology, Longowal is dedicated to the continuing development and practice of creative teaching, innovative research and high impact public service programs that have improved food safety, food quality and processing. He was a visiting Faculty of Asian Institute of Technology, Bangkok (Thailand). He was invited to many countries like Hungary, Germany (twice), Thailand (thrice), Switzerland, U.K., Australia, Japan (six times), The Netherlands, Spain, UAE and USA (twice) to present his research work in International Symposia. He has many awards to his credit as below:*

1. Prof. Carl Hoseney Award -2018 by AFST(India)

2. AP Prize 2014 by FOOMA JAPAN (Japan Machinery Manufacturer's Association)

3. First Prize in the Poster Session at the International Conference 3rd INCOFTECH at IICPT, Thanjavur

4. Prof. JIWAN SINGH SIDHU AWARD- 2009

5. Best Paper in the Poster Session from AFST (I) during IFCON- 93

6. Fellow–95 of International Union of Food Scientists & Technologists (IX World Congress of Food Scientists & Technologists at HUNGARY)

He is actively engaged in providing technical training to student community and technical services to industry personnel around the region. Various research projects sponsored by GOI funding agencies like ICAR and CSIR, MHRD etc. have been undertaken to attain technical competency and to transfer the technology to the interested industrialists. He has developed two innovative machines viz., Amla Pricking Machine and Continuous Tandoori Roti Baking Oven which has been much sought after by industries. He has been a member/life member of various societies /associations as below:

1. Life member - Association of Food Scientists & Technologists (INDIA) [AFST (I)]

2. Life member - Oil Technologists Association of India [OTAI]

3. Life Member - Indian Society of Technical Education (AICTE) [ISTE]

4. Life Member - Punjab Academy of Sciences [PAS]

He has been the Chairman of the Mentor Council for Food Processing & Preservation sector under Ministry of Labour and Employment, Govt. of India. He was in the Editorial Board of Journal of Food Science and Technology for many years and presently an Editorial Board of Nano Science and Technology-Asia. His areas of interest for research include utilization of starches for food and non-food applications from non-conventional sources, nano-technology, traditional product technology, dough rheology, grain quality assessment as evident from his technical publications (over 150) in reputed journals and symposia besides reviewing several technical papers in national and international Journals. He got two Patents published. He has been instrumental in developing his department as a resource centre for Institutions like Panjab University, PAU, Ludhiana and local industries. He has guided many students for their B.Tech.(35), M.Tech. projects (27) and Ph.D. thesis (18). He has contributed a lot to his field through the following methods:

1. Food processing industries –institute interaction in Punjab region.

2. Sharing of facilities (equipment and personnel) with nearby industries and the departments.

3. Imparting expert advice to industries in the vicinity of the institute and also render laboratory facilities to analyze the samples/products.

4. Research projects on innovative ideas.

5. Student projects on industrial problems.

6. Dissemination of knowledge and expertise through extension services.

7. Basic and applied research in food processing, preservation and storage.

8. Training to industry personnel.

1.5. **Roman Bleha**, Prague (Czech Republic)
Fungi, algae and non-traditional fruits are sources of health beneficial polysaccharides

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Wood-decay fungi are important sources of secondary metabolites and structural biopolymers including polysaccharides, proteins and polyphenols (Novák et al., 2010; Zhong et al., 2009). Biological activity was determined in most of these compounds and thus have potential use in medicine (Yuan et al., 2009). β-glucans from fungi cell wall belong to natural immunomodulating agents. Glucans are predominantly linear and branched homopolymers of glucose having (1→3), (1→6) and (1→4) linkages (Synytsya and Novák, 2013).

Biomass from microalgae contains bioactive compounds including polysaccharides that make it very useful food supplement (Champenois, 2015, Sui, 2012, Suárez, 2005). Moreover, *Chlorella* cells have proven antitumor effects based on polysaccharides (Sheng, 2007).

Fruits are very important part of human nutrition. They contain vitamins, carbohydrates, antioxidants, fibres and many other nutritionally valuable substances (Knai, 2006). Fruits from *Z. jujuba* (Zhao, 2006) and mulberry fruits (*Morus alba* L.) (Lee, 2013) contain biologically active pectins.
All these natural polysaccharide sources are thus destined to be used as food supplements.

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- *laboratory and safety manager,*

Education:

- *2012–2019: postgraduate study (doctoral degree – Ph.D.) Food Technology – Structural analysis of compounds characteristic for plant and fungal materials, UCT Prague*

Special skills:

- *isolations, extractions and purification procedures; screening analysis*
- *measurement and evaluation of FTIR, NIR, Raman, NMR and UV/VIS spectra*
- *multivariate analysis (PCA, HCA), GPC, sugar analysis (GC/FID), methylation analysis (GC/MS), other analytical methods related with polysaccharides and polyphenols determination (PSA, Bradford, total phenols)*

1.6. **Y. Yassaroh**, Groningen (Netherlands)
Starch modification and its digestibility

Starch is the main source of carbohydrates for human nutrition. Starch modification has been extensively studied to alter its physicochemical properties based on human needs. Lowering the digestion rate of starch is one of the interests in food science research, since when it is nutritionally improved, it can reduce the risk of human chronic diseases, such as obesity and type II diabetes. In this project, native potato starch was modified to improve its physicochemical properties and reduce its digestibility. The modification combines Heat-Moisture Treatment (HMT) prior to Inclusion Complexation (IC). The HMT was aimed to facilitate better complexation. The inclusion complexation was prepared between the heat-moisture treated starch and fatty acids. The fatty acids used were linoleic acid and stearic acid. The effect of different types of fatty acids were investigated. Furthermore, the effect of time and temperature of complexation were also studied. HMT followed by complexation with fatty acids clearly improved the heating and shearing stability of potato starch in water system. The amylose-fatty acid complexes in the treated starch mostly remained intact even if the application heating temperature is around the boiling temperature of water-based food products since the complexes mostly melted above 100 ºC. In addition, the heat-moisture treated, fatty acid complexes of starch successfully exhibited better thermal and mechanical stability as compared to native starch, confirmed by significantly lower swelling and gelling ability of the modified starch. This improved physicochemical properties of starch modified by HMT followed by complexation is a promising alternative to substitute chemically cross-linked and modified starch. The last part of the experiment is the *in vitro* digestibility study. It was found that the modified starch successfully reduced the digestibility of starch. The lower digestibility is referred to the formation of slowly digestible and partly resistant starch.

Y. Yassaroh *started her PhD degree in August 2016 in Macromolecular Chemistry and New Polymeric Materials research group, Zernike Institute for Advanced Materials, University of Groningen, The Netherlands. She is conducting her research on starch modification for food application during her PhD. Before pursuing her PhD degree, Yassaroh completed her master degree in Chemistry Department, Faculty of Mathematics and Natural Science, Institute Teknologi Bandung (ITB), Indonesia, in a polymeric materials research group.*

1.7. **Mario Martinez,** Aarhus (Denmark)
Starch Nutritional Quality: Beyond Intraluminal Digestion in Response to Current Trends

Starch plays a major structural role in many foods and it is responsible for a large portion of daily dietary caloric intake. However, the stress on the body caused by the high demand for insulin after high-glycemic starch-rich meals is a major contributor in the development of type-2 diabetes. Recently, positive benefits from the consumption of indigestible starch and a slow glucose release from starchy foods have emerged. However, further harmonized metrics considering foods as complex matrices of nutrients, ingredients, and processing characteristics are still needed for the complete depiction of starch nutritional quality and its effect on human health. This presentation expands on potential metrics for starch nutritional quality and the importance of harmonized and simple *in vitro* starch digestion models, and highlights opportunities for minimally processed foods, breeding and gene editing, and food by-products based on consumer's expectations for climate friendly ingredients and individual variation in metabolic responses.

