Summary for the final report
Sustainable antimicrobial/antioxidant active packaging based on natural compounds for shelf life prolongation of cheese and sausages (BioPack4Food)

Background and Objective

The spoilage and safety of meat products and sliced cheese is dominated by microbial contaminations. The majority of those products is sold in packaged form, so that innovative packaging concepts may contribute significantly to the retention of food quality. Within the Cornet-project BioPack4Food, active and bio-based packaging material with antimicrobial compounds from natural sources (spices, herbs) was developed and tested thoroughly. The outcome of the project provides practice related findings regarding the applicability of bioactive plant-based compounds for the microbial stabilization of packaged meat products and cheese. The obtained results are especially beneficial for small and medium sized companies who often do not have capacities for own feasibility studies. Findings of this project can support the decision-making in strategic orientation of SMEs regarding the potential application of antimicrobial plant-based compounds.

Since the use of plant based antimicrobial compounds as a natural form of food preservation is currently in trend, a significant demand for efficiency proven formulations can be observed in the food sector. Accordingly, the research activity in this field has been comparably high for several years now. However, an examination of antimicrobial packaging concepts under practice-oriented conditions is missing in most cases. Especially the proper insertion of antimicrobial compounds in the packaging system has often not been addressed adequately. The release of volatile antimicrobial compounds in the headspace of packaged products appears most promising, since unavoidable process-related secondary contaminations usually lead to superficial microbiological loads on the products. Studies focusing on the application of antimicrobial volatiles for the preservation of perishable foods packed under modified gas atmosphere are still relatively rare. Therefore, the objective of this project was to examine the practical performance of different volatile plant-based antimicrobials in case of bologna, ham and sliced cheese, which are commonly distributed in modified atmosphere packaging.

Results and Discussion

Initially, several promising plant-based compounds were selected according to their antimicrobial potential described in literature. High antimicrobial activities of various compounds were confirmed in-vitro for selected bacteria and molds relevant for meat products and cheese. With a direct contact between antimicrobials like Thymol, Carvacrol or Cinnamaldehyde and the microorganisms, minimum inhibitory concentrations of less than 100 ppm were found within microdilution assays, whereat the temperature and pH-values were adjusted to levels common for refrigerated sausages and cheese.

Subsequently, the antimicrobial activity of the selected plant-based compounds was also examined in indirect contact via the gas phase of a closed system. For this purpose, the test microorganisms were inoculated on a gel matrix which served as food simulant and stored in gas tight tubes at 7°C together with the bioactive compounds which were added to filter papers. The three compounds Citral, Linalool and Cinnamaldehyde exhibited significant antimicrobial properties when applied indirectly via the gas phase of the closed system. Concentrations of 10 µl of antimicrobials in a 50 ml headspace volume led to a significant growth inhibition of Listeria monocytogenes and Lactobacillus sakei on a nutrient rich food simulant with pH 6 at 7°C.

For the production of active packaging materials, PLA (biopolymer) and a PP/EVOH/PP composite (recyclable) were selected as carrier materials and coated with various combinations of lacquer (PVA, shellac) and active compounds on a pilot scale. The antimicrobial effect across the gas phase was investigated within storage tests with a food simulant as well as artificially inoculated cheese, ham and bologna. The use of the active ingredients Citral, Linalool and Cinnamaldehyde in a PVA coating (20% w/w) on a recyclable barrier film with subsequent release in a gas-tight container (2.5 L) caused a significant inhibition of Listeria monocytogenes and Penicillium commune on the food simulant at 7°C throughout 14 days.

However, it turned out that a relevant antimicrobial effect via the gas phase can only be achieved on a fat-free food simulant. The addition of 20 % fat to the gel matrix prevented the antimicrobial effect of Citral, Linalool and Cinnamaldehyde almost completely under otherwise identical conditions. The same applies to the tested products cooked ham, chicken cold cuts and bologna. of the test systems enabled a significant growth inhibition of bacteria (Listeria monocytogenes or Lactobacillus sakei) present on the surface of the fat containing food simulant or the food products. Even very high concentrations of antimicrobials (100 µl/ 50 ml) proved to be ineffective. Only in the case of Penicillium commune, a significant inhibition of mold growth was found for Citral, Linalool and Cinnamaldehyde on both, the fat containing gel matrix and sliced cheese.

Furthermore, a nanoemulsion comprising six different bioactive compounds has been developed by the Canadian partner within this project. The nanoemulsion showed a clear antimicrobial effect in vitro, but no significant effect could be demonstrated when applied indirectly via the gas phase in a closed test system.

Regarding the practical applicability of the lipophilic plant-based bioactive compounds for food preservation, the results of this project clearly indicate that a rather limited effectiveness can be expected, especially in case of fat containing products. In principle, growth inhibition of microbial contaminants present on a food surface appears to be possible via the release of active compounds into the headspace of the packaging. However, the lipophilic nature of the antimicrobial substances seems to cause an accumulation in the fat phase of a fatty food matrix, which means that the bioactive compounds are no longer available in sufficient concentrations to achieve an antimicrobial effect on the food surface.

In addition, significant sensory deviations were found for all substances, even at relatively low concentrations of 10 µl/50 ml headspace volume. The strong impact on the taste and smell of bologna, ham and cheese more or less prevents the practical use of these volatile antimicrobials. Especially compounds such as Citral and Cinnamaldehyde led to massive aroma changes, but also essential oils from oregano or thyme had a strong effect. In case of Citral, significant color changes of ham and cheese were observed as well. From a sensory point of view, linalool proved to be the most tolerable among all compounds when applied in indirect contact to these products. Nevertheless, significant changes in terms of smell and taste are to be expected here as well.

Conclusion

Overall, the application of the antimicrobial compounds investigated in this project for preserving foods such as sausages or semi-hard cheese cannot be recommended. One reason can be found in the low antimicrobial efficiency under practice-oriented conditions, which is attributable to significant matrix effects arising from the food composition, especially the fat content. Furthermore, distinct sensory changes of the products were perceptible at rather low concentrations, which impaired their consumability. In addition, the substances are currently not approved as preservatives.

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