Volumetric preservation technologies for food quality improvement by retention of sensitive and mitigation of neoformed compounds (VolTech) – CORNET –

Coordination:	Forschungskreis der Ernährungsindustrie e. V. (FEI), Bonn (Research Association of the German Food Industry)
National Agencies:	AiF – German Federation of Industrial Research Associations, Cologne/Germany
	MPO – Czech Ministry of Industry and Trade, Prague/Czech Republic
	FFG – Austrian Research Promotion Agency, Vienna/Austria
Research Associations:	RFC – Regional Food Cluster, České Budějovice/Czech Republic
	GLi – Gemeinnützige Lebensmittelinitiative für Österreich Ltd., Linz/Austria
Research Institutes:	Technical University Berlin, Institute of Food Technology and Food Chemistry, Department of Food Biotechnology and Food Process Engineering, Berlin
	University of Natural Resources and Life Sciences (BOKU), Institute of Food Technology, Department of Food Science and Technology, Vienna/Austria
	University of Chemistry and Technology (VSCHT), Department of Food Chemistry and Analysis, Prague/Czech Republic
Industrial Branch:	Food Processing and Packaging Machinery
	Food and Drink Industry
Duration:	2017 - 2020
Volume:	€ 640.735,-- (total)

Initial Situation

Conventional heating and thermal preservation reach their limits, particularly in the case of highly viscous and lumpy foods. In order to achieve appropriate core temperatures, longer heating times must be applied. This leads to an over-processing of the outside areas and thus to loss of quality (degradation of aroma, texture and color as well as formation of heat-induced food process contaminants). This results in long processing times and a higher energy requirement.

Therefore, food manufacturers are looking for new ways to produce food more gently without neglecting the food safety. The food produced in this way should be microbiologically safe, tailored to the consumer needs and have a long shelf life. One way to achieve this aim is to use high hydrostatic pressures in the range of 600 MPa at room temperature (HPP) or at temperatures above 100 °C (HPTS) (high-pressure pasteurization or sterilization). Another technology that leads to heat generation directly in the product is so-called ohmic heating. Here, the heat conduction from the outside is no longer the limiting factor, and the product can be heated quickly and evenly. Although both technologies (HPP and ohmic heating) are already implemented in the food industry, there are still significant scientific and technical questions regarding these technologies that remain unanswered. The influence of intrinsic and extrinsic factors during high pressure treatment or ohmic heating on microorganisms, spores, valuable ingredients, flavors/ aromatics and food process contaminants (such as furan, monochloropropanediol esters etc.) is primarily unknown.

The aim of the research project was to clarify the influence of these factors.

Research Results

For all tested products within the project it was possible to show the desired inactivation levels (-6 or -12 log_{10}) could be achieved by high-pressure processing (HPP; 600 MPa, 20 °C, laboratory scale 0,75 L) and high-pressure sterilization (HPTS; 600 MPa, 110-121 °C, laboratory scale 2 ml) under gentler conditions and shorter process times compared to the thermal industrial reference process (TIRP). Optimal process windows could be determined for all products based on the inactivation or by keeping food safety priority number one. The product groups examined can be categorized into liquid foods (sea buckthorn juice and milk), semi-solid foods (fruit, vegetables and a vegetable-meat-rice puree) and solid foods (cucumber, red pepper, chives, parsley and a strawberry-based dessert).

Liquid foods:

Sea buckthorn juice: It could be shown that sea buckthorn juice is stable for two weeks at 8 °C after a treatment with high pressure (600 MPa, 4 min). The color of the juice hardly changed in comparison to the thermal process (87 °C, 20 min). The nutritional value (Vit C, carotenoid, tocopherol content, TPC or TAA) remained unchanged for HPP and the thermal treatment. An "untargeted chemical fingerprinting" approach revealed that the flavonoid spectrum (due to the presence (HPP) or absence (ohmic heating, thermal treatment) of enzymatic activity) showed differences depending on the treatment. The flavonoids in sea buckthorn juice (also in other juices in which the substances are found) could serve as a chemical marker and thus verify the treatment history as a so-called metabolomic. Within the sensory analysis the high-pressure juice was selected by the panel as the best.