Mario M. Martinez *obtained his PhD in Chemistry from the University of Valladolid (Spain) and worked as a Postdoctoral Research Fellow at Purdue University´s Department of Food Science (USA). In August 2017, he became Tenure Track Assistant Professor at the College of Engineering and Physical Science (CEPS), University of Guelph (Canada), where was awarded the CEPS Assistant Professor Research Excellence Award for his outstanding research productivity in the fields of Food Engineering and Health-Promoting Compounds. In April 2020, he joined the Department of Food Science at Aarhus University (Denmark) as Tenure Track Assistant Professor, from where he was awarded the Young Scientist Research Award by the Cereals & Grains Association (USA). Mario is also Adjunct Assistant Professor at the Whistler Center for Carbohydrate Research (Purdue University, IN, USA) since September 2019. M. Martinez' research group is centered on understanding dietary carbohydrates and associated metabolites as well as the mesoscale structuring and processing of food and bio-based food packaging materials. His research also aims at providing refinery approaches of starchy and lignocellulosic biomass into functional polymeric streams.*

2. Analytics

2.1. **Barry McCleary**, Bray (Ireland)
Digestible starch and available carbohydrates

Barry V. McCleary, MGZ Consultants, Ciara McLoughlin and Lucie Charmier, Megazyme Ltd.

Methods have been developed for the measurement of available carbohydrates, digestible and resistant starch based on the incubations involved in measurement of total dietary fiber (TDF) using AOAC Method 2017.16. Samples are incubated with pancreatic a-amylase and amyloglucosidase (PAA/AMG) under physiological conditions (37°C, pH 6, with shaking or stirring for 4 h). Recently, AOAC Method 2017.16 has gained final approval status. The incubation conditions employed in the TDF procedure have also been employed in the development of a method to measure available carbohydrates. Following incubation with PAA/AMG, specific enzymes have been used to hydrolyse maltose, isomaltose, sucrose and lactose to monosaccharides which are subsequently measured. This method has gained Single Laboratory Validation with AOAC and is now being subjected to Multi-Laboratory Validation. Using these same incubation conditions, rapidly digested starch (RDS), slowly digested starch (SDS), total digestible starch (TDS) and resistant starch can be measured The unique problems associated with the measurement of the resistant starch content of RS_4 (e.g. Fibersym) will be discussed in detail and an analytical format will be proposed.

Barry McCleary received his PhD and DSc degrees from the University of Sydney. His main interests cover plant polysaccharides and the enzymes that modify them and how thse interact in defining quality aspects and the processing of plant products. He and his team have developed twelve AOAC official methods and McCleary has received several prestigious awards for his contributions.

2.2. **Cyntia Klostermann,** Wageningen (The Netherlands)
Production and characterization of resistant starch type 3

Cynthia E. Klostermann[1], MSc; Prof. dr. H.A. Schols[2], Prof. dr. J.H. Bitter[1]
[1]Biobased Chemistry & Technology, Wageningen University & Research, The Netherlands
[2]Laboratory of Food Chemistry, Wageningen University & Research, The Netherlands

Introduction

Resistant starch type 3 (RS-3) is known to have great potential as a prebiotic by supporting gut microbiota after intestinal digestion (Fuentes-Zaragoza et al. 2011). However the factors influencing the digestibility of RS-3 are largely unknown. This research aims to reveal how crystal type, molecular weight and molecular weight distribution of the crystallized α-1,4 linked glucans, i.e. RS-3 preparations, influence its resistance to pancreatic digestion. In addition, this research aims to investigate starch degradation and short chain fatty acid formation during colonic fermentation of these RS-3 preparations.

Approach

To study the effect of average molecular weight on resistance to digestion, three different waxy starches were debranched to obtain a polydisperse mixture of α-1,4 glucans with an average degree of polymerization (DP) of 14, 22 and 40. Narrow disperse α-1,4 glucans with a similar average chain length were enzymatically synthesized by potato glucan phosphorylase (PGP) and sucrose phosphorylase (SP). The obtained α-1,4 glucans after enzymatic synthesis or after debranching amylopectins were crystallized for 24 h at either 4 or 50 °C to form B- or A-type crystals, respectively. The crystallized RS-3 preparations were analysed on Mw, Mw distribution and crystal type. Next, the RS-3 preparations were digested with pancreatin and amyloglucosidase during 360 min of incubation. Lastly, four RS-3 preparations were fermented with the fecal inoculum of one 9-month-old infant.

Results

The 10 obtained RS-3 preparations were digested and after analysis of the free glucose released, it was concluded that A-type RS-3 preparations were much more resistant to digestion compared to B-type RS-3 preparations (Figure 1). In addition, RS-3 preparations made of higher chain length α-1,4 glucans were more resistant than RS-3 preparations made of shorter chain length α-1,4 glucans. Lastly, RS-3 preparations made of narrow disperse α-1,4 glucans were slightly more resistant than RS-3 preparations made of polydisperse α-1,4 glucans.

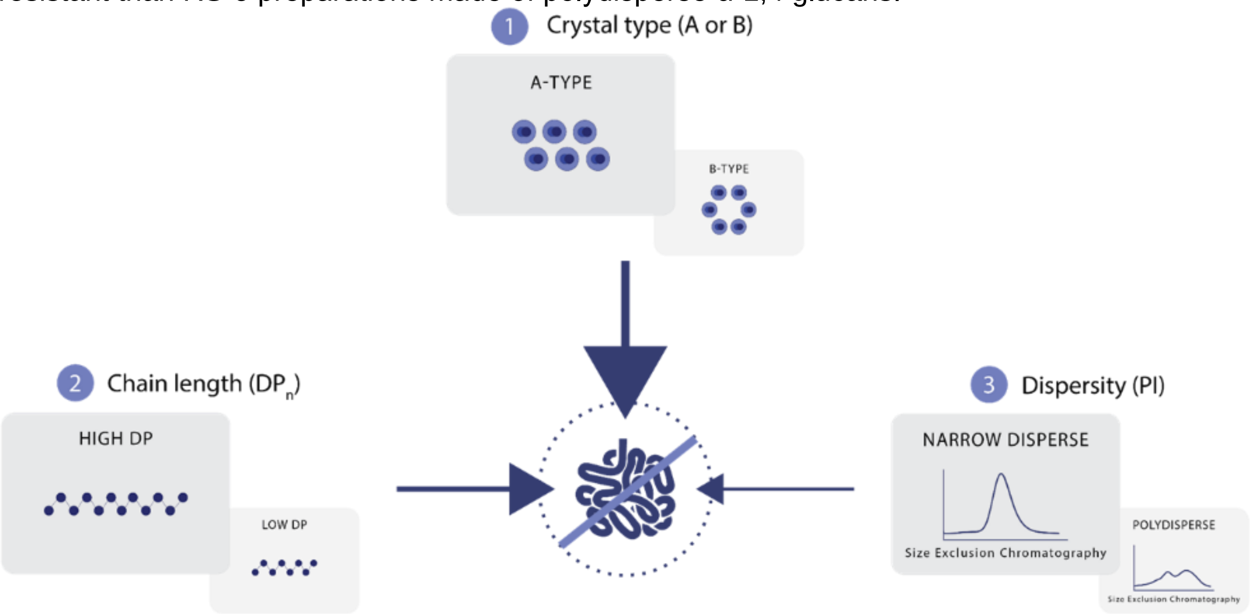


Figure 1: Crystal type has the largest influence on resistance to digestion of RS-3, followed by chain length of the α-1,4 glucans present and polydispersity of these α-1,4 glucans.

