Abstracts of Free Presenters

In the order given in the program.

All names are given without academic titles.

TOPIC A1: Prevention of non-communicable diseases, particularly obesity, sarcopenic obesity, and the metabolic syndrome

Dietary fibers and their impact on (gut) health - the FiberTAG study

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Objectives
The Mediterranean Diet (MedD) is associated with a decreased risk of cardiovascular disease and cancer. It provides large amounts of dietary fibers (DF). DF are indigestible food components that traverse almost unaffected through the digestive tract. However, bacterial inhabitants of the colon ferment most of the DF to short chain fatty acids (SCFA), gases and heat.
It has been shown that these fermentable DF are able to improve glucose tolerance, lower serum lipids and reduce the risk of the metabolic syndrome. SCFA are known to affect gut health, immune function and tumor development. For most of the reputed effects of DF the molecular mechanisms remain unclear.

Methods
The FiberTAG study investigates the interaction between DF, intestinal microbiota, its metabolites and (gut) health. The four country, seven partner multicenter study includes almost 1000 participants from existing cohorts, augmented with two prospective intervention studies. One randomized study involved women at high risk of breast cancer (BRCA1/2 mutation). The intervention group (IG) received regular dietary classes on MedD, the control group (CG) one session on general healthy nutrition (LIBRE study). Here, we examine the effects of DF on calprotectin in stool samples, which serves as a marker for both gut permeability and gut inflammatory status, measured by Enzyme-Linked Immunosorbent Assays. SCFA were measured by gas chromatography in stool samples, in hitherto 100 participants in a preliminary analysis.

Results
After 3 months of intervention the LIBRE-IG appears to have lower levels of calprotectin (32 mg/kg vs. 26 mg/kg; p=0.089), and lower levels compared to the CG (26 vs. 38 mg/kg; p=0.059), yet both not significant. The total number of women with calprotectin levels above cut-off at 100 mg/kg seems to decrease in the IG (8 to 3; p=0.106) and stay constant in the CG (8 to 7; p=0.649). After 3 months of intervention, the IG had higher stool concentrations of total SCFA (11 vs. 7 mg/g; p<0.001) and higher

levels in 4 out of 8 SCFA measured (all: $p<0.01$). One of the main physiologically active SCFA, butyrate, was more than 6-fold higher in the IG than in the CG (0.3 vs. 1.9 mg/g; $p<0.001$).

Conclusion
In our preliminary data the MedD seems to positively influence calprotectin, a marker of gut health, and has a significant impact on SCFA production, presumably due to high amounts of DF. The FiberTAG study is to investigate the effects of dietary interventions and DF in a variety of cohorts in long-term aspects.

Taxing highly processed foods: Impacts on obesity and underweight in Sub-Saharan Africa

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Objectives
The consumption of highly processed food has been singled out as one of the factors responsible for the rapidly increasing prevalence of obesity and its associated non-communicable diseases and costs. While obesity prevalence is still comparatively low in lower-income Sub-Saharan Africa (SSA), development prospects in this region render its markets especially interesting for these foods, whose consumption is already growing at higher rates than in developed countries. This might be reflected in the massive rise in obesity prevalence growth rates in SSA over the past decade, which has occurred while many of these countries are simultaneously struggling with high undernutrition prevalence.

Methods
With a focus on SSA, this study uses a cross-country panel econometric approach to investigates the effect of higher import tariffs on highly processed vis-a-vis less-processed foods with respect to their impacts on obesity and underweight prevalence, utilizing a newly constructed cross-country panel dataset.

Results
The effects of the tariff differences are found to be significant and substantial in cases differentiated by income level of the country as well as by gender.

Conclusion
The results more generally show that policies affecting the consumer price differential between the two food groups are effective for influencing obesity and underweight prevalence and that these two issues cannot be treated separately. Additional trade liberalization is expected to further reduce underweight but at the same time increase obesity prevalence issues in SSA.

Effects of microalgae supplementation on hypercaloric fed mice

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Objectives
Microalgae are a sustainable source for proteins, fatty acids, carbohydrates, minerals, vitamins and trace elements. Therefore, they could provide the basis for a balanced diet and lead to an improvement in quality of life. Especially, omega-3 fatty acids, like eicosapentaenoic acid, could lead to an improvement in omega-3 to omega-6 ratio and hence prevent from inflammatory and cardiovascular diseases. The microalgae Nannochloropsis oceanica and Phaeodactylum tricornutum are characterized by different protein and lipid contents. In a preceded study we were able to show sufficient protein and fatty acid bioavailability. Until now, however, no information about the effects of a microalgae supplementation on hypercaloric fed mice are available. Within the Bioeconomy Research program of Baden-Württemberg, we examine the potential of those microalgae for human nutrition.

Methods
In this project we assessed the effects of microalgae after ball mill disruption in C57Bl/6 mice receiving a “Western-style” diet. The algae were supplemented in 15% to the feed and were fed for 84 days ad libitum. Afterwards, weight gain, organ weights and length of gastrointestinal tract were measured, histological stainings were prepared and fatty acids in liver tissue analyzed.

Results
The obtained results show, that the supplementation of microalgae leads to a favorable change in fatty acids. The omega-3 eicosapentaenoic acid level rises significantly in all microalgae groups leading to a higher omega-3 to omega-6 ratio. Positive changes could also be monitored in liver weight but neither in weight gain nor weight of fat mass. Histological stainings confirm that N. oceanica and P. tricornutum lead to reduced infiltration and tissue damage in the gastrointestinal tract as well as a reduced liver damage score.

Conclusion
These data provide basis information on the safety and effect of microalgae in hypercaloric fed mice. It can be assumed that the algae N. oceanica and P. tricornutum could be used as a vegan omega-3 fatty acid source and also entail health beneficial effects, e.g. prevention of inflammatory diseases.

Inclusive tool for prevention of noncommunicable diseases and maintain health through new nutritional habits

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Objectives
Objective is to prevent the diet-related and non-communicable diseases by innovative evidence and research based personalized nutrition algorithm shaped in reliable and easy-to-use IT tool.

Methods
We had performed clinical trials, cohort studies, in vitro and in vivo experiments, etc. We are using for PNA creation mathematical modelling, data bases and IT tools.

Results
We propose the beta-version of the personalized nutrition algorithm (PNA) for calculation of food/diet requirements based on specific “individual profiles”. Efficacy and accuracy of PNA had been proved recently for diabetes type 2 patients and obese children. We propose to exploit and test this easy-to-use PNA locally in different EU regions in order to adjust it to precise needs of EU citizens.
PNA is based on measurements and an innovative bioinformatics approach applied for interpretation of individual microbiome data with other relevant and crucial factors (evidence-based and correlated biomarkers, calculating age, gender and indicating personal health status, personal nutritional requirements, food composition data, lifestyle specificity, cultural preferences, environment conditions) and also consider the available source and analytical characteristics of ethnic foods and innovative food processing approach of further individualisation proposed for local farmers and food producers.

Conclusion
Noncommunicable diseases correlate with human microbiome status. The ratio of major representatives of individual microbiome is in strong connection with immune, physiological, and also mental health. Configuration and features of human (oral, gut, others sites) microbiome representatives are highly determined by environmental conditions. Our algorithm is based on new way of understanding microbiome – functiome. Thus the targeted / directed correction of personal microbiome ratio by carefully designed pharmabiotics or via consumption of novel folk functional food based on reconstitution of fermented and other traditional ethnical products are promising new tools to develop patient-centred and disease-specific diets for prevention and treatment of noncommunicable diseases initiated by chronic inflammation. The producing of new generation of traditional food – so called folk functional products that are able to improve personal microbiome profile is the first step in the personification of nutrition for the purpose of effective prevention and treatment of a number of human diseases associated with metabolic disorders.

