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Review

Microbial and enzymatic technologies used for the production of natural aroma compounds: Synthesis, recovery modeling, and bioprocesses

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ABSTRACT

This review describes several methodologies of industrial and academic interest which are implied in the synthesis/extraction of natural aroma compounds by biotechnological processes. The production of natural aroma compounds has recently attracted a great deal of research interest and represents a challenging target for academic and industrial research. In order to overcome the exorbitant cost of flavoring and to cover the need of consumer preferences for natural compounds, biotechnological production has become a very attractive alternative to the chemical production. Biocatalysts from natural origin, particularly microbial cells, have a great potential to produce a wide range of flavors. The use of precursors from natural sources as a mean to improve economical feasibility of these processes is also considered. The production of bio-flavors with microorganisms and enzymes is illustrated in this review by the discussion of the current state of the art of biotechnological advances in this field. The present paper reviews also the recent major achievements such as the advances in solid state fermentation, the bioreactors used for the production and recovery of volatile compounds and the modeling approaches used for the theoretical study of transfer in these processes.

Keywords: Aroma; Bioprocess; Chiral separation; Mass transfer; Modeling; Recovery

Contents

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1. Introduction

Flavors and fragrances are extremely important for the food, feed, cosmetic, chemical and pharmaceutical industries. Nowadays, flavors represent over a quarter of the world market for food additives and most of them are provided by extraction from natural sources or by traditional methods as chemical synthesis. They currently represent a worldwide industrial size of almost 7 billion US$ a year, a figure which increases 4.4% each year. Financially this means 25% of the total food additives market (Dubal et al., 2008). There is however an increasing demand for natural products instead of synthetic ones. This increase is especially evident for flavoring compounds, called natural or bio-flavors.

The chemical synthesis constitutes an undesirable way for the production of flavors. Chemical synthesis of food aroma is nowadays under question, due to drawbacks such as poor reactions selectivity leading to undesirable side reactions, low yields, pollution, high manufacturing and costs. Resolution of racemic mixtures is usually difficult to achieve chemically. This leads to the reduction of process efficiency and to the increase of downstream costs. All these factors have encouraged flavor companies to focus their attention toward flavor compounds of biological origin. The natural flavors are generally provided by higher plants. These classical agricultural sources contain however, trace concentrations of active components and their use depends on natural factors difficult to control, such as weather conditions and plant diseases. They may also exist in bound form, which makes their isolation difficult and therefore enhances the cost of flavor products. Natural sources become insufficient to cover the increasing demand of market.

Natural aroma compounds are present in plant essential oils and have been obtained by steam distillation of plant material followed by fractional distillation techniques. Extraction is also subject to various problems. These raw materials often contain low concentrations of the desired compounds, making the extraction expensive.

This great interest for natural products has encouraged aroma industries to develop new biotechnological processes to obtain aroma compounds naturally. Although many biotechnological processes have been reported, most of them have not yet been applied to the industrial production of these compounds due to the low yields and therefore to the high costs of down-stream processing. This results in an increasing price of the naturally produced compounds, which is 10–100 times higher than that of the synthetic ones. For example, the γ-decalactone (flavor compound of peach) extracted from a natural source costs about US$6000/kg, while the synthetic one costs US$150/kg (Dubal et al., 2008). The alternative route used for the natural synthesis is based on microbial biosynthesis or bioconversion. The development of biotechnological methods for the production of flavor and fragrance chemicals could be an arduous task since most natural flavors are composed of several hundred compounds. The aim of this review is to view the current state of the art of bioprocesses used for the production of natural flavor compounds, with emphasis on the methodologies used to improve the production yields, and on the applications of *in situ* product removal techniques. Several approaches will be described with particular attention to microbial and enzymatic syntheses of natural aromatic compounds, engineering aspects of solid state fermentation, chiral separation and extraction, mathematical modeling and design of bioreactors.