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Proton transfer reaction mass spectrometry (PTR-MS) implementation in the dairy industry: New perspectives in quality control of fermented milks

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Summary: In the present study, Proton Transfer Reaction-Mass Spectrometry (PTR-MS) has been successfully used for the monitoring of flavor formation during milk fermentation. Moreover, the impact of both milk base compositional and processing factors on flavor and off-flavor compounds formation were evaluated.

Keywords: proton transfer reaction-mass spectrometry; fermented dairy products; quality control.

1 Introduction

Fermented milks are products highly appreciated by the consumers due to their peculiar sensory (sour and refreshing flavor), nutritional (low lactose) and physiological characteristics (gut regulation, antimicrobial and anticancer properties).

Quality control of fermented milks involves issues that are associated with the colloidal, structural and flavour changes occurring during the particular implemented processing steps (homogenization, heat treatment, incubation and post fermentation handling). With respect to flavour quality of fermented milks, factors such as the severity of heat treatment, the quality of the ingredients supplemented, the liquid to sol-gel phase transitions, the incubation and storage conditions, the type of starter cultures used, etc., affect critically the composition and concentration of the endogenous volatile compounds. Over the last two decades several sensor-technology methods have been developed for the on-line monitoring of bioprocesses in the dairy industry.

Aim of the present study was to evaluate the PTR-MS technique as a useful tool for the quality control purposes such as: the on-line monitoring of the milk fermentation process, the formation of off-flavours, the evaluation of milk base pre-treatment practices, the flavour-texture interactions etc.

2 Experimental

Different milk base systems differing in their composition (milk-fat content, addition of protein fortifying agents or hydrocolloids), or their pre-treatment (conventional heat treatment or minimal processing techniques) have been prepared. All milk systems were inoculated at 42°C with a conventional starter culture (*Chr. Hansen, YoFlex-760*) at the level of 1U/mL and incubated at the same temperature until reaching the end pH-point (pH = 4.6). PTR-MS measurements of the headspace above the acidifying dairy system were carried out at fixed time intervals. The impact of the compositional and technological parameters on the kinetics of the fermentation process was determined by fitting the experimental data to the modified Gompertz sigmoidal model. Principal Components Analysis (PCA) was applied for the mapping of the biochemical pattern of the milk fermentation as function of the milk base supplementation and pre-treatment methods. The texture – flavour interactions were evaluated in the final products (set and stirred style) after a 2 days storage time at 4°C.

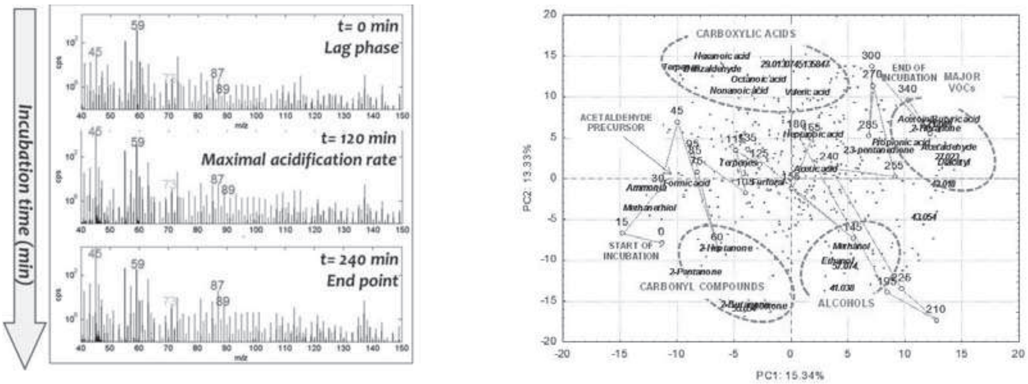

Fig. 1. Mass spectral data acquired at different times of the fermentation process (left) and illustration of the VOCs evolution pattern for a full fat protein fortified milk system (right).

3 Results

Fig. 1 (left) shows the temporal changes in the entire mass spectra acquired at three different times of the fermentation process demonstrating that the PTR-ToF-MS allows the on-line monitoring of the formation of several important endogenous compounds e.g. acetaldehyde, diacetyl, and acetoin or the depletion of other e.g. sulphur compounds. Using the entire data sets we were able to elucidate changes of the endogenous flavor compounds as a function of the milk base treatment. Fig 1(right) provides an example of the mapping of the formation pattern of several VOCs during the milk fermentation. An attempt to reveal the biochemical pathways (proteolysis, lipolysis of the MFGM, major VOCs formation via the EMP pattern related with evolution) has been successfully carried out. Moreover, in the case of the major VOCs (acetaldehyde, diacetyl and acetoin) a sigmoidal dependency has been observed (Fig. 2, left) with the kinetic parameters of the fermentation (lag phase duration, and maximum rates of formation) to be dependent on compositional and processing factors (Fig. 2, right).

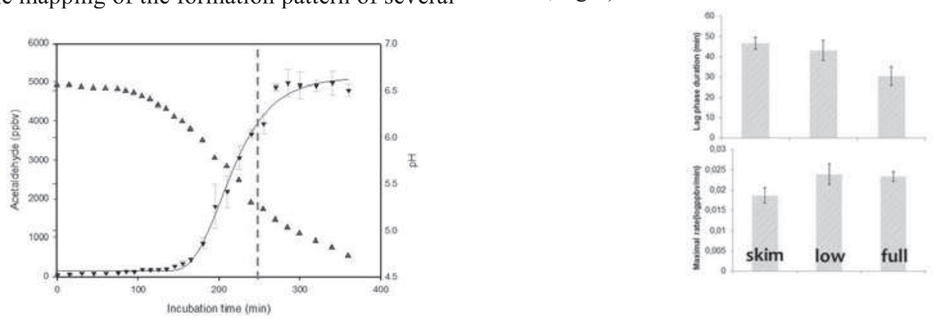

Fig. 2. Modelling of acetaldehyde as function of time (left), and calculation of the kinetic parameters describing its evolution according to the modified Gompertz model as function of milkfat content (right).

4 Conclusions

PTR-ToF-MS has been successfully implemented for the on-line monitoring of dynamic processes relevant to the dairy industry. The data acquired could be used for the mathematical modeling of the formation of major flavor compounds. Such models together with information about the acidity, colloidal and viscoelasticity changes will be very useful for process and product optimization purposes.

References

C. Soukoulis, E. Aprea, F. Biasioli, et al.; Rapid Commun. Mass Spectrom., 24, (2010), pp. 2127-2131.