TOPIC A2: Food and agricultural approaches to reduce malnutrition

Enhancing diet diversification of vulnerable communities after Ebola disease outbreak in Moyamba District, Sierra Leone

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Objectives
One of the major challenges for agriculture is its capacity to ensure sustainable food and nutrition security. In Sierra Leone, these challenges to food and nutrition security were aggravated by the 2014-2015 outbreak of Ebola Virus Disease (EVD) that negatively affected all sectors and livelihoods, including agriculture. This in turn, led to an overall increase in the rates of food and nutrition insecurity. According to the findings of the 2015 Comprehensive Food Security and Vulnerability Analysis, nationwide only 46.5% of the population had an acceptable Food Consumption Score (FCS), and in Moyamba district this percentage decreases to 42.4%. To ensure economic income and improve the diversity of food intake of vulnerable households in Moyamba District, Action Against Hunger with support from Irish Aid implemented an integrated Food and Nutrition Security project in 4 chiefdoms of the district. The intervention aimed to support the recovery from the negative socioeconomic impact of the EVD crisis and improve food and nutrition security status of the vulnerable households.

Methods
Baseline and endline data survey were conducted. Household Dietary Diversity Score (HDDS) and Food Consumption Score (FCS) were collected from representative sample of project beneficiaries at the project start and at the end of the project to assess the changes that occurred following the project. The study covered 45 communities in the District, targeting 1,000 households (about 5,900 individuals).

Results
Comparison between the baseline and the end-line survey shows that at the end of the project 85% of the targeted households increased their HDDS, 15% maintained it at the same level. As for the FCS, 83% of targeted HHs improved their FCS and 100% of targeted HHs increased their monthly income. At the end of the project the number of beneficiary households with acceptable food consumption has increased from 31% at baseline to 81.3% in the end line.

Conclusion
The intervention supported the recovery from the negative socioeconomic impact of the EVD crisis and improved the food and nutrition security status of 1,000 vulnerable households and their communities in Moyamba by improving and diversifying their diet through enhancing the availability, access and utilization of nutritious food crops.

Shaking hands with the devil: more meat, milk and eggs on the plates

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Objectives
One in five children under 5 were stunted in 2017. Poor health and nutrition, in particular during the first 1,000 days of life from conception to 2 years of age, limits the prospects of adulthood and currently threatens the future of 200 million people of the world's next generation. Good nutrition requires a diverse and nutrient-rich diet, which is often available and accessible in high-income countries (HIC); but is hard to achieve for large groups in low- and middle-income countries (LMIC), where poverty and availability limit choices. One important source of highly nutritious foods are livestock-derived foods (LDF), such as meat, milk and eggs. Livestock production is, however, a well-known burden to the environment. Paradoxically, although livestock production and LDF are widely present in LMIC, the poorest, and especially children and women, consume very little of these foods. A recent research study was set to answer three questions on the role of LDF during the first 1,000 days of life in LMIC: 1) Can LDF intake improve nutrition outcomes? 2) Can livestock interventions improve diets and nutrition? 3) What are the health and environmental externalities of LDF consumption in those settings?

Methods
The questions were answered through a systematic literature review and additional extensive narrative reviews.

Results
The review showed that current scientific literature during the first 1,000 days is scarce but suggests that consumption of LDF can improve linear growth, cognition and other nutrition outcomes in children, with greater effects for malnourished children. Livestock interventions targeting smallholder farmers, especially women, increase productivity and incomes, and may improve diets and child nutritional outcomes. Global concerns associated with LDF are some foodborne and non-communicable diseases, including the growing obesity epidemic, and environmental impacts. However, the role of livestock and LDF is markedly different between HICs and LMICs.

Conclusion
To strike the right balance when transforming the global agricultural system in line with the 2030 Agenda and the Paris Agreement, we must recognise the multiple sustainability dimensions of livestock production in LMIC, where it secures the livelihood, health and nutrition of millions. Thus, national agriculture, livestock and nutrition policies must not forget that livestock systems and LDF can do much to boost nutrition for vulnerable groups who would benefit from more diverse and nutrient richer diets.

Contribution of milk from tropical cattle breeds to household food security and income in Mali

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Objectives
Cattle husbandry and particularly milk contribute to household income and food security in developing countries. In southern Mali, the endemic N'Dama breed (Bos taurus) is usually kept by local mixed crop-livestock farmers of the Bambara ethnic group while the larger Fulani Zebu breed (Bos indicus) is predominantly kept by the settled transhumant Fulani cattle keepers. The objective of this study was to investigate the contribution of milk from these tropical breeds and their crossbreds to household food security and income.

Methods
Interviews with 258 households were conducted in southern Mali including households with N'Dama, Zebu, crossbreds and mixed herds as well as households with only oxen and without cattle as reference.

Results
The evaluation of trait preferences revealed that milk yield ranked second behind body size for Fulani cattle keepers whereas milk yield was at fourth rank for local Bambara farmers. The Fulani Zebu breed was valued highest for their milk yield whereas the N'Dama breed was appreciated for its adaptation traits such as diseases resistance and drought tolerance while milk yield was less valued. However, farmers appreciated the taste of N'Dama milk hinting to its high fat content (6.5-7%). Milk offtake in the dry and rainy season was significantly higher of Fulani Zebu than N'Dama breed (on average 1.3 vs. 0.9 liters/cow/day). The crossbreds showed intermediate values. Households keeping Fulani Zebu, mixed, crossbred and N'Dama herds consumed milk, on average 6.7, 5.0 and 3.7 and 3.7 days a week, respectively. Households with only oxen and without cattle consumed milk only 1.6 and 1.4 days a week, respectively. The average daily per capita milk consumption varied significantly, with 222, 140, 84, 115 ml for Fulani Zebu, mixed, crossbred and N'Dama herd categories, while households with only oxen and no cattle consumed 56 and 57 ml milk, respectively. The cash revenue from milk sale was significantly higher for Zebu than for N'Dama and crossbreds.

Conclusion
In conclusion, cattle keeping in general and particularly keeping Fulani Zebu positively influenced food security and cash income from milk.

TOPIC B1: Is zero hunger at zero land use change possible? Future land use strategies: Restoration, intensification or land expansion?

Out of food insecurity and poverty through land use intensification. A good practice example from Ethiopia

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Objectives
The research project "Ways out of extreme poverty, vulnerability and food insecurity" conducted by the Institute for Development and Peace of Duisburg University with funds from the German Federal Ministry for Economic Development and Cooperation (BMZ) aims to develop recommendations for development cooperation regarding how to reach extremely poor, vulnerable and food insecure people and to effectively improve their lives.

Methods
The research approach is based on identifying good practice projects and assessing their outreach approaches, project activities, lessons learnt and above all their impact with regard to the reduction of food insecurity, vulnerability and poverty. For that matter, the research team conducts qualitative and quantitative research in the respective projects applying a household questionnaire survey, wealth ranking before and after the project, intensive household interviews, focus group discussions and key informant interviews.

Results
Around Debre Tabor in the highlands of Northern Ethiopia, people have been food insecure and extremely poor, eking their living from 0.5 ha of land per family. They grew cereals and pulses and left the land bare for the rest of the year. The implementation of the LANN+ (Linking Agriculture and Natural Resource Management for Nutrition Security) approach of Welthungerhilfe enabled them to harvest three times a year on their same 0.5 ha with a diversification of crops including fruit and vegetable and a significant increase of productivity. They apply small scale irrigation as well as improved agronomic practices such as the efficient use of rain water and better natural resource management. Nowadays, they not only manage to feed their families, but they are also able to send their children to school, improve their housing, participate in savings and credit groups and start petty trading and other income generating activities.

Conclusion
The research team found the Debre Tabor project to be one of the good practice examples to sustainably overcome hunger, malnutrition and poverty. Research results from Debre Tabor and other projects point to the conclusion that sustainable land use change and natural resource management on smallholder farms provide a safe and lasting way out of poverty and food insecurity. The research design, general conclusions and recommendations will be presented by a member of the research team, the Debre Tabor experience will be highlighted by the Ethiopian project coordinator of Welthungerhilfe.

