Proteolytic systems in lactic acid bacteria

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The proteolytic systems of lactic acid bacteria are important as a means of making protein and peptide N available for growth and as part of the curing or maturation processes which give foods their characteristic rheological and organoleptic properties. The proteolytic systems of lactic acid bacteria are described in relation to their growth and their functions in protein-rich foods. Their role in the manufacture of milk products is discussed.

INTRODUCTION

When food microbiologists refer to the lactic acid bacteria they generally include the genera Streptococcus (faecal and lactic), Leuconostoc, Lactobacillus (Lb.) and Pediococcus. Taxonomically, such a group presents some contradictions (Hurst and Collins-Thompson, 1979) but this definition is functionally sensible and necessary. The lactic acid bacteria are all nutritionally fastidious, yet they compete remarkably well with other groups of microorganisms in foods, partially because their fermentative metabolism produces inhibitory conditions and compounds (low pH, low $E_h$, organic acids, H$_2$O$_2$, antibiotics) but also because they are well equipped to utilize the wide range of nutrients available in such habitats. They are found as important components of the microflora of a wide variety of fermented foods, including soy sauce, sausages, vegetables and milk products, where their main function is one of acidification. Their proteolytic systems are important, both as a means of making protein and peptide N available for growth and, fortuitously, as part of the curing or maturation processes which give the foods their characteristic rheological and organoleptic properties. This paper describes the proteolytic systems of lactic acid bacteria in

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relation to their growth and functions in protein-rich foods. The discussion is
inevitably weighted towards their role in the manufacture of milk products since
this area has been most intensively investigated. For descriptions of the lactic
floras of fermented foods the reader is referred to articles by the following au-
thors: Reuter (1975; meats), Fleming (1982; vegetables), Law (1982; cheeses),

AMINO ACIDS AND PEPTIDES IN NUTRITION

Pre-formed amino acids are an absolute requirement or a growth stimulant
to all lactic acid bacteria. Detailed experimental data about these requirements
are only available for some of the group, the most definitive studies having been
done with group N streptococci (Reiter and Oram, 1962; Law et al., 1976) and
*S. thermophilus* (Shankar, 1977; Bracquart and Lorient, 1979). Qualitative data
on lactobacilli (Morishita et al., 1981) indicate that this group has most extensive
requirements. A comparison of the amounts of the essential amino acids which
the lactic streptococci need for maximum growth, with the concentrations of
free amino acids in milk (Table 1) emphasizes the importance of proteolytic
enzymes as mediators in releasing further amino acids from milk proteins to
allow maximum growth.

Like other bacteria, the lactic acid bacteria can actively transport amino acids
and peptides across the cell membrane into the cell against a concentration gra-
dient (Leach and Snell, 1960; Mora and Snell, 1963; Brock and Wooley, 1964;

<table>
<thead>
<tr>
<th></th>
<th><em>S. lactis</em></th>
<th><em>S. lactis</em> subsp.</th>
<th><em>S. cremoris</em></th>
<th><em>S. thermophilus</em></th>
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<tbody>
<tr>
<td>Glu</td>
<td>77</td>
<td>87</td>
<td>70</td>
<td>150</td>
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<tr>
<td>Leu</td>
<td>41</td>
<td>37</td>
<td>32</td>
<td>n.e.</td>
</tr>
<tr>
<td>Ile</td>
<td>33</td>
<td>30</td>
<td>32</td>
<td>n.e.</td>
</tr>
<tr>
<td>Val</td>
<td>27</td>
<td>30</td>
<td>41</td>
<td>n.e.</td>
</tr>
<tr>
<td>Arg</td>
<td>37</td>
<td>36</td>
<td>39</td>
<td>n.e.</td>
</tr>
<tr>
<td>Cys</td>
<td>$s^1$</td>
<td>$s$</td>
<td>27</td>
<td>80</td>
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<tr>
<td>Pro</td>
<td>n.e.</td>
<td>n.e.</td>
<td>38</td>
<td>n.e.</td>
</tr>
<tr>
<td>His</td>
<td>23</td>
<td>24</td>
<td>14</td>
<td>60</td>
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<td>Phe</td>
<td>21</td>
<td>n.e.</td>
<td>6</td>
<td>n.e.</td>
</tr>
<tr>
<td>Met</td>
<td>22</td>
<td>21</td>
<td>11</td>
<td>n.e.</td>
</tr>
</tbody>
</table>

Data from Law et al. (1976), Shankar (1977) and Mills and Thomas (1981).

$n.d.$ = not detected; n.e. = not estimated; $s$ = stimulatory.