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Autor: Knorr, Dietrich

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Food processing: Paving the way for sustainable nourishment

Dietrich Knorr*

«Essen muss der Mensch» (We all have to eat)
Franz Grillparzer, Austrian writer 1791–1872

1. History and role of food processing

According to the interactive, infographic World Food Clock (Thomson 2014) globally we eat 11.5 million pounds (approx. 5,150 t) of food every minute. In Switzerland the average dietary energy consumption (2006–2008) was 14,430 kJ. Considering that two thirds of the expected world population of up to 10 billion people will be living in mega cities, proving adequate, safe and nutritious food for all will be a tremendous challenge.

The oldest food processing tools known are 2.6–2.1 million years old and food processing has progressed through the ages from the use of fire, pickling, fermentation, drying, freezing and packaging to today's 3D printing and cultured meats.

The need for food processing, to convert often non-edible raw materials into digestible, safe and tasteful foods, as well as the necessity of preservation to retain food, to increase palatability, transport stability and convenience have been demonstrated convincingly. Recently there has been increased attention to fresh, green, tasty, healthy and sustainable foods generated with minimum impact on the environment.

Whilst traditional thermal processing has advantages such as resulting food safety, flavor and texture generation it often destroys heat sensitive nutrients. The development of gentle (the German word "schonend" would be more accurate) processes was originally initiated with the development of the hurdle concept for meat products. The concept is based on a combination of microbial reduction steps (pH, water activity, antimicrobial agents…) which in sum lead to an effective inactivation of vegetative microorganisms.

Interestingly, Pueyo (2020) in a popular publication entitled "Coronavirus: the Swiss cheese strategy" suggested 4 layers of defense against SARS-CoV-2 which are like slices of Swiss cheese with individual holes the virus can penetrate but in sequence and together they form an impenetrable defense as we have been using in food processing with the hurdle concept since the 1970s.

In addition, new processing tools and concepts have been applied such as high hydrostatic pressure, pulsed electric fields, ohmic heating, pulsed light, cold atmospheric plasma etc. The scientific basis provided led to industrial applications especially for high-pressure pasteurization and pulsed electric fields membrane permeabilization (Sevenich et al 2021, Barba *et al.*2020). In addition, high-pressure–high-temperature processes and electric-field–high-temperature processes, high-pressure homogenization, low-energy and high-energy electron-beam processes for bacterial spore inactivation have been developed and related mechanism revealed (Reineke and Mathys 2020).

Further, in order to generate consumer-guided food processing systems, the PAN concept (adapting food processes to the Preference, Acceptance and Needs of consumers rather than adapting raw materials to the requirement of processing) as well as the Process – Structure -Property model (generation of specific food structures *via* targeted processing to achieve tailor made foods for specific consumer requirement) have been presented (ETP 2007).

* Technische Universität Berlin, Department of Food Biotechnology and Food Process Engineering, Königin-Luise-Str. 22, 14195 Berlin, Germany.

E-mail: *dietrich.knorr@tu-berlin.de*
Web: *www.foodtech.tu-berlin.de*

Dietrich Knorr, Dr. rer. nat. techn., received his Engineering (Dipl.-Ing.) Degree and doctoral degree in Food and Fermentation Technology from the University of Agriculture in Vienna in 1974. Research Associate at the Department of Food Technology in Vienna, Austria; Visiting Scientist at the Western Regional Research Centre, USDA, Berkeley, USA; Cornell University, Ithaca, USA; Associate Professor, Full Professor, Department of Food Science, University of Delaware, USA. Full Professor and Head of Department Food Biotechnology and Food Process Engineering and Director of the Institute of Food Technology and Food Chemistry, Technische Universität Berlin, DE; Research Professor University of Delaware, Adjunct Professor Cornell University. Now Professor emeritus and visiting professor, Technische Universität Berlin. President of International Union of Food Science and Technology; President European Federation Food Science and Technology; Member of the German Research Foundation Senate Committee for Food; Scientific Advisory Boards: Agropolis Fondation, Montpellier, F; TEAGSC, Irish Agriculture and Food Development Authority, IE; International Life Science Institute Europe), Brussels; European Technology Platform: Food for Life, ICAA Brussels. Chair working group Food, European Federation Chemical Engineering and EU PhD Workshops on Food Engineering and Processing. Coordinator and member of numerous national and international research projects. Committee member or chair of academic program reviews, industrial research centers, granting agencies and national academies.
Editor of the Journal "Innovative Food Science and Emerging Technologies", co-editor "Frontiers in Nutrition: Nutrition and Food Science Technology". Various international Lifetime Achievement Awards (EFFoST, ASABE, IFT, IAEF). ISI highly cited scientist.