Food security in South America towards 2050, crop expansion and demand impacts on biodiversity

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Objectives
In the coming decades, humanity will face several challenges, including how to feed a growing population in the face of climate change in an environment that has already reached some of its planetary boundaries. The main objective of this study is to analyze the possible consequences on the environment of a growing aggregated food demand in South America.

Methods
Among the methods used in this study are a literature review, econometric demand methods, analysis of spatially explicit data sets comprising future land use change and biodiversity value.

Results
Food demand is expected to rise between a 30% and a 45%, depending on the scenario, in South America towards 2030 compared to the current demand level. These numbers increase to 50% and almost a doubling of the current demand towards 2050. The food demand increase is driven by population growth and a higher income base among other factors. To satisfy the growing food demand, it is possible to intensify agricultural practices and to expand arable lands. In this study, both alternatives are evaluated considering the impacts these actions have on biodiversity. As most of the best croplands are already under use, further expansions in arable land come at a high biodiversity cost. Some of the areas characterized by a potential future conflict between agriculture and biodiversity are located in south-western Brazil, the tropical Andes and the southern part of the continent.

Conclusion
Even though the rate of undernourishment in South America had been going down during the last decades, in the last few years this indicator experienced a rise. In this context, the current 5,1% of the population affected by severe food insecurity could also increase in the coming decades. In order to meet the objectives of the sustainable development goals, specifically those concerning food security and biodiversity conservation, it is necessary to understand the possible future developments of humanity and the ecosystems that sustain us. This study contributes information that is relevant to plan ahead and avoid unwanted consequences harmful to ourselves and the planet.

The potential of sustainable intensification of food production in Europe based on the natural resilience and performance of soils

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Objectives
The increasing population and changes in diet patterns will cause an about 50% higher demand for agricultural products in the next 35 years, but a further intensification of agriculture on the actual basis would cause severe negative environmental impacts. To overcome this problem and to increase the yields simultaneously, the concept of "sustainable intensification" (SI) was introduced. This concept aims at improving the productivity as well as the environmental safety of agricultural land. So far, the intrinsic capacity of soils and its natural resilience was not included in the studies of SI. The aim of this study is to identify and to localize arable land in Europe with a high potential for SI based on the natural productivity and resilience of soils.

Methods
A classification scheme was elaborated identifying six soil and land indicators (organic C content, clay + silt content, pH, CEC, soil depth and slope). These six indicators comprise the main biochemical and physical soil properties influencing soil resilience and performance. The data for these indicators were taken from the LUCAS 2009 topsoil data set and attributed to the arable land according to the Corine Land Use Cover 2006 data set as well as to the European Digital Soil Map (ESDB). This was done at a field scale (Rutzendorf/Austria), a national scale (Germany) and at a continental scale (EU-25).

Results
The results show that from a soil's perspective, almost half (44%) of the investigated arable land in EU25 has such a low resilience and performance that it cannot be recommended for SI. More than 3% of the area should be even extensified in order to reduce environmental risks. 16% of the arable land can be recommended for SI with restrictions, and only about 40% of the analyzed arable land has a high potential for SI without impacting the delivery of further goods and services provided by soils, such as clean water and the protection of biodiversity.

Conclusion
The comparison of our classification scheme at the field and national scale with other soil quality ratings revealed, that our scheme can be applied at different scales. Furthermore, we have shown that the concept of SI is limited by the intrinsic natural properties of soils.

Rude awakening of a sleeping giant? Exploring costs and potentials of intensification options in African savannas

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Objectives
With reference to food security, conversion of assumedly underutilised grass- to cropland has been proposed for large portions of Subsaharan savannas – entitled Awakening the sleeping giant. Environmental risks of such conversion, while generally acknowledged, have not been specified nor quantified. The same is true for sustainability and resilience of the proposed cropping systems in a region where climate change impacts are expected to be most severe and smallholders lack resources required for intensified systems. Our objective was to provide a generic tool that allows ex ante assessment of intensification options and land use scenarios for semi-arid African conditions regarding food security, income generation and environmental implications. This tool should be capable of representing crop and livestock systems and their integration, driven by farmers' decisions.

Methods
To this end a multi-agent model, a landscape-scale plant and soil model, both developed at the Hans Ruthenberg Institute, and the livestock simulator LIVSIM from WUR have been dynamically coupled at a monthly data-exchange interval. The system accounts for impacts of land use and herd composition decisions on soils, vegetation and yields; feedback of environmental degradation (e.g. declining soil fertility) and herd status on food provision and farmer decisions; grazing pressure and manure inputs on plant biomass, and plant quality on herd status and manure quality, among others.

Results
We show the conceptual set-up of the coupled model system, the simulated case study of a cattle farm in an East African environment and model outputs that highlight the main processes on the ground and functionality of the model system. Special features of the coupled system are its representation of different animal feeding groups with specific food preferences in a herd; rule-based paddock selection for rangeland and managed grazing systems; a grassland module that accounts for resprouting of vegetation after grazing.

Conclusion
Extension of the prototype towards a parallelised multi-herd and multiple land use model system including transhumance is outlined. The added value of dynamic model coupling for projections of longer term effects of land use change on the environment and household well-being is shown. Potential scenarios and applications of the coupled system are explored.

TOPIC B2: Trade-offs and synergies between climate mitigation and food security

Re-establishing legumes as a socio-economic necessity for sustainable and resilient agri-food systems

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Objectives
Legume crops can help underpin the necessary paradigm shift towards more sustainable agri-food systems. Legume crops deliver nutritious food and feed, and can be among the most profitable crops of diversified crop rotations. Critically, legumes need little or no nitrogenous fertiliser, as this requirement is met by biological nitrogen fixation. Legumes can also encourage natural nitrogen cycling, enhance soil qualities and provide for beneficial insects. Yet, EU policies to increase legume production have failed: legume inclusion in European cropping systems averages 3%, while the EU imports around 70% of its protein requirement.

Methods
We present a range of tools spanning enabling- and disruptive-technologies, -supply chain structures and analytical approaches that may enhance the role of legumes as agents of sustainable economic development. We demonstrate the potential of various legume-centred approaches from a socio-economic perspective gained via a series of European Legume Innovation Network (ELIN) workshops.

Results
The low production of legumes (and reliance on imports) is not due to biophysical constraints of soil and climate, but to a disconnection between producers and consumers that in turn has led to diminished capacity for local processing and a low variety of high value products. The trends can only be reversed by effective policies that support legumes through increasing consumer awareness of their benefits and developing the technological infrastructure to increase efficiency and innovation at local- and regional-scales.

Conclusion
Legumes can be defined as 'facilitative cash crops', or 'net-givers' to food systems which can improve the resilience of society and the environment, including mitigating climate change and its impact. Holistic approaches need embodied within strategies to expand legume production and use, such as the emerging 'protein plan for Europe'. Such strategies should ensure reliance on a greater array of

legume types, and develop diverse approaches to realise 'sustainable consumption' over the long-term, and for the well-being of all sectors of society as well as the environment.

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Understanding the variability in diet-related environmental sustainability

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Objectives
The aim of this study is to assess greenhouse gas emissions (GHGE) and land use (LU) associated with dietary intake across four European countries, and to identify sources of variation in GHGE and LU between and within these countries.

Methods
Consumption data assessed at the individual level were obtained from nationally-representative dietary survey from France and Denmark (seven-day food record), Czech Republic (two replicates of 24-hour recall), and Italy (three-day food record), and were linked to a similar food-item LCA database to quantify the GHGE and LU of each individual diet using the mean of two randomly selected days and calculated for a 2,000 kcal diet. Multi-level models were used to explore associations with individual-level demographical variables, such as age, gender, educational level and overweight status, across the countries under study.