To investigate the colonic fermentation of these RS-3 preparations, two A- and two B-type RS-3 preparations were incubated anaerobically with the fecal microbiota of one 9-month-old infant. The results clearly showed that the B-type RS-3 preparations were more degradable and lead to a higher amount of short-chain fatty acids produced, compared to the A-type RS-3 preparations.

Interestingly, both A- and B-type RS-3 preparations were fermented to mostly acetate and butyrate.

Conclusions

Our study revealed that especially medium-chain (DP 22) A-type or narrow disperse long-chain (DP>32) B-type RS-3 preparations are of interest as RS-3 ingredients, since they are for >90 % resistant to hydrolysis by pancreatic α-amylase and will thus arrive in the colon. In addition, it can be concluded that RS-3 holds potential as a food ingredient to produce the health beneficial compound butyrate.

References

Fuentes-Zaragoza, E., Sanchez-Zapata, E., Sendra, E., Sayas, E., Navarro, C., Fernandez-Lopez, J., & Perez-Alvarez, J. A. (2011). Resistant starch as prebiotic: A review. *Starch-Starke,* 63(7), 406-415.

Cynthia Klostermann *studied Food Technology at Wageningen University & Research (WUR) and did her MSc thesis on the enzymatic fingerprinting of modified starches. After her graduation, she run a research project at WUR for a coffee company for 1 year. She started her PhD at WUR in November 2018 with a focus on the digestibility and fermentability of resistant starch type 3.*

3. Technology

3.1. **Markus Eggenmüller**, Augsburg (Germany)
Secrets in the dry fractionation process of pulses

Plant based food… everyone has heard about it and has seen the impact in their own lives and perhaps in their business. Almost no magazine, event or newsletter is publishing anything which is not related to that. I think everyone knows what are behind this increasing development: a growing world population and a lack of proteins, a change in the consciousness. The secret of pulses as a perfect food ingredient is that pulses are a highly valuable and sustainable food. Pulses are part of the legume family with the most common varieties being dried peas, edible beans, lentils and chickpeas.

The trend towards vegetable protein and the associated demand for special flours is increasing. Since a couple of years meat analogues are on the rise. Due to new process technologies the bitterness, the taste and the structure of plant based meat is coming more and more similar to real meat.

When we started with the dry fractionation process at Hosokawa Alpine in the 1970´s the focus has been on the starch rich fraction. Over the decades this focus has changed on the protein rich fraction.

But what happens in the dry fractionation? What is the difference to the wet fractionation process and how does it work?

In the dry fractionation process, classic flours such as wheat flour, but also flours from pulses, are separated by two process steps of milling and classification into two fractions: a starch-rich and a protein-rich fraction. One secret is to use high performance mills for a gentle deagglomeration of the starch-protein-matrix and by this creating a flour in the micron range. Pending on sort and needs we are talking about a flour below 50µm to later generate the best separation. (Proteins normally have a size < 3µm and starch granules pending on sort have an average size of 23 µm.)

In the second step of classification protein bodies are separated from the starch granules. Conventional classification methods like sieving are not working proper anymore at this fineness range. We use an air classifier with a sharp top cut to create best results. Due to that dry process a cost-, environment- and resource-saving production without using water or chemicals takes place in comparison to the wet fractionation.

An Outlook: Combining these two processing methods could also be a profitable solution: when starting with higher and purer values from the dry fractionation the energy and water consumption in the wet process can be reduced.

Markus Eggenmüller *works in the international food industry for over 10 years after graduating as industrial engineer (FH). He started his career as a Product Manager at Buhler In 2015 he moved to Hosokawa Alpine as an Area Sales Manager. Since 2018 he is responsible for the New Business Development in the food division. Beginning 2021 he took over the responsibity for the sales at the food division at Hosokawa Alpine*

3.2. **Maurice Essers**, Wageningen (The Netherlands)
Thermally inhibition of tuber starches

The principle of alkaline roasting was first described by an article of I. Martin in 1967 (JOURNAL OF APPLIED POLYMER SCIENCE VOL. 11, PP. 1283-1288. This article describes the influence of the alkaline roasting procedure on the emerging viscosity characteristics of the starch which are similar to chemically crosslinked starches. Hence alkaline roasting is often described as thermally inhibition. An important feature of this process is the use of alkalinity in combination with elevated temperatures (above 140°C) and the removal of water during the process.
Decades later, as the replacement of chemically modified food starches (clean label) started to become a trend in food, alkaline roasting gained a renewed interest as a non-chemically method for making food starch derivatives. This resulted in a number of new publications, based upon the original article, in which this technology is further explored by the use of fluidized bed technology in order to obtain the desirable functional characteristics. A further important feature which is mentioned in these articles, is the elimination of water prior to the alkaline roasting process in order to prevent hydrolysis.
Nevertheless, draw backs are still observed. Alkalinity in combination with high temperatures and prolonged reaction times cause browning of the starch. Furthermore, the process itself turns out difficult to scale up and does not seem to be very robust. The desirable functional characteristics, e.g. viscosity stability in neutral and acid environment are still lacking behind to those of the chemically crosslinked starches. Just a few companies were able to produce these starches on commercial level.
Later research, carried out by TNO/WUR, pointed out the inhibition reaction needs to be initiated during dehydration and that the method of dehydration impacts the final roasting process and the emerging product quality. Hence, it is more than likely that water plays a role in the mechanism of inhibition and that the control of the water household during the thermal phase of this process is of crucial importance to gain control over the complete reaction and the final product characteristics while avoiding hydrolysis. This part of the reaction was not well described in prior art and its influence was neglected.

The relationship between the conditions of dehydration and its influence on the roasting process and the emerging functional properties have been presented during the starch convention Detmold in 2016. The results of this study were carried out with waxy corn starch.

Nevertheless, thermally inhibition of tuber starches, such as waxy potato starch turns out to be more difficult than other sources of starch. In order to obtain viscosity stable waxy potato starches, one needed to apply high alkalinity (initial pH 11) and prolonged reaction times which cause sever browning, which is undesirable.
Hence, we were encouraged to investigate this more in depth what is causing the differences between tuber and other starch sources and how we can overcome this problem.

Hence, in the presentation we will demonstrate that alkaline roasting of tuber starches is possible. Via incorporation of a heat-moisture treatment, prior to dehydration and further roasting, we observed that the above-mentioned hurdles can be solved. With this additional treatment we can use lower initial pH levels and reduce the further reaction time of the process. Hence, less colorization is observed and viscosity stability in both neutral and acidic environment can be achieved.

Maruice Essers: *After attending the Joan of Arc lyceum in the Netherland, I studied chemistry at the technical university in Aachen (RWTH) in Germany. My diploma thesis was about "Synthesis of UV curing polymers by living radical polymerization" and carried out under supervision of prof. dr. Hartwig Hoecker (DWI, Aachen). My professional career started at the R&D department of the South African Paper and Pulp industry (SAPPI) in Maastricht, with a main focus on colloid chemistry. In 2000, I joined Cargill and worked in several global R&D laboratories, e.g. Bergen op Zoom, Ceder Rapids (USA) and Krefeld (Germany). My research activities in this period were on carbohydrate modification for industrial applications. In 2004, I joined Tate & Lyle in Aalst (Belgium). During this period my research covered carbohydrate development for both food and non-food applications. I was also involved in the implementation of new modification processes in production. In 2009 I joined TNO and was located at the carbohydrate research and development group in Zeist. During this period I was responsible for the development of clean label modification technology and the development of new processes for making resistant starches. Furthermore, I was involved in several programs regarding bio- refinery and development of food application processes. In 2017, carbohydrate development of TNO merged with Food and Bio based research Wageningen. Since then, most of my work is related toward enzymatic remodelling of carbohydrates and physical modification of carbohydrates for food and pharma application and the development of reactive extrusion processes for modification of biopolymers. I am prime inventor of 7 patents regarding food starch modification and main/co-inventor in 3 other application fields.*

