MYCOLOGY ANSWERS

HOW ARE THE ACTIVITIES OF ENZYMES FROM FUNGI UTILISED IN CHEESE PRODUCTION?

Cheese making is an ancient and important procedure. It is a very useful way to preserve the nutrients available in the milk of cows, ewes and goats. Cheese is an important source of calcium and vitamins for the human diet and also provides an interesting variety of flavours and textures. The actions of fungal enzymes have very important roles to play in some stages of cheese production and many varieties of mould-ripened cheeses are available.

In the modern commercial production of cheese the milk is normally pasteurised prior to use. This does have the effect of changing the flavour of the milk and also of the resulting cheese. Some chemical changes also occur which makes pasteurised milk more suitable for the growth of starter cultures, but unpasteurised milks are still used for some more specialised products. The process also destroys the natural microbial flora of the milk and therefore gives rise to a more consistent product helping to eliminate variations between batches which is an important consideration for the dairy industry and often a requirement of retailers.

Cheese production takes place in a number of stages with fungi playing their major role in the ripening processes. Initially activities of bacteria are utilised. The pre-treated milk is inoculated with starter cultures of lactic acid bacteria (e.g. *Streptococcus lactis, Lactobacillus helveticus*) which convert the lactose in the milk to lactic acid (over a temperature range of 30-50°C depending on the type of cheese to be produced). This aids the curdling of the milk and influences the consistency and represents the first step in development of the flavour of the cheese through the modification of proteins and fats in the milk. The lactic acid produced also acts as a preservative and in addition, another product of lactic acid fermentation, propionic acid, has antimicrobial properties and ultimately aids the prevention of mould growth.

Further coagulation of the milk proteins is brought about by the addition of the enzyme rennin. Modern processes now make increasing use of rennin from microbial origins in place of the more traditional systems that used rennet (chymosin) from the stomachs of calves. Microbial rennin is produced by some species of fungi (e.g. *Mucor pusillus, Endothia parasitica*) which is used in commercial production. The use of microbial rennin slightly alters the flavour of the resulting cheese but its use is increasing. Subsequently, the fluid whey is removed from the curd solids. For unripened cheeses the curd is cut, drained and washed, with the addition of a little salt. These cheeses have a high moisture content (e.g. Cottage cheese, 60-80% moisture) and will keep chilled for only a relatively short time. For longer-term storage the moisture content of the cheese is an important factor. Very dry cheeses have a longer keeping ability (e.g. Parmesan, 32% moisture) than the moister varieties. Curds that will be ripened are first separated from the whey and formed into shapes. Salt is added to improve the keeping quality as well as to enhance the flavours. For other hard cheeses such as Cheddar the whey is first drained from the curds and then pressed out to give a 35% moisture content and a good storage potential. Swiss cheese is produced similarly with lactic acid and propionic acid contributing to the flavours and the production of CO_2 by *Propionibacterium* spp. giving rise to the characteristic large holes or 'eyes'.

For mould-ripened cheeses the curds are inoculated with fungal spores as appropriate and allowed to ripen under conducive environmental conditions, usually cool temperatures (68°C) and moderate humidity. The greater the control over the inoculation and incubation conditions the more uniform the product. In addition it is vital that all steps are conducted in as clean and contaminant-free an environment as possible to prevent spoilage during production. The main types of cheeses are ripened slightly differently.

Blue Cheeses

The main Blue Cheeses are Roquefort, Danish Blue, Stilton and Gorgonzola. The keeping quali-

ty is good since the moisture content is about 45% and the cheese is surface salted. For ripening the whey is drained off, spores of *Penicillium roquefortii* grown on bread crumbs are mixed with the curd, and then slightly compressed to shape. The surface of the blocks is salted, which tends to set up a concentration gradient favouring fungal growth within the curd mass. The blocks are spiked to allow diffusion of carbon dioxide and oxygen and it is along these channels that mould growth begins and further sporulation occurs (forming the blue veins) under conditions of controlled temperature and humidity. As it grows the fungus produces proteolytic and lipolytic enzymes which release amino acids and peptides from proteins and fatty acids in the ripening curd. The strong flavour develops as a result of the production of methyl ketones (2-heptanone) and lactone by the fungus.

Camembert-type

Camembert and Brie (40-50% moisture content) are produced by draining off the whey into disc shaped containers. The surface of the discs is salted and either inoculated or naturally colonised by *Penicillium camembertii*. Where ripening of such cheese is carried out regularly, inoculation of the fungus is not usually necessary. The fungus grows as a surface rind, not penetrating into the cheese but the action of extracellular proteases alters the consistency of the cheese. As the milk proteins are digested the texture becomes soft and runny. The mild flavour of these cheeses is not directly the result of fungal activity but is attributed to bacterial growth.

It is important to remember that the abilities of some species of fungi, including yeasts, to grow under dry conditions (xerotolerance) is such that even Cheddar will go mouldy. In addition many are also able to proliferate at low temperature (psychrotolerance) so cheese will also mould in the fridge. The action of the fungi is mainly to enhance the flavour production or to change the texture of the milk curds. It is clear that in this way the activities of these fungi contribute delicious variety to our diets.

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