Results
There was clear geographical variability in diet-related GHGE and LU, whereby 17% of the variation in GHGE and 11% of the variation in LU was accounted for by the countries under study. Mean daily GHGE ranged from 4.4 to 6.4 kg CO2-eq, and LU from 5.7 to 7.8 m2*year for a 2,000 kcal diet, with the lowest values for Czech Republic and the highest for France. Being female was consistently associated with a lower diet-related environmental impact. In all population (sub)groups, animal-based products were the main contributor to GHGE and LU, however considerable variation existed in the share of the different animal-based products to total GHGE and LU between and within countries related to differences in consumption quantity and food choice.

Conclusion
This data based on individual-level assessment showed that variation in GHGE and LU between and within countries is clearly related to cultural differences in food choice and consumption quantities.

Linking climate action and nutrition in food systems: lessons from developing countries

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Objectives
Ensuring food security and nutrition for a growing global population in the context of climate change and changing diets is one of the greatest planetary challenges of our time. Climate change affects all four dimensions of food security as well as impacting short and long-term causes of malnutrition. Rural farmers, children and women are expected to be the hardest hit by climate change, while the regions to be the most adversely affected are often those already suffering most from multiple burdens of malnutrition and food insecurity, most notably Sub-Saharan Africa. Despite a growing consensus on the importance of addressing these issues in an integrated manner, data on the direct and indirect linkages between nutrition outcomes and climate change are still scarce. It is clear however that food systems are contributors and effectors of these impacts and linkages.

Methods
The analysis carried out builds on information and lessons learnt from the livestock sector in the work carried out by the Food and Agriculture Organization of the United Nations (FAO) and McGill University. The livestock sector is a cornerstone of food and livelihoods systems in many developing countries and is illustrative of the complexities and benefits of responding to climate change in a way that takes into account the importance of nutrition. The proposed approach will take a food systems approach that evaluates the linkages at each step of the livestock-dairy supply chain (food production; food handling, storage and processing; food trade and marketing; consumption and utilization), including an evaluation synergies, trade-offs and knowledge gaps.

Results
The study lays the groundwork for an approach to improve analysis and decision making capacity of the climate change practices and options which contribute to improving food systems while addressing multiple socio-economic, environmental and nutritional objectives and goals.

Conclusion
The initial framework of analysis on the impacts of food systems on climate change, food security and nutrition as well as their interlinkages serves to raise attention and initiate a discussion on this subject. It will support the initial identification of requirements for and elements of appropriate interventions to link climate action and nutrition from a food systems approach that is relevant especially for developing countries within the context of their Nationally Determined Contributions (NDCs) and the 2030 Agenda for Sustainable Development.

Opportunities that agroforestry offers for increasing the resilience of food production systems

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Agroforestry can be defined as the purposeful integration of trees and crops and/or livestock systems onto one land management unit. A project undertaken by the Institute of Natural Resources NPC on behalf of the South African Water Research Commission has investigated different spatial and temporal arrangements of systems making use of multi-purpose leguminous shrubs, as well as the water use of these systems. The specific systems that have been tested include alley cropped maize and *Sesbania sesban*, silvopastoral systems comprising long-duration pigeon pea (*Cajanus cajan*) and *Panicum maximum*, and improved fallows using pigeon pea. The trees provide a range of benefits including fodder for livestock, grain for human consumption and soil improvement through nitrogen fixation, nutrient cycling and effects on soil structure and water holding capacity. Pigeon pea has shown great promise for intensifying land use while reducing risks associated climate change impacts in Southern Africa, specifically increasing temperatures and erratic rainfall. On-farm experimentation with smallholder farmers has investigated alley cropping, biomass transfer systems and fodder provision. Farmers have been very receptive to the integration of multi-purpose shrubs into their farming systems although they have recognised the challenge of managing competition between the trees and the understorey crop for light and water.

TOPIC B3: Adaptation to global social and environmental change: Technical, digital and social innovations

Social food-related well-being in a diaspora situation

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Objectives
Recently, food has been considered as an avenue for helping refugees to resettle and integrate into their new communities. The aim of this study was to investigate refugees' social well-being in a food context.

Methods
Following a positive psychology framework of well-being, I conducted a qualitative content-based analysis of 34 in-depth interviews with Syrian refugees residing in Stuttgart, Germany.

Results
The study revealed that participants have a strong appreciation of the healthfulness of the German food but not the palatability. An explanation for this is that they make a direct association between German food and the food they received in the initials reception centers, which forms an inhibitor to trying German food outside the camps (social acceptance). Participants expressed their attachment to traditions and customs and tended to draw a distinction between their own food and the one of their new host society. Meanwhile, children's food desires appear to prompt the discovery of new foods and tastes in the household (social integration). Moreover, a sense of optimism in the perception of future food habits was observed, which was strongly linked with the feeling of stability (social actualization). Food was used as a way to build new relationships with the host society and demonstrate culture (social contribution). Caring about climate change, food waste, and other issues appeared only marginally during the interviews, and this was from a religious point of view rather than from an environmental perspective (social coherence).

Conclusion
The insights gained from this research are useful for generating a better understanding of the challenges faced by refugees and for informing strategies on how to enhance refugees' integration through food and improving their overall well-being.

Facilitating Climate Change Adaptation through Institutional Interventions in India

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Objectives
Agriculture remains the most important sector of Indian economy. As per the fourth advance estimates for 2013–14, total food grain production in India has been estimated at 264.77 Mt (DAC, 2015). Total food grain demand is estimated to be 291 Mt by 2025 and 377 Mt by 2050, whereas the total production is estimated to be 292 Mt by 2025 and 385 Mt by 2050, which is 2.0% more than the demand.Climate change affects food security in complex ways. It impacts crops, livestock, forestry, fisheries and aquaculture, and can cause grave social and economic consequences in the form of reduced incomes, eroded livelihoods, trade disruption and adverse health impacts.

Methods
Climate change adaptation is a wholistic strategy where the whole society has to take initiatives and farmers need to be in the forefront. In North Wes India, burning of crop residue has been resolved by the innovative latest version of the Turbo Happy Seeder, which is recognized as a significant technological innovation for in-situ residue management. Through extensive trials, participatory validation and demonstrations, the Turbo Happy Seeder has proven to be extremely useful (Sidhu, et al., 2015). It was a step forward for developing viable solution to rice crop residue burning. Crop residue burning decreased about 40 per cent during 2017-18 in Punjab and Haryana states of India compared to the previous year and it has been mapped through satellite imagery by the scientists of ICAR-IARI.

Results
Bottom-up planning and participatory technology demonstration approach was adopted to enhance the coping ability of farmers to climate variability. A The concept of climate resilient villages (CRVs) consists of implementing these resilient practices at a scale to cover the entire village in a saturation mode depending on the resource endowments of the farmers with one or several interventions for imparting resilience to the production systems. Social mobilization, awareness and involvement of public is very crucial for climate resilient agricultural interventions.

Conclusion
Adaptation to climate change and climate variability are context-location specific. As a result, community awareness, participation and involvement in decision making is crucial for enhancing the coping ability of farmers. This was achieved through establishment of VCRMC comprises of villagers & empowering them to make decisions on appropriate interventions that are to be incorporated in local adaptation plans.

Analysing supply chain resilience with a Bayesian Network

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Objectives
Many food production systems have been designed to maximize productivity and efficiency under standard conditions. This has increased their vulnerability to changes in their surrounding natural, technological and social systems. Insufficient attention has been paid to resilience, the capacity to absorb disruptions and thereby retain essentially the same function. A company can be affected by disruptions hitting the company directly, but also by disruptions occurring in other links in its supply chain. A company's capacity to absorb disruptions occurring in other links we define as supply chain resilience (SCR). This study aims to develop a method to quantitatively analyse the SCR of a company.

