Solid-state Fermentation for Food and Feed Application

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17.1. INTRODUCTION

In the last decades, there has been an increasing trend towards the utilization of the solid-state fermentation (SSF) technique to produce several bulk chemicals and enzymes. This methodology has often been found to produce a more stable product, with less energy requirements, in smaller fermenters and smaller volumes of polluting effluents, than submerged fermentation (SmF) systems. SSF is defined as any fermentation process carried out on a solid material in absence of free flowing liquid (Pandey 1992). The low moisture content means that fermentation can only be carried out by a limited number of microorganisms, mainly yeasts and fungi, although some bacteria have also been used.

A wide range of solid materials can be employed as supports in SSF and they are usually classified into two great categories: non-inert and inert materials (Krishna 2005). In the first, a divided and humidified solid (e.g. cereal grain, flour, bran, sawdust) behaves as both support and nutrient source, while in the second, a nutritionally inert solid (e.g., synthetic foam), acting exclusively as a support, is soaked in a nutrient solution. It is noteworthy the growing interest in utilizing agro-industrial wastes as non-inert SSF supports, making the whole process much more economical (Pandey et al., 2000a, b). Thus, SSF is considered as an advantageous technology in a number of processes related to different industrial sectors. Some of the first known uses of this culture mode were the manufacture of foodstuffs, and nowadays the food and feed industry still constitutes one of its main fields of application. The use of SSF has been proposed not only as a method for food preparation or amelioration, but also as a suitable technology for obtaining useful additives for food and feeds or reagents usually employed in food manufacture (Figure 1).

This chapter focuses on the main current applications of SSF, in relation with the feed and food sectors. Special attention will be paid to the choice of raw materials and the main variables involved in process optimization.
17.2. TRADITIONAL AND FUNCTIONAL FOODS AND UPGRADING OF RAW MATERIALS

SSF is considered an advantageous technology for obtaining edible products with adequate sensory properties and functionality, as well as for improving the nutritional value of raw materials such as legumes and cereals. Traditional food fermentations such as Japanese “koji”, Indonesian “tempeh”, Indian “ragi” and French “blue cheese” can be cited as some of the oldest documented applications of SSF. However, the implementation of this kind of procedures at industrial scale requires a considerable research effort, in order to optimize the processes as much as possible. An example of this ongoing endeavour is the case of “tempeh”, usually obtained by fermenting boiled and dehulled soybeans, or other substrates such as common beans, chickpeas, rapeseed, lupin, horsebean, groundnut, wheat or corn/soybean. Some authors have recently investigated the best combinations of SSF variables (temperature, time) for production of quality protein maize or chickpea “tempeh” flour (Reyes-Moreno et al., 2004, Cuevas-Rodríguez et al., 2004, Cuevas-Rodríguez et al., 2006). Also, the acceptability of sorghum-based “tempeh”, obtained by SSF, has been considered (Mugula & Lyimo 2000).

During recent years, the growing interest of the population on adequate nutrition habits has caused a considerable increase in the investigation of the functional properties of foods. The manufacture of prebiotic and probiotic products has