3.3. **Markus Götz**, Hohenheim (Germany)
Building up modular, regional biorefineries – Starch-rich residues to Hydroxymethylfurfural and coatings

The German bakery sector produced and sold around 4.99 million tons of bread and rolls in 2019. Various studies assume that about 10 to 20 % of this is not sold and is primarily used for energy in biogas plants and incinerators. For the researchers at the University of Hohenheim, this carbohydrate and carbon source can be better and more profitably utilized. They are developing a biorefinery that first uses the residual biomass as a material in the sense of the bioeconomy. The platform chemical 5-hydroxymethylfurfural, or HMF for short, is synthesized from the carbohydrates in the waste baked goods by hydrothermal processes. This process also always produces a solid byproduct, a biochar, and an aqueous process water stream, which is then subsequently utilized in a biogas plant. HMF is a very versatile chemical and is one of the 10 most important chemicals for a biobased future. In the project presented, the project partner Fraunhofer WKI in Braunschweig used the HMF in research to develop formaldehyde-free resins, bioadhesives and self-healing materials.

Mr. Götz *has been working on the topic of 5-HMF for more than 5 years and on the conceptual design and development of modular, decentralized biorefineries as a tools for the bioeconomy for about 3 years. He studied the course "Renewable Resources and Bioenergy" at the University of Hohenheim in the Bachelor as well as in hisMasters and successfully completed the Master program in the beginning of 2018. Already since the middle of his bachelor studies, Mr. Götz deepened his skills in the department of conversion technologies of renewable resources of Prof. Dr. Andrea Kruse at the Institute of Agricultural Engineering of the University of Hohenheim. First as a student assistant, later as a research assistant of the department.*
Since Febraur 2018, Mr. Götz has been working on his PhD on the research project "Basic chemicals and coal from waste bakery products", conducting research in various projects on the development and implementation of regional, decentralized biorefinery concepts with residues from the agricultural and food industry. His focus is on process simulation and scale-up of processes for HMF production, cost and life cycle analysis of processes up to business model development of end-user products such as PEF packaging. Entire value chains are mapped and evaluated.

3.4. **Marco Ulbrich,** Berlin (Germany)
The supporting effect of ultrasound on the acid hydrolysis of granular potato starch

Marco Ulbrich, Yang Bai, Eckhard Flöter
Technische Universität Berlin, Department of Food Technology and Food Chemistry, Chair of Food Process Engineering, Berlin, Germany

The modification of starch owing to acid-thinning (AT) is intensified by a concomitant ultrasound (US) treatment. However, the potential reasons, in particular the specific effect of the US on molecular changes of the polymer structure, and the respective detailed contribution of the single impacts are still unknown. The present study investigates the supporting effect of the US via examination and comparison of the single modifications [general conditions: starch slurry (40 % w/w), 40 °C, stirring; US: gradation of amplitude (50 and 100 %) and sonication time (20 and 60 min) at cycle of 0.50; AT: 0.36 M HCl, hydrolysis time of 4 h] with the corresponding US assisted AT modified starches (US-AT) in terms of granular, molecular and functional properties.
With increasing intensity, the US treatment caused increased carbohydrate solubilization and visible damages on the granule surface. Moreover, the US induced essentially a molecular degradation (debranching) of the amylopectin (AP), whereas a certain chain cleavage within the amylose (AM) wasn't excluded completely. Reduced M_w lowered the hot paste viscosity and the ability to gel. Compared to the AT starch, the US-AT samples showed changes which were basically adequate and ascribed to the corresponding (single) US treatment (exception gel strength: noticeable improvement due to the US assistance of the AT).
The US-AT samples basically incorporated the specificity and the extent of the molecular degradation of both single modifications in a cumulative manner. Based on the analysis data of the present study, the (additional) US was estimated to be a separate and individual component and quasi an additional modification rather than an AT accelerating and facilitating component.

***Marco Ulbrich** – academic experience, studied Food Technology at Technical University Berlin (1997-2003) and worked subsequently as a PhD student in the group of Dr. Vorwerg and Dr. Radosta at the Fraunhofer Institute for Applied Polymer Research (IAP) in Potsdam-Golm (2003-2007; Doctoral thesis: Investigation of the Interaction of Cationic Starch Derivatives with Cellulose Fibres). Since 2008, he works as a scientific assistant (Institute of Agricultural and Urban Ecological Projects (IASP), affiliated to Berlin Humboldt University, 2008-2010; Technical University Berlin, Department of Food Technology and Food Chemistry, Chair of Food Process Engineering, research and teaching, since 2010).*

3.5. **Sajid Alavi,** Kansas (USA)
Starch Extrusion Processing

Preconditioning is often an essential part in extrusion processing of food materials, but is also one of the least studied operations. It is a continuous process, by which starchy materials are hydrated, pre-heated and softened with the aid of water and steam injection before entering the extruder barrel. There are several advantages of pre-conditioning including increasing the 'wear life' of extruder parts such as screw and barrel, enhancing the throughput in an extruder and thus the process efficiency and improving product quality. It is especially advantageous for high protein or high fiber applications. This presentation will describe data related to preconditioning during extrusion of starch-protein mixes, and provide scientific evidence related to enhancement of extruder performance and product quality.

***Dr. Sajid Alavi** is a Professor in Grain Science and Industry at Kansas State University, USA. He received his doctorate in Food Science/Food Engineering from Cornell University in 2002. His research is in the areas of food engineering, extrusion processing for food and other applications, interfaces between processing and nutrition, food microstructure imaging, and structure - texture relationships. He received the 2010 Young Research Scientist Award from AACC International (formerly American Association of Cereal Chemists). Dr. Alavi designs technology and R&D solutions for food, feed and pet food processors, and is involved in projects in USA, Africa, Brazil, India and other countries/ regions around the world. He has provided training and networking opportunities to close to 1000 industry leaders from 30 countries spanning all 6 continents through the internationally reputed short course 'Extrusion Processing: Technology and Commercialization' at K-State and similar offerings and workshops in other countries.*

3.6. **Bart Koops**, Hilversum (The Netherlands)
Improved method for the production of Iso-Malto-Oligosaccharides with higher molecular weight and lower glucose

Isomalto-oligosaccharides are traditionally produced from starch by first hydrolyzing the starch into a maltose syrup and then converting it to a IMO rich syrup with a Transglucosidase. This process can either be done in a two-step reaction, as described above, or in a one-step reaction, where saccharification into maltose and transglycosilation are taking place simultaneously.
In this presentation, a new method for the production of IMO rich syrups is described that result in production of an IMO syrup with lower glucose content and increased content of longer chain oligosaccharides. This improved IMO is, as a result, richer in dietary fiber content.

***Bart Koops** is Global Technology and Application Leader Carbohydrate Processing at IFF Nutrition and Health/*
Bart studied biochemistry at the University of Utrecht in The Netherlands and obtained his PhD in enzymology at the same university in 1999.
After working at both Royal Numico and Yakult in the Netherlands, he joined Genencor in 2005, which became first Danisco then DuPont and now IFF.
After being responsible for technical sales for 6 years Bart became Regional Application Development Leader in 2011 and additionally holds the current position since mid 2020. He is leading his Regional team in developing new products and processes for the grain processing industry, providing support for customers and supports global projects in Carbohydrate processing.