Despite all these efforts and processing achievements there are continuing negative perceptions towards processed foods, and more unbiased views are required on the role of food processes for food safety and security and on the role which food processing plays and can play for sustainability development. These needs have been intensified by the occurrence of a new food classification system despite all the existing and sophisticated ones such as the EPIC, Foodex, Langual. The proposed NOVA classification and the creation of an ultra-processed food category are unfortunately based on a lack of understanding of food processing and a subsequent confusion between food formulation and food processing (Knorr and Watzke 2019, Knorr and Augustin 2020).

This clearly stresses the need for improved consumer information and education as well as of open, scientific and rational debates within the food and nutrition scientific community.

2. Future processing potential and needs

The benefits of thermal processing as well as those of emerging, mostly ambient-temperature processes have been discussed extensively (van Boekel *et al.* 2010, Barba *et al.* 2020, Sevenich *et al.* 2021).

For example, retention of valuable food constituents (e.g., the retention of the antimicrobials lacto-peroxidase, lysozyme, lactoferrin in raw and mother's milk while inactivating vegetative pathogenic microorganisms), health-related benefits such as reduction of allergens, reduced fat uptake, higher secondary plant metabolites recovery, or reduction of food contaminants (e.g., furan, acrylamide) have been achieved (Barba *et al.* 2020, Sevenich *et al.* 2021).

Historically, food materials have been identified and selected based on their safety and edibility prior to or after thermal processing or fermentation. Emerging technologies can have different modes of action (e.g., activation volume for hydrostatic pressure which affects only non-covalent bonds in relevant domains), and the selection of new food raw materials becomes possible. In addition, the combination of processes such as emerging technologies with existing thermal or non-thermal processes offers a broad spectrum for new process development.

The collaboration of food scientists, biotechnologists, environmental scientists and medical scientists around one technology (pulsed electric fields) offers an impressive example for the potential of an emerging technology *via* inter-disciplinary collaboration (Miklavcic 2017). The use of moderate high-pressure treatment of probiotic organisms for stress protein induction and thus allowing more sustainable preservation processes for probiotic starter cultures is another one (Ananta *et al.* 2003).

Barabasi *et al.* (2020) recently reported that only a small portion of our food constituents has been characterized so far, demonstrating the shortage of data available for food processing. More knowledge regarding these compounds including their interactions during different processing steps is necessary.

High-pressure modification of proteins and gelatinization of polysaccharides at ambient temperatures (cold cooking) on food digestibility in comparison with traditional thermal processing is another example of an existing knowledge gap looking for answers.

Emerging technologies per se need to be better understood for appropriate use and future work on mechanisms and kinetics (e.g., microbial inactivation, stress responses of treated foods or constituents). Clear definitions and descriptions of processes for consumer acceptance and sufficient description of critical process variables for process validation are also necessary.

The COVID-19 pandemic drastically demonstrates the continuous need for food safety although luckily so far no direct food-related SARS-CoV-2 contaminations are known (Anelich *et al.* 2020). Increasing concern and demands for more knowledge related to viral inactivation through food processing are foreseeable (Hirneisen *et al.* 2010).

3. Sustainable food processing

The most likely first individual to report a need for sustainability ("nachhaltige Nutzung"), the lasting utilization of future resources, was H.C. von Carlowitz in 1713. Sustainability discussions were intensified in the 1970s and 1980s. Numerous, often vague and conflicting definitions have been put forward; the one developed for the Bruntland Report (WCED 1987) remains valid:

Sustainable development is development that meets the needs of the present without compromising the ability of future generations to meet their own need.

The UN Sustainable Development Goals were launched in 2015 with up to 12 of the 17 being food related, stressing once again the importance and responsibilities of the food and nutrition community. Besides the absence of a globally accepted definition for sustainability there is also a lack of accepted sustainability indicators. The use of different sustainability indicators and methodologies may lead to different conclusions and actions among stakeholders on the choice of indicators and targets for performance.

Chaudhary *et al.* (2018) developed a concept based on 25 sustainability indicators across 7 domains with food safety, nutrient adequacy, wellbeing, waste and loss reduction, ecosystem stability, resilience, affordability and availability which present a basis for international scientific debates.