Methods
To identify weak and strong points in the SCR of a company, we are developing a quantitative model based on a Bayesian Network (BN). Weak and strong points for SCR are based on the 4 principles of SCR, as identified in SCR literature: 1) Supply chain reengineering, achievable through incorporating redundancy and flexibility into the supply chain; 2) Supply chain collaboration, enhanced through members of a supply chain sharing information and develop trust; 3) Supply chain agility, improved by visibility and velocity enabling a quick response to unpredictable changes in demand and supply; and 4) Supply chain risk management culture, achievable through innovation and leadership enabling effective responsive actions. The BN is being developed using a use case of a disruption, a hypothetical contamination in pig feed with a recall of pig meat for a slaughter company sourcing from a selected number of qualified pig farms. Expert elicitation is used to determine variables, causal relations between variables, and parameter values. Profit stability, defined as the difference in profit between the situation with and the situation without the disruption, is used as an indicator of resilience. Flows of pigs, pig meat and money through the supply chain are modelled for both situations to determine profits.

Results
The 4 principles of SCR link to the resilience indicator through e.g. the number of pig farmers (reengineering), the speed of information sharing on the contamination (collaboration), the speed to make internal decisions (agility), and presence of insurance (risk management culture).

Conclusion
With the BN, we will analyse the strong and weak points of the company's SCR in this use case. The BN will be set up for applicability to other disruptions and other supply chains.

Citizen science meets informatics: Crowdsourcing participatory millet variety selection in Hoima, Uganda for climate change adaptation through Triadic Comparisons of Technologies (TRICOT) Methodology

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Objectives
Climate change is a key issue affecting agriculture in Uganda. A base line survey done in Hoima indicates that there have been changes in climate, such as shifting seasons, erratic rainfall; an increase in temperature; and, increased pests and diseases. This has led to loss of agricultural productivity and loss of genetic diversity. Among the strategies identified for coping with the effects of climate change is the access of genetic diversity necessary for communities to adapt to climate change and development of new varieties of crops through plant breeding.

Methods
Using geographical information systems (GIS) and climate profiles consisting similarities in temperature and precipitation; 43 millet landraces were identified from national gene bank collections in Uganda and Tanzania. These were exchanged using Standard Material Transfer Agreements (SMTAs) and multiplied at National Agricultural Research Organization. These were then distributed to 200 farmers for participatory trials. Crowdsourcing trials were done using Triadic Comparison of Technologies (TRICOT) Methodology, where farmers were randomly allocated three blind varieties coded A, B and C and trained on the data collection methods. They were tasked to evaluate six traits which included faster maturity, pest and disease resistance, drought resistance, yield and overall performance. ClimMob manager – a software for crowd sourcing climate smart agriculture, was then used to collect and analyze the data. Varieties performance ranking was done and analyzed using Bradley-Terry Models.

Results
The analysis gave three top performing accessions for each trait. From the results, out of the 43 millet accessions TZA 1695 and UNGB 4146 matured fastest. In the category of pest resistance, TZA 1700 and UNGB 4146 were not affected by pests or diseases. However, these accessions are still not the best in terms of overall performance. The overall performance of the 43 tested accessions showed that UNGB 43, UNGB 4400 and TZA 186 were the top three varieties recommended for Hoima.

Conclusion
Citizens Science approaches used provide a platform for evaluating a large number of genetic resources with the contribution of a large number of "farmer scientists" evaluating multiple traits t the same time, giving a large number of observations which are then analyzed using TRICOT methodologies. This helps in identifying to ranking varieties for each trait are then isolated to produce elite lines for participatory plant breeding.

Disseminating promising high-yielding tetraploid plantain bred-hybrids in francophone West Africa

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Objectives
The rapid spread and threat of black leaf streak disease on plantain production in the humid lowland ecologies o Africa in the 1980s spurred the establishment of *Musa* breeding at the International Institute of Tropical Agriculture (IITA) with a focus of host plant resistance against the causing pathogen *Pseudocercospora fijiensis*. The identification of 37 seed-fertile African plantain cultivars in the late 1980s paved the way to crossbreeding of this Musa cultigen with diploid male fertile bananas from Asia. The goal of this research-for-development (R4D) undertaking was assessing the agronomic performance and dissemination of plantain hybrids in West Africa.

Methods
IITA plantain breeding developed several black leaf streak disease-resistant tetraploid hybrids (or PITAs) through interspecific hybridization, ploidy manipulation, embryo culture, micropropagation, field evaluation and selection. These hybrids, which are in the public domain, have been distributed in several African countries through on-farm and varietal mixture trials. Plantain hybrids identified by IITA and national partners as promising cultivars include PITA 3 and PITA 5 in Côte d'Ivoire, PITA 2, PITA 3 and PITA 5 in Ghana, PITA 14 and PITA 17 in Nigeria.

Results
All the hybrids tested in different trials out-yielded the local plantain cultivars across sites. The hybrids also enhanced the fruit yield of local cultivars when utilized in varietal mixtures. In Côte d'Ivoire, plantain growers selected PITA 3 and FHIA 21 (bred in Honduras) based on their fruit yield and taste quality. Between 2012 and 2016, these hybrids were massively propagated and distributed to farmers in several regions of Côte d'Ivoire, Benin, Burkina Faso and Togo under the West Africa Agricultural Productivity Program coordinated by the West and Central Africa Council for Agricultural Research and Development (CORAF). In 2016, the National Center for Agronomic Research in Côte d'Ivoire included PITA 3 and FHIA 21 in the varietal directory of improved cultivars.

Conclusion
This R4D undertaking illustrates how after 3 decades from breeding, selection, and distribution led to local acceptance. It also highlights how a CORAF-led partnership harnessed CGIAR research-for-development. The dissemination and acceptance of these plantain hybrid cultivars by growers will enhance the sustainable intensification in plantain-based farming systems across the humid lowlands of West Africa; i.e., increasing steady harvests of plantain fruit from existing farmland

The role of not-knowing, uncertainty and ambiguity for the performance of innovation processes in sustainable land management

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Objectives
The demand for a transformation towards sustainable alternatives to highly specialized animal production systems constantly increases against the background of societal, scientific or political discourses around ethical questions, consumption behaviour or land use. However, such transformative innovation processes involve various socio-natural-technical interdependencies due to the multi-level and multi-actor nature of farming systems, which may bear not only contradictory dimensions with regard to SDG's but also knowledge gaps to identify and asses these conflicting sustainability targets. This contribution takes the example of a niche innovation: re-introducing dual purpose chicken breeds into German chicken production. This innovation is rather radical; includes extensive modification of the value-chain and challenges traditional mechanisms of knowledge production and sharing among involved stakeholders. We present a conceptual framework and empirical results for analyzing knowledge aspects as a prerequisite to assess and discuss conflicting dimensions.
Such potentially system-changing innovation activities often take place in a niche, initiated by small and medium-sized enterprises (SMEs). However, SMEs often face restrictions with regard to resources and knowledge or management capabilities, impacting their innovative capacity and innovation success. In this contribution we focus on the knowledge aspect and base our insights on data obtained within the frame of the transdisciplinary project ginkoo, funded by the BMBF.

Methods
Methodology includes a transdisciplinary situation analysis, transdisciplinary workshops, expert interviews, three field excursions, participatory observation and feedback interviews with practical partners.

Results
Major results involve a continuous mapping of the process leading to identification of major knowledge gaps and uncertainties at different steps of the value chain impeding innovation success, namely: breeding/ rearing, transportation or data-management. Gaps where identified on three levels: individual, value chain and system and with regard to three knowledge dimensions: action-, target- and system knowledge.

Conclusion
In response to the knowledge challenges identified, we developed and iteratively tested two knowledge management tools with practical partners over the four years in this project but also planned for future transferability of the tools to other sustainability innovations.