3.7 **Mario Martinez,** Aarhus (Denmark)
Mesoscale structuring of gluten-free bread with starch

Mario M. Martinez[1], Manuel Gomez[2], Laura Roman[1]

[1]Department of Food Science, CiFOOD Multidisciplinary Center, Aarhus University, Agro Food Park 48, Aarhus N, 8200, Denmark.
[2]Food Technology Area, College of Agricultural Engineering, University of Valladolid, Palencia, 34004, Spain.

The gluten-free bread (GFB) market is steadily growing. Nonetheless, GFB-making still remains more of an art than a science. Although there are studies showing the effect of certain starchy materials on the final GFB quality, mechanistic understanding on the fundamental principles governing the mesoscale structural changes and interactions of starchy tissues during the different stages of processing is limited. This work highlights the importance of understanding GFB as a multistage, thermodynamically unstable system and the enormous potential of starchy ingredients to stabilize it (from batter to retail-packed long-self life GFB). This presentation will also expand on the structuring potential of starchy flour particles, starch granules and dispersed starch molecules to improve GFB quality in terms of loaf specific volume and crumb hardness, cohesiveness, elasticity and staling.

***Mario M. Martinez** obtained his PhD in Chemistry from the University of Valladolid (Spain) and worked as a Postdoctoral Research Fellow at Purdue University´s Department of Food Science (USA). In August 2017, he became Tenure Track Assistant Professor at the College of Engineering and Physical Science (CEPS), University of Guelph (Canada), where was awarded the CEPS Assistant Professor Research Excellence Award for his outstanding research productivity in the fields of Food Engineering and Health-Promoting Compounds. In April 2020, he joined the Department of Food Science at Aarhus University (Denmark) as Tenure Track Assistant Professor, from where he was awarded the Young Scientist Research Award by the Cereals & Grains Association (USA). Mario is also Adjunct Assistant Professor at the Whistler Center for Carbohydrate Research (Purdue University, IN, USA) since September 2019. M. Martinez' research group is centered on understanding dietary carbohydrates and associated metabolites as well as the mesoscale structuring and processing of food and bio-based food packaging materials. His research also aims at providing refinery approaches of starchy and lignocellulosic biomass into functional polymeric streams.*

3.8. **Lilith Baczynski**, Gent (Belgium)
Improved process control using Oxamine in wet starch separation

In starch production from wheat and potatoes, the application of monochloramine provides significant benefits on various levels beyond its antimicrobial properties. Other than peracetic acid, monochloramine is most effective at a pH 6 and provides ideal conditions for wheat wet separation and gluten agglomeration. The use of monochloramine eliminates the need to counterbalance an acidic environment caused by technological requirements or by microbial formation of organic acids through the addition of caustic soda /sodium carbonate. The process stability in combination with infection control allows for the use of higher capacity and retention time.

Monochloramine acts as a mild oxidant with a high affinity for specific microbial proteins. The mode of action on microorganisms inhibits food uptake and formation of lactic and acetic acid by blocking microbial enzymes. Buckman's proprietary dosing equipment is designed to apply different dosages flexibly to the various parts of the process. The application can thus be regulated to achieve the desired level of microbial control, from bactericidal action to meet food specification requirements to a mild bacteriostatic action where subsequent lactic acid formation is desired for conservation of animal feed products. Every gram of lactic acid saved in wet separation results in 0.9g starch and is directly reflected in starch, glucose and ethanol yield.

Moreover, monochloramine is also an extremely effective bio dispersant and able to penetrate organic deposits even if they are layered with mineral scale. It helps to clean up the process and keeps it free from organic deposits going forward, providing an opportunity to reduce stops for cleaning/CIP and schedule stops only around required maintenance. Especially in potato processing, this feature provides significant savings.

Monochloramine is the chemical compound with the formula NH_2Cl. It is commonly used in low concentrations as a secondary disinfectant in municipal water distribution systems as an alternative to chlorination in many European countries and all over the world. Monochloramine has replaced drinking water chlorination in many places as it is much more stable than free chlorine and has a much lower tendency than free chlorine to convert to organic materials into carcinogenic by-products such as such as chloroform and carbon tetrachloride. During the oxidation reaction monochloramine is consumed and small amounts of ammonium chloride are formed. Due to the specific action of the molecule on microbial targets, required dosages of monochloramine are much lower than with traditional chlorination methods or strong oxidants. An average dosage of monochloramine will introduce roughly 20 ppm chloride ions into the process and stay therefore well below the levels for corrosion around 100 ppm.

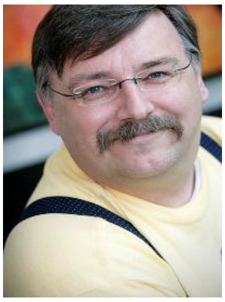
Monochloramine has been added to the Annex 1A of the EU Order of 2006 relating to the use of processing aids in the manufacturing of certain foodstuffs per decree of April 22, 2020 and is the only EU recognized processing aid for starch production besides peracetic acid. Buckman has been supplying the industrial application of MCA in food processes since 2014 and has been offering its patented low chlorate monochloramine application for starch production since 2019. US EPA drinking water quality standards limit chloramine concentration for public water systems

to 4 parts per million (ppm) based on a running annual average of all samples in the distribution system. In comparison, use of the Oxamine technology in starch processes will result in residual chloramine concentrations of not more than 1 ppm.
A component of concern in traditional chlorination and the use of halogens as disinfectants is the formation of chlorate. Chlorate in food was discovered in 2014 by an official control laboratory by coincidence. In 2015, EFSA found that levels of chlorate in drinking water and in foods were too high and could result in potential serious health, especially among infants and children. Chlorate originates from chlorine disinfectants widely and legally used in water treatment and in food processing with drinking water being by far the main contributor. Regulation (EU) 2020/749 amended the MRLs for chlorate for all food products. It has been applicable since 28 June 2020. The specification of chlorate levels for processed food are still under review, but since chlorate is no longer approved as a pesticide in the EU, the origin of chlorate has to be revealed for processed foods.
Buckman's patented low chlorate monochloramine application, using in-situ electrolytically produced sodium hypochlorite is designed to introduce virtually no additional chlorate into the process. During the storage of liquid bleach, hypochlorite ions decompose to form chlorate ions. This decomposition is mainly a function of storage time, concentration, temperature, and alkalinity. By producing a very dilute sodium hypochlorite to be freshly used as a precursor on site, chlorate formation in sodium hypochlorite solution can be prevented. Near the end of the nineteenth century, E. S. Smith patented the chloralkali process: a method of producing sodium hypochlorite involving the electrolysis of salt brine to produce sodium hydroxide and chlorine gas, which then mixed to form sodium hypochlorite with water and stabilized by caustic soda. Dutch company Van den Heuvel Watertechnologies have upgraded this technology into their CHLORINSITU® III membrane cell electrolysis system. The advantage of the membrane cell electrolysis systems lies in its excellent efficiency (85% yield) and minimal chloride input compared to open cell systems. By discarding the anolyte of the production process, extremely low chlorate levels of the fresh diluted bleach are achieved.
Buckman and VDH have made the CHLORINSITU® III generator available in containerized form to provide a means of testing the technology as a plug-and-play system. The patented combination of using fresh in-situ production of low concentration-low chlorate bleach as a precursor to the production of monochloramine, allows starch factories to enjoy the full benefits of Oxamine® as a processing aid for process stability, biofilm removal and microbial control while producing fully compliant end-products when it comes to regulatory requirements and customer expectations.

Lilith Baczynski, Business Development Manager Bioprocess, Buckman Laboratories nv
As Business Development Manager Bioprocess EMENA for Buckman Laboratories, Lilith focuses on chemical and digital applications in the starch, sugar and ethanol industries, helping customers to improve process performance while continually improving Buckman's offerings and portfolio for this segment. Lilith Baczynski holds a Dipl.-Ing, degree in Food Technology Engineering from the University Hohenheim, Germany and an International Executive MBA from the University of Maastricht, Netherlands. She has been working for Buckman EMENA in this function since 2018, and in a variety of related Business Development, Sales& Marketing, and Management functions in the bioprocess industries since 2004.