Emerging technologies have been and are being developed on the basis of low resource consumption (water, energy, minimum waste generation) and can play an important role in future sustainable process development (Knorr *et al.* 2020).

As for Switzerland, the national research program project (NRP69) entitled "Healthy Diets from a Sustainable Food Production System" and the running NRP73 project on "Sustainable Economy" can be seen as a first step towards future national inter-disciplinary sustainable food systems activities. In addition, the ETH Zurich World Food Systems Centers Research Funds were a unique concept for also integrating retailers in sustainability research, and the initiation of a professorship for Sustainable Food Processing at ETH Zurich is a timely and forward-looking approach.

4. Food chains and webs

The most widely used way to view the food value system is *via* a linear approach. This is based on the earliest origins from naturalists in the later 1600s with significant negative effects on the environment. The current food chains include trade, production, processing, retail, preparation, consumption, losses and waste with transport, storage and water use between these steps.

Various concepts have been suggested for describing the reality of global and highly complex food systems. The development of inter- and intra-connected food models to circular food systems including resources (water, energy, environment, air, supplies & materials, transport & storage) and the inclusion of the above-mentioned food chain connections and sustainability indicators stress the multi-dimensionality, non-linearity and interconnections of food systems (e.g., regional). This seems a worthwhile step towards resilient food system approaches.

5. Global issues

COVID-19. SARS-CoV-2 has an extraordinary impact on almost every part of our societies including research and development. Consequently, we need to ask ourselves whether the existing food systems are capable to resist a continuing pandemic. Besides the disruption on national and international food suppliers, guest workers, restaurants, food processing operations and consumers, acute hunger was estimated to double by the end of 2020 with 370 million children with no access to school lunches (often the only food for the day) due to national lockdowns. COVID-19 is also changing where, how and what consumers consume including the purchase of more packaged food, home deliveries or take-outs and home cooking. This raises hope that amidst the pandemic, higher appreciation for food, its safety and its value as well as its health and wellbeing implication might emerge. Creation of clear global food safety requirements, of food traceability tools, designing alternative concepts to the existing just-in-time availabilities and coming-from-nowhere food systems, recognition of the need for behavioral changes of all stakeholders as well as increasing self-sufficiency for food and food supplies may be steps towards a resilient exit strategy (Anelich *et al.* 2020, Knorr and Khoo 2020).

Water. One of the key safety and hygiene recommendations during the COVID-19 pandemic is washing hands. However, in many parts of the world this is not possible due to the lack of water. Assuring safe supplies will be one of the ongoing key responsibilities, especially when considering that most of the 17 UN SDGs currently cannot be met. Cheap and reliable water purification units are urgently needed.

Urban planet. The increasing urbanization of our planet will require a radical change of the existing food systems such as increased creations of closed-loop systems. Recirculation of food wastes/losses and water, highly flexible, appropriate scale and local food processing equipment (de Vries *et al.* 2018), accounting for dietary changes and requirements in urban communities and related delivery and low energy food preparation tools will become essential.

Consumer trust. In addition to all these challenges and the continued needs for improved food safety and security, for sustainability and climate change, regaining consumer trust in our food will be of prime importance (Siegrist and Hartmann 2020, Meijer *et al.* 2020). This requires the building of inter- and trans-disciplinary approaches with multi-stakeholder engagement.

6. Conclusion

Summarizing the key global requirements and needs for food science and technology, seven missions have been identified: novel raw materials, changes in process and system engineering, waste reduction, product safety and traceability, approaches to better health, hidden hunger, and digital technologies (Lillford and Hermansson 2020).

Our science bases for food, food processing technologies, the interaction between food constituens during and after food processing (including food preparation), the consequences to human health and wellness and to the related environment need continuous improvements. This will require dealing with uncertainties. Gibney *et al.* (2020), tackling uncertainties in nutrition research, stated: "In many areas of science, ranging from nutrition to climate change, we must live with imperfect data." This awareness of uncertainty should be expanded to our entire food system and, as Novotny (2016) put it: "Embracing uncertainty and entering into collusion with its cunning remains an open ended process". ■

References

Ananta, E., Birkeland, S.E., Corcoran, B., *et al.*: Processing effects on the nutritional advancement of probiotics and prebiotics. *Microbial Ecology in Health and Disease* 16, 2003. *DOI:10.1080/08910600410032277*

Anelich, L.E., Lues, R., Farber, J-M., and Parreira,V.R.: SARS-CoV-2 and risk to food safety. *Front. Nutr.* Nov.02–2020. *https://doi.org.3389/fnut.2020.58055*

Barabasi, A.-L., Menichetti, G., and Loscalzo, J.: The unmapped chemical complexity of our diet. *Nature Food* 1, 2020, 33–37. *www.nature.com/natfood*

Barba, F.J., Wiktor, A., and Parniakov, O.: Pulsed Electric Fields to obtain healthier and sustainable food for tomorrow. Academic Press, 2020. ISBM: 978–0–12–81640–20, eBook ISBN:9780128172643.

