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Scientific basis for high pressure/thermal food processes

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Abstract
Research needs are identified, and an overall strategy is presented for establishing a scientific basis for assessment, design and optimization of processes combining high pressure and moderately high temperatures (HP/T). In an initial phase, the kinetics is studied of HP/T induced changes in relevant food aspects. The kinetic knowledge obtained is indispensable to the development of a terminology and methods for quantitative HP/T- process assessment. At its turn, quantitative process assessment enables process design and optimization. Also self-life studies, and studies of the performance of HP/T-equipment, rely on the terminology and methods developed.

Keywords: Scientific basis for high pressure, thermal food processes

Introduction
It is now a day's an established fact that preservation by high pressure (HP) between 1 to 10 kbar, can offer major advantages over the other available methods. HP can inactivate microorganisms and enzymes, while it only slightly affects nutritional and sensorial quality aspects of food [1, 3, 6, 9, 10]. This responds to the consumer demand for fresh like products. However, the industrial breakthrough of HP for preservation, like that of other novel technologies, will be delayed if there is no scientific basis for ascertaining the reliability, for fulfilling necessary safety requirements and consumer quality demands. A study of the literature reveals that a tremendous amount of work remains to be done in this aspect [2].
Since it is probable that the most safe and economically feasible use of HP in food preservation will be in combination with moderate temperature elevation (HP/T), the discussion in this paper is conducted with a view to HP/T –processes.

Kinetics of HP/T- induced changes in food aspects
The kinetics of HP/T- induced changes is indispensable information to any quantitative or engineering approach. Although there is rather large volume of literature on HP effects on microorganisms and bio-macromolecules, only part of these works are related to food aspects, few contain data that allow the determination of kinetics, and even fewer have a discussion of results in quantitative kinetic terms [2]. Farr [3] and Cheftel [1] have summarized the actual knowledge on HP effects on several food safety and quality aspects. Knorr [7] presents a more specific review on food microorganisms. On the effects of HP on proteins in general, there are some extensive and in-depth reviews e.g. [5, 8]. These are focussed on thermodynamics, equilibrium and mechanistic aspects and contribute largely to the elucidation of underlying mechanisms, but do not contain data directly useful with a view to preservation applications on foods. Chemical aspects of food treatment with HP are reviewed by Tauscher [10].
The study of kinetics implies model fitting and determination of kinetic parameter values like reaction order, rate constant, activation energy, activation volume, and lag phase. Initially, model systems are studied, i.e. starting from a purified isolate of the examined subject, and with fully characterized media. This approach allows attributing observed changes in kinetics to known and controlled variations in experimental conditions, and reduces analytical difficulties. Later, increasingly complex systems are studied, including real food materials.

Process of impact assessment
Up to date, there is no mention of a concept, terminology or method for quantitative HP/T – process impact assessment in the available literature. However, this is indispensable to fulfil safety requirements as well as consumer quality demands.
A straightforward approach to the development of such terminology and methods is to follow the lines of the existing terminology and methods for classical thermal (HT) process impact assessment.

This means the "extrapolation" of the equivalent time concept (F), the physical mathematical method and the development and use of process history integrators from the HT-area (4) to the HP/T-area. In the physical-mathematical method, a process impact is calculated from the process history, i.e. the process variables as a function of process time. With a process history integrator, the process impact is calculated from the integrator response before and after the process. Such integrators are not yet available and needs to be developed.

Equipment performance studies

On the processing equipment side, insight in the performance in terms of process impact uniformity and process repeatability is indispensable with a view to scaling-up and future design.

The question of process repeatability is to what extent a time-T-P profile can be reproduced in subsequent runs with the same settings of desired time, T and P. Hence, this a matter of control and accuracy of HP equipment.

The question of uniformity is to what extent there is a spread in the process impact at different locations in a HP vessel. Again, one can refer to an analogues problem in the thermal preservation area, i.e. thermal penetration and distribution. In principle, a spread in HP/T-process impact can arise from variations in P and/or T with respect to time and/or position. Variations of P with position are avoided when working with hydrostatic pressure, this is pressure transmitted by a liquid medium. The main variations will most probably be in T with respect to time, as a consequence of adiabatic heating [2].

The influence of factors like the P-transferring liquid, the P build up velocity, the vessel dimension (volume/surface area) is examined.

These studies rely on the newly developed concept and methods. The studied process impact is expressed in terms of the concept developed, and both the physical-mathematical method and process history integrators are used for determining the process impact value.

Shelf life studies

To date, there is no basis to predict the shelf life of pressurized products. The long-term post-pressurization behaviour of relevant food aspects needs to be studied. This includes resuscitation of sub-lethally injured microorganisms, outgrowth of super dormant spores, regeneration of enzyme activity, changes in structural properties, generation of off-flavours, and propagation of HP/T-initiated reactions.

In this study, samples are submitted to a HP/T-treatment that is quantitatively characterized using the newly developed concept and methods, then stored in controlled conditions, and monitored for weeks or months.

Analogously to the approach of the kinetic studies discussed above, model systems are used before the more complex systems like real food materials.

Process optimization

It is observed that HP is usually less detrimental to the nutritional and sensory quality than HT. However, since HP will most probably be combined with moderate heat for preservation, optimization studies are needed to enable maximum quality retention within the constraints of legislative safety requirements. The procedures and programmes developed are formulated in terms of the newly developed concept and terminology.

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