3.9. **Ted Slaghek**, Wageningen (The Netherlands)
Starch from the oil palm trunk

The paper describes the efforts that were undertaken by the Malaysian Palm Oil Board (MPOB) and Wageningen Food and Biobased research in investigating if it is possible to extract starch from the oil palm tree trunk after the tree has been harvested. In principle a palm oil tree is producing oil palm fruit for around 25 years and then replaced by a new tree. In Malaysia every year large amount of trees are replaced in a rotation scheme. The paper describes the endeavors that were under taken by the two research institutes in harvesting, isolating and preparation of oil palm starch based plastics. Some of the harvested trees are used for the production of veneer by peeling of the outside of the tree leaving an inner core called the oil palm trunk. The focus of the research has been on this trunk. However not all of the trees are used for veneer therefore also whole trees have been investigated.



Ted Slaghek *received his PhD in carbohydrate chemistry in 1989 at the University of Utrecht in the group of Prof Vliegenthart on synthesis of capsular polysaccharide epitopes. He then moved to Japan for two year post-doc as a STA-Fellow at the RIKEN institute in the group of Tomoya Ogawa on the topic of synthesis of fragments of hyaluronic acid. He returned to Utrecht in 1992 as a Royal Dutch Academy of Arts and Sciences fellow continuing the research initiated in Japan. In 1993 he moved to Wageningen to the Agrotechnological Research Institute as head of the section carbohydrate modification. The focus of the research was the development of non-food applications for industrial carbohydrates. In 2001 he moved to TNO location Zeist and accepted the position of Product Manager Ingredients and Functionality. His research topics at TNO was development of new ingredients for food and non-food applications using natural polymers. In 2018 he moved back to Wageningen University and Research in the department of Wageningen Food and BioBased Research. He is currently a senior scientist with a research focus on the use of organic raw materials for on-food applications. He published more that 37 papers and over 42 patent applications in this research area.*

4. Application

4.1. **Martin Kozich**, Tulln (Austria)
Foamed starch adhesives

Paper bags, which are utilized in construction and food industry, are produced with the aid of aqueous starch-based glues. Usually, starch adhesives with low solids content are used for this purpose. Thus, a considerable amount of water is applied which leads to an increase in drying time required for the development of sufficient strength properties.
In the case of insufficient drying (e.g. due to fully utilized production capacities) expensive complaints can be expected as an improperly closed seam is likely to be pulled apart during the filling process, which furthermore leads to product leakage.
As the overall objective is to decrease the drying time, one approach could be the reduction in water content by means of the adhesive itself. In this context, the utilization of adhesives with higher solids content could be reasonable but would entail considerably higher costs.
The aim of this project is to reduce the required drying time (filling should be possible after only two days) as well as the overall glue consumption by applying the adhesive in the form of a foam. To enable this target, an adaptation of the starch raw materials inherent functionalities was inevitable. Furthermore, it was necessary to find an appropriate surfactant which 1) enabled a sufficient foaming efficiency and 2) fulfilled the requirements according to the regulations set by BfR/FDA. In addition to a sufficient foam stability the foaming agent must not adversely affect the bonding strength. Processing with industrial gluing equipment as well as a homogeneous glue application had to be ensured and glue splashing had to be avoided (even at high production speed).
A positive influence of the novel invention on the foamability has successfully been verified in the presence of industry partners during the course of application testing.

Martin Kozich *studied chemistry at the Technical University of Vienna and obtained his PhD in Organic Chemistry in 1994. In 1997 he started working at ARIC (former Zuckerforschung Tulln) holding various functions. In 2004 he took over the current position as head of the department Starch Non-Food at Agrana Research & Innovation Center (ARIC). He is in charge of research projects which focus on the further development and utilization of modified starches for different applications like e.g. paper, adhesive, bioplastics, or construction.*

4.2. **Laura Roman**, Montserrat P. Reguilon, Manuel Gomez, Mario M. Martinez, Aarhus (Denmark)

The importance of amylose retrogradation in the textural attributes of starch based foods

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Consumers of bakery goods seek soft, cohesive and resilient crumbs. This presentation will highlight the combined effect of amylose (AM) content and chain length, as opposed to only AM content, on starch retrogradation and crumb hardness. Firstly, selected rice flours from tempered kernels from 5 different varieties (Basmati, Thai, Waxy, Sushi and Bomba), with less than 8% starch damage, and possessing markedly different AM fine structure, served to investigate the role of AM fine structure on retrogradation and, ultimately, the texture of bread crumbs. Dynamic rheology of rice flour gels revealed that Basmati flour exhibited a six-fold higher propensity to form internal Physical Junction Zones (PJZ), those that contribute to the food mechanical properties, than the rest of the starches. Frequency and temperature sweeps revealed AM-AM and AM-AP interactions, respectively, as the internal PJZ. Since Basmati and Bomba exhibited similar AM content and amylopectin (AP) fine structure, the intermediate length amylose (699 DP) of Basmati is proved to be the responsible for a greater amount of AM-AM and AM-AP internal PJZ. Interestingly, GFB crumbs made with Bomba flour were 20% softer than those made with Basmati flour. Since AM length is suggested to be a crucial parameter to attain breads with softer and more cohesive crumbs, this presentation will also cover the efficacy of extrusion to decrease the propensity of different cereal starches to form AM-driven PJZ worsening texture. Thermo-rheological analyses revealed two distinct mechanisms depending on the cereal source. In maize and wheat flours, AM fragmentation through extrusion decreased the residual G′ at 85 °C of 7-day stored gels, which represents AM-AM physical junction zones that build gel structure. On the other hand, the extrusion of rice flour, which contained starch with lower AM ratio than maize and wheat counterparts, resulted in a marked AP fragmentation that decreased the relative G′ drop, representing inter-molecular interactions involving AP. Results suggest that extrusion is a useful technology to decrease starch retrogradation, although attention must be paid to the raw material and extrusion conditions used. This presentation gives important understanding at the molecular level for the optimization of flour functionality through the selection of starch biosynthesis targets and high-shear extrusion in order to reduce retrogradation-controlled phenomena such as bread staling, sauce/pure syneresis and optimize rice stickiness, among others.

***Laura Roman** earned her PhD in Food Engineering from the University of Valladolid (Spain). After her PhD graduation in 2018, she worked as a Postdoctoral Researcher at University of Guelph (Canada). In April 2021, she joined the Department of Food Science at Aarhus University (Denmark) as a Postdoctoral Researcher after being awarded a Novo Nordisk Fonden Fellowship. Laura has worked on the elucidation of the fine structure of starch and the basic principles and mechanisms for its amylase-resistant property and mechanical properties with application on baked goods. Her research also focuses on understanding the structure of complex carbohydrates and its relationship to processing performance.*

4.3. **Francisco Vilaplana**, Stockholm (Sweden)
Compatibilization of corn starch in engineered bioplastic blends for automotive and construction applications – BARBARA Project

In this presentation I will present the main results obtained in the Bio-Based Industries (BBI) BARBARA project "Biopolymers with advanced functionalities for building and automotive parts processed through additive manufacturing" (https://www.barbaraproject.eu) funded by the European Commission under the Horizon 2020 program. The BARBARA project developed new bio-based materials with innovative functionalities through fused filament fabrication (3D-printing). We used food waste and agricultural by-products to extract polysaccharide matrices and additives, which were further processed in bioplastic masterbatches with customized properties. These novel bioplastics were transformed into prototypes by additive manufacturing (3D printing) and validated in the construction and automotive industry (Figure 1). Our role in BARBARA involved the extraction of polysaccharides (starch and arabinoxylan) from corn by-products and their chemical modification and compatibilization with engineered plastics (polyesters and polyamides). Carbohydrate chemistry offers various reaction routes to achieve this, such as esterification with carboxylic acids and derivatives, graft ring-opening polymerization with cyclic monomers or grafting with reactive polymers. We optimized the organocatalytic esterification of corn starch in terms of catalysts and reactive agents for improved thermal stability and moisture resistance, in order to make it more suitable for blending with engineering thermoplastics. Finally, we followed different strategies in order to compatibilize corn starches with engineering thermoplastics such as polyesters and polyamides, maintaining the mechanical properties and thermal stability. We successfully prepared starch blend masterbatches, which could be then converted into the final prototypes by 3D printing.