Milk: After a treatment for 8 minutes at 600 MPa, the milk was stable at 8 °C for 2 weeks. The measured values of vitamin D in the untreated milk corresponded to those values found in the literature. Furthermore, no decrease in the vitamin content depending on the tested processes could be found. The color and taste of the milk (especially the absence of the cooking flavor) was superior to the thermally treated milk after HPP.

Semi-solid foods:

The two fruit and vegetable purees (apple-banana-blueberry (ABBA) and carrot-apple-pear (CAP), both pH ≤ 4,5) were pasteurized using HPP. The optimal process window for ABBA was 3 min and for CAP 4,5 min at 600 MPa. The loss of ascorbic acid for both products was between 2-4 % compared to the untreated sample (thermal 12-44 % depending on whether sterilization or pasteurization). Carotenoid content, color (HPP: Δ E = 1-2, thermal: Δ E = 3,5-7) and texture of the products were significantly closer to the untreated sample.

The optimal process parameters for HPTS of the **vegetable-rice-meat-puree** (GRFB) to achieve a sterile product were 600 MPa for a treatment time of 5-10 min at temperatures between 110-116 °C. This was verified by an accelerated storage test. The color (HPTS: Δ E = 2, TIRP Δ E = 4,3), texture and carotenoid content (loss HPTS: ~ 6 %; loss TIRP: 14 %) of the products were closer to the untreated product. The analysis of furan (also 2- and 3-methylfuran and 2,5-dimethylfuran) and acrylamide showed no formation under HPTS conditions. In comparison, large amounts of furan and especially 2,5-dimethylfuran were formed under thermal conditions. By applying HPTS the toxicological potential of the food can be mitigated. Since the product is also feasible as a baby food, the reduction of these carcinogenic compounds for this sensitive consumer group could be quite important.

For liquid and semi-solid foods it should be noted that HPP or HPTS treatment can lead to a safe product in the first place, but the product outcome is superior to the thermal product in terms of its sensory and nutritional properties. A scale-up of HPP (300 L system) and HPTS (4 L system) showed that the results achieved on a laboratory scale could be verified at an industrial scale.

Solid foods:

Strawberry-based dessert: Three different hydrocolloid combinations (pectin, starch and pectin starch) with strawberry and sugar were tested for their high-pressure applicability. Durability, syneresis, texture and color changes were examined. HPP for 8 minutes at 600 MPa lead to a safe and high-quality product. The most suitable mixture compared to thermal treatment (in terms of microbiology, texture, syneresis and color) would be the starch-strawberry mixture, followed by the pectin-starch-strawberry mixture.

Red pepper, cucumber, chives and parsley: The treatment of herbs and vegetables with HPP is always associated with a loss of texture. This trend was also observed for the tested products within the project. The natural flora of microorganisms on red pepper, chives and cucumber were completely inactivated with HPP at 600 MPa for 5 minutes. This was not possible with parsley, since 3 * 10^3 CFU/g could not be inactivated after 600 MPa, 10 min. This remaining population were spores which cannot be inactivated by this process respectively the parameter combination. Texture, color measurement and the impedance measurement showed that HPP lead to strong losses of color and texture compared to the thermal process. An inactivation of enzymatic activity resp. enzymes was not possible since the desired inactivation of 100 % could not be reached for any product. Since the fresh product was chosen as reference product, it should be noted that HPP is not a suitable process to produce fresh-like herbs and vegetables.

High pressure as pasteurization or sterilization offers the possibility for high quality or heat sensitive products to maintain the quality of the product with the same level of safety.

Economic Impact

Both high-pressure treatment and ohmic heating are innovative process technologies that could be used in a wide range of business sectors. These, especially for small and medium enterprises, open a wide range of possibilities and give them the opportunity to cover niches with highly innovative products. This is particularly true for companies that are producing ready to eat meals, dietary supplements, dietetic foods, baby food or fruit juices.

