2 Executive Summary

The research strategy of the Controlled Release" project is summarized by "... structure design (structure engineering) of the interior and the surface structures of the capsules" with the aim to deliver capsule for flavor-release by manipulate the interior by interface or vice versa (see Figure D33-3).

The structuring of the interior (Workpackage WP1 and WP2) was addressed by Partners SIK and ETH focusing on phase-separating and heat set biopolymer systems as reported in Research Topic RT1, RT4, RT7, and RT8. The design of container walls (Workpackage WP2 and WP3) was addressed by Partners WUR, TUM, URDV, and ETH, which focused on zein protein, spider silk protein and protein fibril/pectin complexes. The research is summarized here in Research Topic RT2, RT3, RT4, RT5, RT6 and RT 9. The organization around the described objectives, workpackage, and research topics has proven very suitable for the project.

Research Topics (RT)
One major effort during the first year was to identify suitable model systems to address our scientific goal and to eventually narrowing the choices of material to be investigated during the second and third year of the project. The meetings in Vlaardingen and later on in Munich were used to identify suitable materials, material combinations, experimental setups, and methods to model and analyze the experimental findings. The initial list of Research Topics (RT) (along with the partners involved) were:

1) Influence of surfactants on the phase separation (SIK, ETH)
2) Generation of multi-layer capsules (WUR, ETH)
3) Mechanics and breakage of capsules (WUR, ETH)
4) Capsules for aroma studies (WUR, TUM, ETH, URDV)
5) Microfluidic device for the production of zein hollow shells (ETH, TUM
6) Free energy calculation (ETH, WUR)
7) Microrheology for modulus determination (SIK, TUM)
8) Simulation & Experiment on phase separation (SIK, ETH)
9) Microfluidics of phase separating and gelling particles (SIK, ETH)
10) Gel morphology for controlled release (SIK)
11) Silk protein (TUM)

Due to the established collaboration between the partners the Research Topics span across the original Work Packages and Deliverables keeping the final goal of the project in mind. The introduced Research Topics allowed to cover additional collaborations not foreseen in the proposal and Description of Work (Annex 1). During the second year RT7 was set aside because microrheology suffers from uncontrolled drifts of the observed object, which can influence the accuracy of the measurements. Since various other methods to measure release and diffusion are available (e.g. FRAP), microrheology is considered as an add-on technique. Further RT11 focusing on silk protein was adapted to other materials because silk proteins proved to be not stable enough for capsule materials. These decisions were communicated to the Commission in the Mid Term Assessment and approved. During the third year further consolidation took place, e.g. RT1 and RT9 were joined. The final list of research Topic to be reported on is as follows:

1) Microfluidics of phase separating, gelling particles and the influence of surfactants thereon (SIK, ETH)
2) Generation of multi-layer capsules (WUR, ETH)
3) Mechanics and breakage of capsules (WUR, ETH)
4) Capsules for aroma studies (WUR, TUM, ETH, URDV)
5) Robust microfluidic device for capsule formation (ETH, TUM)

6) Free energy calculation for interfaces (WUR, ETH)
7) Simulation and experiment on phase separating biopolymers in confined geometries (SIK, ETH)
8) Gel morphology for controlled release (SIK)
9) Alternative encapsulation materials (TUM, ETH, WUR)

Before focusing on the individual Research Topics a short summary of the achievements of the "Controlled Release" project are given in the next paragraph.

Project Summary

As major achievements of the entire project we can summarized the flowing items:

- **Linking the material properties and structure of the shell and the interior in a modeling effort (Research Topic RT3 and RT6).**
- **Production of multi-shell containers for flavor release (Research Topic RT2)**
- **Establishing a production method for solid and hollow zein protein spheres flavor release (Research Topic RT4).**
- **Utilization of heat-set biopolymers in confinement for flavor release purposes (Research Topic RT4).**
- **Establishing a robust and versatile microfluidics environment to study container morphology and dynamic (Research Topic RT1, RT3, and RT5)**
- **Description of phase separating of biopolymers in confinement with the Soft Solid model. (Research Topic RT7).**
- **Establishing of comprehensive methods to study the flavor release by FRAP method (Research Topic RT8).**
- **Screening of suitable container wall materials from proteins, hydrocolloids, and colloidosomes (Research Topic RT9)**

It should be noted that all achievements summarized in the Research Topics are fully inline with the Objectives, Deliverables and Milestones of the project. In particular, several Research Topics lay solid ground for the future research amongst the partners of the project. The project "Controlled Release" has delivered all its Objectives, Deliverables and Milestones to a full extend and has already initiated research beyond the duration of the project.