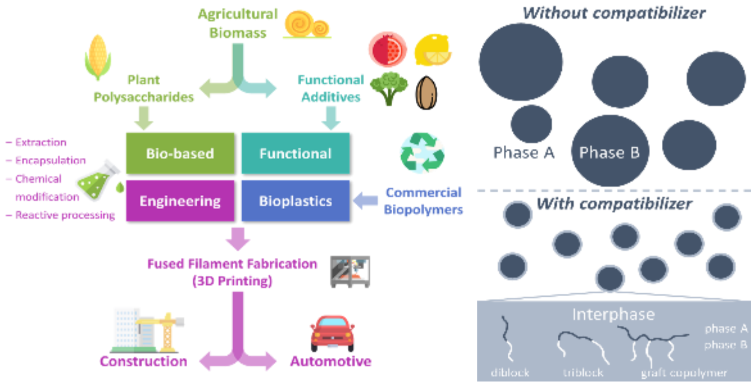

Figure 1. Scheme of BARBARA project scope and applications.

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Francisco Vilaplana *is Associate Professor and Head of the Division of Glycoscience at KTH Royal Institute of Technology (Stockholm, Sweden). He is a multidisciplinary researcher with competences on chemical (process) engineering, polymer/material sciences, analytical chemistry, and carbohydrate biotechnology. Francisco leads the research group “Biotechnology of Carbohydrates from Biomass”, with the vision to exploit the rich molecular diversity in terrestrial and marine biomass towards novel functional products for food, biomedical and structural applications (e.g. food packaging). His group targets a wide range of biomass feedstock, including terrestrial plant sources (cereals and wood), fungi, and algae. His research activities involve (i) the development of advanced analytical methods to decipher (sequence) the molecular structure of complex carbohydrates, (ii) understanding the architecture and assembly of plant and fungal cell walls, (iii) design of 'biorefinery' processes for biomass exploitation using green chemistry and biocatalysis, (iv) chemo-enzymatic modification of carbohydrates for material and food applications, and (v) correlating dietary polysaccharide structure with nutritional properties. Dr. Vilaplana is Honorary Research Fellow at the Centre for Nutrition and Food Sciences, The University of Queensland (Australia).*

17th European Bioethanol and Bioconversion Technology Meeting

1. Alternative Feedstocks

1.1. **Arjen van Tuijl**, Hilversum (The Netherlands)
State of the art technology in developing a new and efficient SSF enzyme for high ethanol yield in fuel ethanol production

Arjen van Tuijl, Bart Koops, Nadia Ramirez Angulo, Sindy Morales Suan

Nowadays, increasingly more fuel ethanol producers focus on extracting maximum value from their grain. This can be accomplished by optimizing different stages in the process (upfront fiber removal, improved liquefaction, down-stream corn oil recovery), but it can also be done by optimizing the fermentation process itself.
One of the best options is to decrease the residual starch level after fermentation, for example by improving the glucoamylase product. Not only will this have the potential to increase ethanol levels, it will also result in increased DDGS quality, due to lower starch levels thus higher protein levels.

At IFF, we have taken a systematic approach to screen a vast number of enzymes and activities for their action on the remaining end-of-fermentation material. Activities tested include glucoamylase, alpha amylase, cellulase, glucanase and many others.
A wide range of whole stillages (wheat and corn) were prepared with different standard alpha- and glucoamylases. These were incubated with different enzymes to find enzyme activities important to solubilize more starch than the current products.

In this presentation we will show the strategy that was used to test over 40 different enzymes. The best performing enzyme activities were then tested in lab-scale fermentations to verify their performance. From this an optimal blend of enzymes was proposed, which on lab-scale showed a spectacular reduction of residual starch. This blend is currently being tested in plant trials.

IFF technical sales managers will be happy to answer any questions you may have and are happy to support you in trialing this new blend.

***Arjen van Tuijl** joined IFF Health & Biosciences in 2007, and has been working in the Grain Applications team since then. His job consists of product development and technical support, both for the fuel ethanol market as well as carbohydrate processing market. He holds a BASc in Biotechnology and has worked at two universities (Delft and Amsterdam) before joining DuPont.*

1.2 **Stefanie Graber**, Völs (Austria)
Flasche statt Tonne - Lebensmittelmüllvermeidung bei Therese Mölk - Use it don't waste it – how the Therese Mölk bakery supports recycling instead of wasting bread

MPREIS is a food retailing and family-owned company in Tyrol (Austria) and offers 260 stores in the western part of Austria and South Tyrol (Italy). The MPREIS group includes a butchery, a convenience food production and a bakery. The company stands for regional food, unique architecture and sustainable living.

The Therese Mölk bakery was already founded in 1925 as part of MPREIS and delivers bread and confectionary for the shops. Baking bread the traditional and natural way without food additives by using long-time and sour dough methods is part of the corporate philosophy. Sustainability is a central part too.

Statistics in Austria show that every 5th piece of bread ends up in the garbage pin. Main sources are bakeries, but also private households throw away lots of bread. Over the past years the Therese Mölk bakery aims to set up different projects to avoid this kind of food waste. In the first place they try to prevent rejects within the bakery. This does not always succeed a 100 %. And that is why they use bread from rejects to produce spirits, a very modern way of recycling.

“Herr Friedrich Gin” was one of their first products launched. For 400 bottles of gin they use 1000 kilos of bread, which is first mashed and then distilled. The gin was awarded by the Austrian Gin Trophy of Falstaff with 92 points and is one of the 5 best gins in Austria. Over the past four years the Therese Mölk bakery was able to recycle more than 76.000 kilos of bread by distilling it to gin.

Because this project has been successful, Therese Mölk 2019 build their own distillery within the bakery. Up to now they launched 11 different kinds of spirits made of bread. Overall, Therese Mölk was able to recycle more than 140.000 kilos of bread by reusing them for spirit drinks over the past 4 years.

Find more information about Therese Mölk bakery: www.therese-moelk.at

***Stefanie Graber**, BA*
I am head of marketing at the Therese Mölk bakery in Tyrol (Austria) for almost 8 years and am responsible for the product development and launch on the market for our spirits made from bread.