TOPIC C1: Evaluation of policy instruments for sustainable food production and healthy nutrition

Global insights into future opportunities and developments in the bioeconomy: A global expert survey

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Objectives
Effective global collaboration is crucial on the way to achieving the UN Sustainable Development Goals (SDGs). It requires an understanding of the needs of individual countries alongside with their expectations related to bioeconomy. With the aim to explore the prospective developments in the global bioeconomy over the next 20 years, the German Bioeconomy Council, an independent advisory body to the German Federal Government, commissioned BIOCOM AG to invite experts from around the globe to share their insights in a Global Expert Survey.

Methods
The survey was conducted online in autumn 2017. 345 of the invited experts from 46 countries completed the questionnaire about future developments and strategies in the global bioeconomy.

Results
As claimed by the experts, the upcoming bioeconomy will primarily have to meet humanity's needs in the energy, agriculture and food sector. Moreover, innovative products based on renewable resources are anticipated to be of high importance. Even though all SDGs will be affected by future bioeconomy success stories, five SDGs stood out within the sample: SDG 12: responsible consumption and production; SDG 9: industry, innovation and infrastructure; SDG 13: climate action; SDG 7: affordable and clean energy; and SDG 3: good health and wellbeing.

Furthermore, about 90% of the experts emphasized the necessity to specifically address three conflicting goals in any future bioeconomy strategy: non-food uses of arable land, use of crop land to produce feedstock for meat, milk and egg production and, finally, the conversion of virgin forests into agricultural land. The challenge of providing enough food for the growing world population was approached in 1035 solutions offered by the experts. In this respect, most respondents agreed on the idea that reducing food loss and waste is crucial to eradicate the world hunger problem. The proposed solutions relied greatly on innovation and technological development.

Conclusion
However, differences do exist among the experts from different countries. Generally, the more advanced the national economies are, the less important specific policy measures are rated. One reason might be the different levels of prevailing technological, scientific, economic and political conditions. Therefore, the expertise and know-how in the bioeconomy should be shared between developed and developing economies. A supportive political framework would be the ultimate goal towards boosting the progress of a future bioeconomy all over the world.

The role of certificates and standards to support healthy and sustainable food systems

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Objectives
Public standards and private certificates play a key role in the food system transformation process that takes place in response to rapid dietary changes, with an increasing local demand for fresh perishables products, e.g. vegetables, dairy and meat, next to the demand for export products of higher/consistent quality.

We argue that a combination of public standards and private certificates may reinforce the stable access to more rewarding market outlets. While public standards and private certification determine market access, market development asks for a level-playing field regarding the characteristics of products (e.g. maximum residue levels) and their production systems (labour and environmental standards).

Methods
we identify the diverging and complementary character and define the possible linkages between public standards and private certificates in order to achieve healthier and sustainable food system. We first present a conceptual framework that we subsequently apply to particular cases.

In the comparison, we rely on recent systematic reviews and consider the following aspects: effectiveness (which changes are promoted?), efficiency (what are the compliance costs?), environmental (what type of externalities?) and impact (who are winners and losers?). While making use of existing sources, we synthesise the results and interpret them in the context of the coordination of food system

Results
Whereas public standards and private certificates address particular areas, it should be recognized that their mutual interactions become increasingly relevant. In some cases there are clear trade-offs; in other cases they can reinforce each other.

Furthermore, standards and certificates pursue different functions in the development of market linkages between producers, processors, traders and consumers, while having different direct and indirect effects.

Conclusion
We conclude that public standards and private certificates are both relevant for healthier and sustainable food systems. Where certification provide cheaper farm-level enforcement, standards perform better for market integration and upgrading.

This would involve streamlining requirements, possibly by benchmarking them against each other. Since private certificates tend to develop particular market segments and product differentiation, this also emphasises the need for public standards that set minimum requirements applicable to all business.

Increased urban demand for indigenous vegetables – multiplier effects in the rural Kenyan economy

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Objectives
Despite continuous efforts of policy makers to improve food security outcomes in the country, Kenya still is still among of the countries with the highest micronutrient deficiency worldwide. African Indigenous Vegetables (AIVs) can be an answer to this problem thanks to their high contents of micronutrients. In fact, those crops have seen a rise in appreciation and demand in urban areas in Kenya in the last decade. Income effects for farmers adopting AIVs are ambiguous and depend on the availability of assets, markets and public infrastructure. However, measuring only direct effects can understate the income and food security effects of an increased demand of AIVs on the rural population. Thus, the following research questions arise: a) What are the characteristics of food insecure households in the villages? b) Which crop has the best direct and indirect income effects for food insecure households?

Methods
For the analysis, a total of 706 small-scale vegetable producers were interviewed in Kiambu, Nakuru, Kakamega and Kisii County in Kenya in 2015. A two-step cluster analysis is applied to the sample with several food security indicators to cover the multidimensionality of food security. This way, households are grouped into food secure and food insecure households in peri-urban and rural areas. A Social Accounting Matrix is then generated to show direct and indirect income effects of different food secure households in the village economy.

Results
Results show a significant higher prevalence of food insecurity in the rural areas especially in the utilization and stability dimension. Food secure producers have higher levels of education and own more land, have more income from off-farm employment and less from crop production than food insecure ones. AIVs have higher multiplier effects in the village economy than many cash crops like coffee, tea or maize. Especially the less commonly produced AIVs such as Murenda, Pumpkin leaves and Enderema have the highest income effects for the households.

Conclusion
Because of their nutritional benefits and the effect on the regional economy, the authors conclude that the production of AIVs should be favoured especially in the rural areas in Kenya.

Input price liberalisation and starting uprising in Syria, March 2011

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Objectives
This paper assesses how the policy change and economic reform implanted by the previous Government in 2008 have impacted the economic sectors and the welfare of households. This will contribute to shed some light on the economic background behind the spreading of unrest across the country over seven years.

Methods
The qualitative and descriptive methods were applied in order to describe the reality of the agricultural sector before and during the Syrian crisis and to analyze the agricultural policies changes and its tools. The data and information needed for this research were collected from numerous local, regional and international sources, published reports, previous studies and the statistics of the World Bank, Food and Agriculture Organisation (FAO) and the central bureau of statistics, the office of Prime Minister in Syria.

Results
The results show that liberalization of diesel price affected negatively all economic sectors and all life aspects. The contribution of the agricultural sector in the gross domestic product (GDP) reduced from 24% to 18% between 2007 and 2009, the fallow land rise from 16% to 24% in same period and the inflation rate of prices reached 15% in 2008 which reflected in dramatically dropping the purchasing power of the Syrian families. However, after seven years of war, Syria still covers about 50% of its domestic food needs. This is a proof of the country's ability to recapture the role of the agricultural sector in the economic activity and to reach the self-sufficiency again before 2030.

Conclusion
Even though the war is not over, the conditions for investing in the recovery of the agricultural sector are present in many areas of the country. Such investment with lifting the international economic sanctions will not only reduce the need for humanitarian assistance but also stem migration and encourage the return of migrants.

TOPIC C2: New approaches in food design

Production parameter optimization for bread rolls using the Nelder-Mead simplex algorithm

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Objectives
The optimization of production parameters to increase the food security by decreasing the energy or material consumption is of fundamental importance. In this contribution we will present the Nelder-Mead simplex method step by step using one example. We assume that the auditorium might find topics in their own field of work that might be fast optimized by this method as well.

Methods
The Nelder-Mead simplex method is presented as a fast and easy to apply optimization method. The main benefit of this method is the beginning with x starting experiments, depending on the number of parameters chosen for the optimization and defined out of the needs of the performing person. No sophisticated design of experiments is needed. The Nelder-Mead simplex method is a kind of hill climbing procedure, so no local optimum should be in the search space. The aim is to optimize parameters by maximizing or minimizing an objective or quality function. The simplex method is an alternative to the response surface method, however the optimization is carried out in an iterative approach. It might need less experiments than the response surface method, because it will directly climb up the hill to the optimal value. The Nelder-Mead simplex method can be performed within arbitrary dimensions. The parameters must not be depending on each other. It is also possible to combine this method with another optimization method, depending on the needs.

