Analysis and modeling of the interactions of the lactic acid bacteria in kimchi fermentation

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ABSTRACT

Mixed cultures of *Lactobacillus plantarum* and *Leuconostoc mesenteroides* were chosen as a model system to study microbial interactions in kimchi. As these two lactic acid bacteria play an important role in kimchi fermentation, mathematical models were used to describe the growth behavior of *L. plantarum* and *L. mesenteroides* in pure suspension cultures as a function of temperature, pH and lactate concentration.[1] The plate counting and quantitative competitive PCR methods were employed to measure the size of each bacterium in a mixed fermentation system.[2] The competitive PCR method was found to be accurate to determine the time-dependent profiles of two lactic acid bacteria in real fermented watery kimchi using the species-specific primer sets. The two primer sets were constructed based on the 16S rRNA gene of *L. plantarum*[3] and the dextransucrase gene of *L. mesenteroides*. The competitor of each target gene could be used as an internal standard template for correction of experimental error occurred during the amplification process between templates and products.[4] The amplified products are distinguishable from the target because the sizes of products are different. The sense and antisense primers for the DNA competitor were prepared by flanking the sequence for amplification of the template DNA at the 3'-termini of each sense and antisense primer for amplification of two target DNAs. By coamplification of the two species-specific target with the competitors, DNA concentrations of lactic acid bacteria in fermented kimchi could be estimated specifically from the known concentrations of each competitor. The effect of initial medium pH on the maximum specific growth rate could be described by a parabolic equation for *L. plantarum* and *L. mesenteroides*. *L. mesenteroides* was clearly more sensitive to a pH decrease than *L. plantarum*[5]. The effect of lactate on the maximum specific growth rate at different initial pH values was gentle for *L. plantarum* while serious for *L.*

mesenteroides. It suggests that the concentration of lactic acid was the most critical factor in determining the dominant organism in mixed cultures. The 'Lotka-Volterra' competition model was used to predict the pattern of interaction in mixed suspension cultures and to study the growth stability of the two-lactic acid bacteria system.[6] The model prediction of mixed growth was also carried out with Lotka-Volterra model equation and mathematical analysis is accurate over 90% by investigation of specific growth rate. The mathematical analysis of the interaction pattern between *L. plantarum* and *L. mesenteroides* indicated a competition relationship near amensalism since the competition coefficients α_{12} is close to zero (0.83)[7]. As the pH of the system decreased, such a relationship collapsed due to the different tolerance level of each organism to acidity. The interesting feature would be the stability characteristics of the mixed fermentation. *L. mesenteroides* had higher maximum specific growth rate than *L. plantarum* and hence was dominant in the early stage of the fermentation while the latter took over the former to become a dominant strain mainly due to a high acid tolerance regardless of an initial size of both populations.

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