The application of the two technologies could lead to an improvement in the quality of certain products regarding toxicology, bacteriology as well as the nutritional, sensory and olfactory properties of the food. At the same time the results of the project could open new sales markets for high-pressure and ohmic heating systems and the possibility of integrating these technologies into existing process lines. The project could help to improve the competitiveness of both German food and their cooperating system manufacturers on local and international markets.

Publications (Selection)

1. FEI-Schlussbericht 2020.
2. Aganovic, K., Hertel, C., Vogel, R. F., Johne, R., Schlüter, O., Schwarzenbolz, U., Jäger, H., Holzhauser, T., Bergmair, J., Roth, A., Sevenich, R., Bandick, N., Kulling, S. E., Knorr, D., Engel, K.-H. & Heinz, V.: Aspects of high hydrostatic pressure food processing: Perspectives on technology and food safety. Compr. Rev. Food Sci. Food Saf. 20, 3225–3266, doi: 10.1111/1541-4337.12763 (2021).
3. Gratz, M., Sevenich, R., Hoppe, T., Schottroff, F., Vlaskovic, N., Belkova, B., Chytilova, L., Filatova, M., Stupak, M., Hajslova, J., Rauh, C. & Jaeger, H.: Gentle Sterilization of Carrot-Based Purees by High-Pressure Thermal Sterilization and Ohmic Heating and Influence on Food Processing Contaminants and Quality Attributes. Front. Nutr. 8, 643837, doi: 10.3389/fnut.2021.643837 (2021).
4. Sevenich, R., Rauh, C., Belkova, B. & Hajslova, J.: Effect of high-pressure thermal sterilization (HPTS) on the reduction of food processing contaminants (e.g., furan, acrylamide, 3-MCPD-esters, HMF). In: Present and Future of High Pressure Processing, Elsevier, 139–172 (2020).

Further Information

Technical University Berlin
Institute of Food Technology and Food
Chemistry
Department of Food Biotechnology and Food Process Engineering
Prof. Dr. Cornelia Rauh/Dr. Robert Sevenich
Königin-Luise-Straße 22, 14195 Berlin/Germany
Phone: +49 30 314-71254
Fax: +49 30 832-7663
E-Mail: cornelia.rauh@tu-berlin.de
E-Mail: r.sevenich@tu-berlin.de

Research Association of the German Food Industry
GFPi/FEI EU-Office
Dr. Jan Jacobi
47-51, Rue du Luxembourg
B-1050 Brussels/Belgium
Phone: +49 172 2643357
Fax: +32 2 2820841
E-Mail: gfpi-fei@bdp-online.de

University of Natural Resources and Life Sciences (BOKU)
Institute of Food Technology
Department of Food Science and Technology
Prof. Dr. Henry Jäger/Dr. Felix Schotroff Muthgasse 18, 1190 Vienna/Austria
Phone: +43 147 654 75 233
Fax: +43 147 654 75 009
E-Mail: henry.jaeger@boku.ac.at
E-Mail: felix.schottroff@boku.ac.at

University of Chemistry and Technology (VSCHT)
Department of Food Chemistry and Analysis,
Prof. Dr. Jana Hajšlová/Dr. Monika Tomaniova
Technická 5, 16628 Prague/Czech Republic
Phone: +420 2 2044 3185
Fax: +420 2 2044 3890
E-Mail: jana.hajslova@vscht.cz
E-Mail: monika.tomaniova@vscht.cz

Funding reference

… ein Projekt der ***Industriellen Gemeinschaftsforschung (IGF)***

gefördert durch/via

Bundesministerium für Wirtschaft und Energie
aufgrund eines Beschlusses des Deutschen Bundestages

Forschungsnetzwerk Mittelstand

FORSCHUNGSKREIS DER ERNÄHRUNGSINDUSTRIE E.V.

Das o. g. IGF-Vorhaben der Forschungsvereinigung Forschungskreis der Ernährungsindustrie e. V. (FEI), Godesberger Allee 125, 53175 Bonn, wird/wurde über die AiF im Rahmen des Programms zur Förderung der Industriellen Gemeinschaftsforschung (IGF) vom Bundesministerium für Wirtschaft und Energie aufgrund eines Beschlusses des Deutschen Bundestages gefördert.

Status Date: 11. Oktober 2022