Results
The Nelder-Mead simplex method led within 10 experiments to an optimal baking result. The optimization was terminated when the values for the confidence interval of the objective function include zero. The quality criterion was defined by the characteristics of bread rolls obtained from the conventional oven using the specific volume, the baking loss, the colour saturation, crumb firmness as well as the elasticity.

Conclusion
An efficient method for the optimization of processing parameters is presented using the example of bread roll production. The optimization was carried out to find the production parameters for a new oven type. A standard recipe for bread rolls was used. The baking process in the new oven is accelerated, because it was coated with a ceramic that increased the infrared radiation during the baking process. Two process parameters, proofing time and baking temperature, were successfully optimized.

Non-invasive flour and dough characterization through the application of Raman spectroscopy in combination with chemometric methods

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Objectives
In an effort to develop a quick, precise and non-invasive way to determine various quality parameters of flours and freshly prepared doughs, Raman spectroscopy was applied. The resulting spectra were processed with chemometrical methods and later correlated to known properties of the flours and doughs.
The advantages of spectroscopy are the quick assessment of the relevant quality parameters, which can save valuable time in the receiving of the raw materials as well as in the production process. Therefore, Raman spectroscopy was used to determine the gluten content of flours, adulterations of high quality spelt-wheat flours with common wheat and to assess the quality of a freshly kneaded dough.

Methods
Raman spectra where gained by a Raman 785 spectrometer (inno-spec GmbH, Nürnberg). The baseline of the spectra was corrected with the IBPF algorithm. Afterwards Principal component regression was applied to correlate the corrected spectra with the offline values. The calibration was done with wheat starch/ gluten mixtures, but at the appropriate ratio (80 % starch and 15 % protein) no difference between a reference flour was detectable ($p < 0.05$).

Results
The prediction of the gluten content in flours worked well with an average calibration $R^2 = 0.976 +- 0.004$. For the adulteration of spelt wheat flours, concentrations of higher than 10 % of regular wheat flours were detectable.The progress of the kneading step can be determined within one minute of the actual optimum as determined in the farinograph (as dough development time).

Conclusion
These first results showed very promising performance of Raman spectroscopy the determination of ideal kneading time to avoid waste in the production. The determination of the gluten content and the amount of possible adulteration of flours can prevent the inadequate use of the flours and therefor will result in a more wholesome usage of the ingredients.

Disgusting or innovative? Consumer willingness to pay for insect based burger patties in Germany

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Objectives
In large parts of the world the human consumption of insects is part of the everyday diet. Insects represent an excellent source of food due to their density in unsaturated fatty acids, vitamins, and minerals, while the level of proteins is similar to conventional sources. In addition, the ecological benefits, which include lower emissions of greenhouse gases as well as lower resource use of land and water, during the production of insects in comparison to meat (Oonincx and de Boer, 2012; Lundy and Parella, 2015). Although, insect farming has several advantages, as compared to livestock, in most Western countries, the human consumption of insects is very low and often perceived culturally inappropriate. For this reason, and related to EU food safety regulations, it is currently not possible to purchase insect-based products in normal grocery stores in the EU. However, since the beginning of 2018, the new Novel Food Regulation by the European Union explicitly lists insects in the Novel Food Catalogue and allows authorization as foodstuffs after testing regarding health safety.
In this study, we analyze the preferences of German consumers for insect-based products to enrich the knowledge about specific consumer segments who are willing to adopt insects into their diet.

Methods
For this purpose, an online based choice experiment was conducted in 2016, in which respondents chose between an ordinary hamburger and a hamburger with a beef burger patty fortified with insect flour. An additional questionnaire attached to the online experiment allowed us to identify specific socio-economic and attitudinal characteristics of the respondents using a latent class model.

Results
Accordingly, the largest of three consumer groups (45%) is willing to consume insect-based hamburgers with an only small price discount of 0.47€, while the other respondents had a prohibitively high willingness-to-accept. The group of possible adopters is open towards new foodstuffs and is characterized by lower levels of disgust towards insects. Moreover, they have a high preference for sustainable low emission products and a healthy diet.

Conclusion
The results are in accordance with earlier studies from Germany (Hartmann et al., 2015) and the Netherlands (Verbeke, 2015), but our study is the first to provide willingness-to-pay estimates for an insect-based product for German consumers. The results enable the food industry to improve targeting of consumers and to design marketing tools for the different consumer groups.

Beyond Whole Cells and Dietary Supplements: Microalgae Protein Extracts as Techno-functional Ingredient in Foods

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Objectives
In foods microalgae are currently mainly used in two ways: (i) as dietary supplement, and (ii) as whole cells that are incorporated as value giving component. However, proteins from microalgae have shown to possess unique technofunctional properties in foods, which go beyond their nutritional value. For these reasons, this work presents a protein extraction process to obtain liberated proteins from the whole microalgae cells and technofunctional properties of the obtained extracts are shown in detail for three different microalgae: Chlorella protothecoides, Chlorella sorokiniana, and Phaeodactylum tricornutum.

Methods
A minimal processing approach was carried out to obtain protein extracts with a protein content of 37 – 39 wt%.

Results
The protein extracts showed an unusually high solubility in water in a broad pH-range (e.g. extracts of Chlorella protothecoides showed a solubility of >84 % in the pH-range 2 to 12), which might be useful in formulation protein-enriched foods at low pH-values. Moreover, promising emulsifying properties were obtained for proteins of Chlorella protothecoides and Chlorella sorokiniana, and therefore these proteins might act as novel natural emulsifier. Lastly, proteins of Chlorella sorokiniana acted as gelation agent, which is a unique property to structure viscous foods.

Conclusion
These results suggest that microalgae proteins are a highly functional food ingredient, which might be used in foods more often in the near future.

TOPIC C3: Sustainability advances for the production of high value food components

The contribution of food engineering to achieve global food security

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Objectives
One of the most pressing problems that the World Community will be exposed to will be the provision of sufficient food to the global population. Factors impeding global Food Security are the expected climate change and the growing world population. If the presently high losses in the food chain can be reduced, then the pressure on an expanding of food production can be released. The Food Engineering community has developed in the past a variety of solutions to reduce losses, to optimize processing and to exploit unconventional resources to produce food and feed. In this context especially, the utilization of solar energy must be mentioned. Of relevance is also the conversion of cellulose, hemicelluloses and lignin into edible products. The efficiency of food processing will also be improved by new packaging and distribution systems as well as the integration of the IT into processing and the exploitation of Engineeringomics. The development of the engineering toolbox to provide sufficient food to the growing world population must follow ecological and ethical guidelines. It should be paralleled by an education of the public regarding the handling and the use of food.

Methods
In practical terms the tense global food supply situation can be relieved by utilizing agricultural produce designated as feed for food production; utilizing of biomass for single cell protein-, insect-protein-, added-value-products-, and bio-fuel production. The formation of large population agglomerates will result in the development of new storage, packaging and transportation technologies together with new types of distribution and retail outlets and after all new types of food preparation. In Developing Countries conventional technologies improved by new technological advances will contribute to an improvement of the present situation e.g. the application of convective (solar-) drying, osmotic-drying, controlled atmosphere storage (CA-storage), solar energy powered refrigeration. Of relevance will also be the elimination of defective/contaminated material and the reduction of mycotoxin contamination.

Results
Considering the entire situation, the prospects of feeding the growing world population can be looked in a positive way.

Conclusion
The intellectual capacities of mankind and especially the knowledge base of the engineering community will be challenged and have to be used in a constructive way to ensure a safe global food supply.