2. Process optimization (Bioconversion)

2.1. **Elia Tomás Pejó,** Madrid (Spain)
Biotechnological advances in lactic acid production by lactic acid bacteria: lignocellulose as novel substrate

Lignocellulosic biomass is an interesting substrate for producing fuels and chemicals due to its sugar content, high availability and low price. Among the bioproducts obtained through fermentative processes from lignocellulose, lactic acid is a building block for biopolymers and a versatile chemical with numerous applications in food and pharma.
While, glucose obtained from the cellulose-rich solid fraction has been widely utilized for bioethanol production, the use of hemicellulosic-rich prehydrolysates needs to be optimized. Hemicellulosic liquid fractions mainly contain, apart from degradation compounds, five-carbon sugars which cannot be metabolized by most of wild-type microorganisms making their use very challenging
In this study, the heterolactic bacteria *Lactobacillus pentosus* CECT 4023T demonstrated its ability to co-metabolize different sugars from lignocellulosic liquid fractions with low carbon catabolite repression effect. In this case, limitation of oxygen presence was shown as a key factor to promote xylose fermentation. In fact, under strict anaerobiosis and pH-controlled conditions, 81 % and 95 % of the theoretical maximum lactic acid were obtained from wheat straw and gardening hydrolysates, respectively. *L. pentosus* was also subjected to adaptive laboratory evolution by serial batch cultivation at increasing xylose concentrations in order to increase xylose uptake. As a result, an evolved *L. pentosus* strain with increased xylose consumption rate at low pH was obtained with the aim to reduce the need of neutralizing agents and to produce free lactic acid, facilitating the purification step.
Between 90 % and 100 % of the theoretical maximum lactic acid were obtained from gardening hydrolysates by homolactic *Bacillus coagulans* strains because five-carbon sugars were metabolized by the pentoses phosphate pathway without by-products generation. Furthermore, *B. coagulans* produced optically pure L-lactic acid, with higher added value than the racemic mixture produced by *L. pentosus*.
Following a biorefinery approach, the sequential co-generation of lactic acid and bioethanol was also proposed. With this in mind, an evolved *B. coagulans* was obtained by adaptive laboratory evolution in chemostat, making it more resistant to ethanol. The evolved bacterium was used for fermentation of five-carbon sugars from a 50 % ($v\ v^{-1}$) bioethanol-rich wheat straw hydrolysate

previously obtained by simultaneous saccharification and ethanol fermentation of the whole slurry. As a result, the evolved *B. coagulans* reached the maximum lactic acid theoretical yield (1 g g^{-1}), tolerating the combined inhibitory effect bioethanol and lignocellulosic inhibitors.
This work has provided new knowledge about the optimum fermentation conditions of different hetero- and homolactic lactic acid producers. Furthermore, efforts have been addressed to the development of new lactic acid producing strains fitted to industrial fermentation processes using adaptive laboratory evolution.

Dr. Elia Tomás Pejó *works as a senior assistant researcher in the Biotechnological Processes Unit at the IMDEA Energy Institute. During her PhD, she studied the different stages of the lignocellulosic bioethanol production process. As a post-doctoral researcher at Chalmers University of Technology (Sweden), her research line was extended to the use of recombinant yeasts for xylose fermentation at industrial scale. Nowadays, she mainly studies different fermentation technologies for the production of biofuels and bioproducts from organic wastes by means of both sugars and carboxylate platforms. Dr. Tomás-Pejó is co-author of more than 55 scientific articles and chairs the COST Action YEAST4BIO "Non-conventional yeasts for the production of bioproducts" (2019-2023), which involves more than 100 scientists from 34 countries.*

2.2. **Jovan Nizeyimaana,** Kampala (Uganda)
Effect of thermal pretreatment of East African Highland banana peels on biogas production

There has been increase in banana value addition processing activities of the East African Highland cooking banana (EAHB) at The Presidential Initiative on Banana Industrial Development (PIBID)/ The Banana Industrial Research and Development Center (BIRDC), it is estimated that the level of waste generated in the form of banana peels, pseudo-stem, leaves, fruit-bunch stalk, and rhizome will also increase. Though banana peels form a significant portion of the organic waste produced in The Republic of Uganda their effective utilization remains a challenge. The East African Highland cooking banana (EAHB), a distinct group of AAA bananas, like all other crops generates huge amounts of bio-waste especially when the banana is being processed into value-added products.
EAHB peels possess suitable properties for biogas production through anaerobic digestion however hydrolysis of EAHB Peels like other lignocellulosic materials is slow and therefore limited to compounds that are not encapsulated by lignin. Different methods have been sought to improve the biogas yield from this kind of biomass and these include mechanical, chemical, and biological methods. The present study investigated the effect of thermal pretreatment of EAHB peels on biogas production through conducting anaerobic batch fermentation.
The results from this study showed that generally, EAHB peels are viable for biogas production through anaerobic digestion. From proximate analysis the EAHB peels had ash content ranging between 8.54 – 9.34% *db*; moisture content 84.2 – 84.5% *wb*; and dry matter content 14.7 – 15.5% *wb* and volatile solids ranged between 13.5 – 14.2% *wb*. Hydrothermal pretreatment had the highest C:N ratio, cellulose, and hemicellulose at 15.11, 39.63±1.42% and 44.69±1.10% respectively. Hydrolysis of lignin led to increase in percentage hemicellulose and cellulose as a result of thermal pretreatment. Biogas yield was observed to increase significantly with thermal pretreatment yielding 614±23 l_N/kg VS biogas while the untreated had 571±28% l_N/kg VS biogas. Methane yield also increased with the hydrothermal pretreatment giving highest methane yield at 296±7 l_N/kg VS methane compared to the untreated with 279±13% l_N/kg VS methane. In conclusion, thermal pretreatment improved the hydrolysis of lignin which improved degradability and digestibility of the EAHB peels as well as biogas yield.

Research conducted by: Nizeyimaana Jovan[1,2*], Florence I Muranga[2], Kawongolo John[1,2] and Kyambadde Joseph[1.2].
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Presidential Initiative on Banana Industrial Development (PIBID) / Banana Industrial Research and Development Centre (BIRDC)

Study conducted at: University of Natural Resources and Life Sciences, Vienna Gregor-Mendel-Straße 33 1180 Vienna, Austria and Makerere University P.O Box 7062, Kampala – Uganda

Nizeyimaana Jovan *obtained his BSc in Biotechnology in 2016 and his MSc in Biochemistry in 2021 at Makerere University, Uganda. He is currently studying optimization of biogas and bioethanol production and therapeutic benefits of antioxidants produced by East African Highland Cooking Banana peels (EAHB peels) at the Presidential Initiative on Banana Industrial Development / Banana Industrial Research and Development Centre.*

3. Future trends & regulation

3.1. **Nelli Elizarov**, Berlin (Germany))
Towards Zero Emissions in Transport: Role of crop-based biofuels

With the Green Deal the European Union set an overarching aim of becoming climate neutral in 2050. Nearly one quarter of Europe's greenhouse gas emissions can be attributed to the transport sector, whereby the road transport is accounting for more than 70 percent. Due to increasing mobility the transport sector has not seen a decline in emissions as other sectors and remains the main cause of air pollution in cities.
On the way towards a low-carbon economy it is pivotal to consider the existing passenger car fleet as it consists to 95 percent of vehicles powered by an internal combustion engine. An already available alternative to fossil fuels are sustainable biofuels like bioethanol showing a high capacity to contribute to Europe's emission reduction targets. Bioethanol features not only high GHG-emission savings compared to fossil fuels but also a potential to reduce emissions harmful to the environment and human health.
As part of the Clean Energy for all Europeans package, the revised Renewable Energy Directive (RED II) entered into force to promote and increase the renewable energy share across all sectors. How will Germany implement the RED II into national law? What are future possibilities and challenges for crop-based biofuels and advanced biofuels in Germany?

Nelli Elizarov *Since 2017 Adviser for Research and Statistics, German Bioethanol Industry Association, 2016-2017 Research Fellow, Université Côte d'Azur, Medicinal Chemistry (Total Synthesis), 2015-2016 Post-Doc, Université Côte d'Azur, Green Chemistry (Heterogeneous Bi- and Au-catalyzed reactions and Flow-Chemistry), 2010-2014 PhD, University of Potsdam, Organic Chemistry (Sequential oxidative and non-oxidative Pd-catalyzed reactions), 2005-2010 Chemistry, University of Potsdam*

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