Chaudhhary, A., Gustafson, D., and Mathys, A.: Multi-indictor sustainability assessment of global food systems. *Nature Comm.* 6, 2019, 848. *https://doi.org/10.1038/s41597-019-0301-5*

De Vries, H., Mikolajczak, M., Salmon, J-M., *et al.*: Small-scale food process engineering-challenges and perspectives. *Innovative Food Sci. & Emerging Technol.* 46, 2017, 122–130. *DOI: 1016/j.ifset.09.009*

ETP: European Technology Platform: Food for Live. Strategic Research Agenda 2007–2020. CIAA, Brussels, 2007.

Gibney, M., Allison, D., Bier, D., and Dwyer, J.: Uncertainty in human nutrition. *Nature Food* 1, 247–249. *www.narure.com/natfood*

Hirneisen, K.A., Black, E.P., Cascarino, J.L., *et al.*: Viral inactivation in foods: A review of traditional and novel food processing technologies. *Comprehensive Rev. Food Sci. & Technol.* 9, 2010, 3–20.

Knorr, D., and Augustin, M.A.: Food processing needs, advantages and misconceptions. *Trends in Food Sci. & Technol.* 108, 2021, 103–110. *https://doi.org/10.1016/j.tifs.2020.10.026*

Knorr, D., and Khoo, C.S.: COVID-19 and food: Challenges and research needs. *Front. Nutr.* Oct.-08–2020. *doi: 10.3389/fnut.2020.598913*

Knorr, D., and Watzke, H.: Food Processing at a Crossroad. *Front.Nutr.* 6, 2010, 85. *doi: 10.3389/fnut.2019.00085*

Knorr, D., Augustin, M.A., and Tiwari, B.: Advancing the role of food processing for improved integration in sustainable food chains. *Front. Nutr.* 7, 2020, 34. *doi: 10.3389/fnut.2020.00034*

Lillford, P, and Hermansson, A-M.: Global missions and the critical needs of food science and technology. *Trends in Food Sci.& Technol.* Online 05–13–2020. *https://doi.org/10.1016/j.tifs.2020.04.009*

Meijer *et al.*: Crit. Reviews Food Sci. & Nutr.6, 2021, 1, 97–115. published online 31 January, 2020. *https://doi.org/10.1080/10408398.2020.1718597*

Miklavcic, D. (Ed.): Handbook of Electroporation. Springer, Berlin, Heidelberg, 2017.

Novotny, H.: The Cunning of Uncertainty. Polity Press, Cambridge, 2016.

Pueyo, T.: Coronavirus: The Swiss cheese strategy. tomaspueyo.medium.com/coronavirus. Updated Nov. 8, 2020.

Reineke & Mathys: Annual Review in Food Science & Technology, 2020,11, 255–74. *https://doi.org/10.1146/annurev-food-032519-051632*

Sevenich, R., Rauh, C., and Knorr, D.: Overview of research needs, future and potential applications of high pressure processing. In: Knoerzer, K., and Mutukumarappan, K. (eds.): Innovative Food Processing Technologies: A Comprehensive Review. P.1–48. Elsevier, NY, 2020.

Siegrist, M., and Hartman, C.: Consumer acceptance of novel food technologies. *Nature Food* 1, 2020, 343–350. *www.nature.com/natfood*

Thomson, J.R.: The world consumes more than 11 million pounds of food every minute of every day. World Food Clock by White Vinyl Design, The Huffington Post, updated March 24. 2014.

Van Boekel, M., Fogliano, V., Pellegrini, N., *et al.*: A review on the beneficial aspects of food processing. *Molecular Nutrition and Food Research* 54(9), 2009, 1215–1247. *https://doi.org/10.1002/mnfr.200900608*

WCED: World Commission on Environment and Development. Our Common Future. Oxford University Press, Oxford, 1987.