Valorization of quinoa by-products after oil extraction with supercritical CO_2

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Objectives
Quinoa has recently been considered as an alternative oilseed crop due to the quality and quantity of its lipid fraction. Further to the lipids, quinoa presents other important components such as fiber, protein and minerals. Also, it is a gluten free raw material. Therefore, the defatted-quinoa flour could be considered as a potentially valuable material still useful for many uses. Alternatively, to the organic solvents, the supercritical fluid extraction (SFE) is used as a green process to extract high added value compounds from many different sources without solvent residues.
The objective of this work is to study the whole grain defatted-quinoa flour as the by-product of CO2 supercritical extraction of quinoa oil to evaluate its use in new food applications.

Methods
Different properties of starch granules of defatted-quinoa obtained after SFE was studied in order to know the great potencial that this by-product could have in food industry. The microstructure was evaluated by scanning electron microscopy, the crystallinity was assessed by X-ray diffraction analysis, and thermal and pasting analysis were done to study the gelatinization and retrogradation properties of starch granules of the defatted-quinoa. The starch digestibility was also studied measuring the rapidly digestible starch, slowly digestible starch and resistant starch by the in vitro Englyst method. All analyses were done in parallel with both a control whole grain quinoa flour and whole grain defatted-quinoa flour obtained from conventional Soxhlet extraction with hexane.

Results
After removal of quinoa oil from the raw material, the microstructure and some starch properties changed. Defatted-quinoa showed both higher retrogradation and rate of starch hydrolysis giving lower amount of slowly digestible starch fraction than the control whole grain quinoa flour.

Conclusion
These results suggest that defatted-quinoa flour obtained after SFE could be used in many applications as a valuable material. It keeps the most important properties despite of the lack of lipids. Concluding that other non-starch components such as fiber and protein contribute in a greater extent to physicochemical properties of whole grain quinoa flour.

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Biorecovery of antioxidants from apple pomace by supercritical fluid extraction

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Objectives
Reduction of food losses and by-products valorization is an important issue in food processing. Research over the past 20 years has revealed that many food wastes could serve as a source of potentially valuable bioactive compounds, such as antioxidants, vitamins and fibers with increasing scientific interest thanks to their beneficial effects on human health. In particular, industrial by-products derived from apple transformation are rich in antioxidants such as polyphenols. The recovery of phenolic compounds, using conventional or innovative technologies, represents an alternative for the valorization of apple by-products. Many studies demonstrate that conventional solvent extraction technologies show good recovery of polyphenols. However, solvent extraction has several drawbacks like the use of high amount of solvents, long extraction time and possible degradation of target compounds. In the last years, innovative green technologies have been proposed for the recovery of valuable compounds from fruit by-products, such as pressurized liquid extraction, supercritical fluid extraction, microwave assisted extraction and ultrasonic extraction. This work explored the potential of supercritical fluid extraction (SFE) to recover phenolic compounds and antioxidants from apple pomace.

Methods
SFE was carried out at 20 and 30 MPa and temperature of 45 and 55 °C in absence and presence of ethanol (5 %) as co-solvent. The results were then compared to those obtained by Soxhlet extraction with ethanol and boiling water maceration. All the extraction techniques were performed on fresh, oven and freeze dried samples. The extracts were characterized for their antioxidants capacity with different assays, such as the Folin-Ciocalteu, the 2,2-diphenyl-1-picryhydrazyl radical (DPPH) and a flow injection coulometry technique.

Results
The results showed that the extracts obtained from SFE, carried out on freeze dried apple pomace at 30 MPa and 45 °C for 2 h with ethanol (5%) as co-solvent, led to a higher antioxidant activity (5.63 ± 0.10 mg TEA/ g of extract) than conventional extraction technologies such as Soxhlet with ethanol (2.05 ± 0.21 mg TEA/ g of extract) and boiling water maceration (1.14 ± 0.01 mg TEA/ g of extract). The HPLC-DAD-MS analysis also confirmed the abundance of some phenolic compounds in SFE extract.

Conclusion
Overall, the study presented here is one of the first investigations to assess the impact of SFE for the extraction of antioxidants from apple pomace.

Assessing the sustainability of natural and artificial food colorants

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Objectives
Food producers thrive towards the satisfaction of today's consumers who demand natural, safe, and sustainable food products. Thereby, the application of food colorants is a major issue. In this article we aimed at giving insights in the evaluation of natural and artificial food colorants and revealed weaknesses within the value chain by use of a Hot Sport Analysis.

Methods
Implying red hues, natural, plant-based anthocyanin (E163) and lycopene (E160d), natural, animal-derived carmine (E120), and chemically synthesized Allura Red AC (E129) were chosen to cover all possible value chains. Three major metrics were identified being serviceability, ethnics and environment, and economics. The first combined all topics important for consumers such as health promoting or harming properties, consumers' attitudes, and the food colorants' inherent naturalness. The other two metrics considered producer and employees related topics. Working conditions, procurement of raw material, maximum yield obtainable from the sources, environment-friendly production, and exploitation of by-products were part of the second metrics. The last metrics consisted of the additives' convenience for application, its price, availability, sensory properties, shelf life, legal restrictions and labelling obligations, and stability within the food matrix.

Results
Applying the indicators on the four food colorants, the natural, plant-derived colorant anthocyanin was found to be more sustainable than the natural, animal-derived colorant carmine, the natural, plant-derived colorant lycopene, and the artificial colorant Allura Red AC. Major Hot Spots during the production of natural food colorants were the low raw material exploitation, the lack of environment-friendly production as well as impurities and further residues in the food colorant formulations. Food colorant preparations from natural pigments are burdened with short shelf life, unfavorable sensory properties, and limitations during the application in food products due to chemical and physical hindrances. To overcome these Hot Spots novel sources could be valorized, extraction processes improved, and stabilizing agents applied to produce more convenient preparations.

Conclusion
In conclusion, natural, plant-derived food colorants enable the production of consumer-friendly and sustainable products. Weaknesses during production, formulation, and application of the respective additives may be revealed by the presented Hot Spot Analysis.

Protein extraction via pulsed electric field (PEF) treatment of microalgae Chlorella vulgaris for food and feed applications

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Objectives
Microalgae are currently being discussed as a source of protein as well as a renewable source of energy for the growing world population. In order to extract proteins from biological cells it is usually necessary to mechanically disrupt them. An alternative to these mechanical approaches is to apply pulsed electric fields (PEF).

Methods
PEF-treatment permeabilizes the cell membrane and allows proteins to exit the cell. The extraction efficiency is lower compared to mechanical disruption methods, but the biomass separability is maintained since the morphology of the cells barely changes whereas with mechanical disruption methods, a lot of cell debris is created which needs to be separated from the extract. This allows PEF-treatment to be embedded in a biomass fractionation process in which proteins and oils can be extracted sequentially and separately. With high pressure homogenization (HPH) for instance, the protein fraction and lipid fraction are scrambled together and form an emulsion. Separating proteins and oils from this extract is more challenging and demanding.

Results
In our experiments using the microalgae Chlorella vulgaris we observed that proteins are leaking out of the PEF-treated cells in a time-dependent manner. The progress and kinetics of this leakage is dependent on the biomass concentration and the incubation temperature: the higher the biomass concentration is, the lower the extraction efficiency becomes. This is a clue for a chemical gradient that is also influenced by temperature. We determined that there is an extraction optimum around 30°C, but at extreme temperatures (cold, 4°C; hot, 50°C) the extraction yield was significantly worse. This is a clue for a biological, enzyme-regulated process within the PEF-treated biomass that facilitates release of proteins from the cells. The inhibitory effect of these non-physiological temperatures can be mimicked at room temperature by incubating the PEF-treated biomass with protease inhibitors. Furthermore, we observed that incubation in 0.1M NaOH after PEF treatment also yielded a lower extraction efficiency than simply incubating the biomass in its culture medium or water. It seems that extreme pH is also having a rather negative effect on the extraction yield.

Conclusion
In summary our results suggest that PEF-assisted protein extraction should be done under physiological conditions (no extreme temperatures, no extreme pH), which has important implications for up-scaled industrial processes.