Applications of Modern Separation and Recombination Technology in the Study of Mushroom Functional Foods

YU LI
Jilin Agricultural University, Xincheng Street, Changchun City, Jilin 130118, China.
E-mail: liyu@jlau.edu.cn

Abstract: China has the longest history of mushroom cultivation and presently produces the highest yields worldwide of ten different kinds of mushrooms. At the end of 20th Century, the annual total yield of mushrooms in China was more than 4,000,000 tons, comprising more than 60% of the world's total output. China is also the world's biggest mushroom exporter. The total yield value ranks sixth of the world, superceded only by grain, cotton, oil, fruit and vegetables, and exceeding tea, silk and other traditional economic crops. In this rapidly developing area, mushrooms have already become the buttress or main industry of local rural economics. Some mushrooms have highly nutritional and/or medical value, and scientific research has shown them to be rich in protein, essential amino acids and bioactive polysaccharides, and to have a low fat content. Hence, mushrooms have numerous functions including enhancing immunity, restraining tumors and reducing blood fat. They have been widely exploited and applied as functional foods. However, the technology for extensive processing of mushrooms is still relatively elementary. Mushrooms are mainly made into dry products as food for consumption at mealtimes. Only a few parts of the mushroom are converted into healthy food or medicinal materials through traditional technology. Since the effective elements are either destroyed or altered during processing, the content of the active components are reduced and the healthy function poor. Modern separation and recombination technology is recommended to produce high quality mushroom functional food. A series of mushroom functional foods can be prepared from fresh or dried mushrooms using new technologies such as supercritical fluid extraction, high vacuum and low temperature molecular distillation, extrusion, ultrafiltration and chromatography. These kinds of food maintain the bioactive components and maximal biological activity, and compete very effectively in market terms. Furthermore, there is full utilisation of the materials present in the mushroom feedstock.

Key words: Modern separation technology, recombinant technology, mushrooms, functional foods, processing, food engineering

1 Present Situation Relating to Mushroom Processing Technology

China has the longest history of mushroom cultivation and presently produces the highest yields worldwide of ten different kinds of mushrooms. The principles of mushroom cultivation technology established by China's growers are still efficient because of continual and extensive scientific input. At the end of 20th Century, the annual total yield of mushrooms in China was more than 4,000,000 tons, comprising more than 60% of the world's total output. China is the world's biggest mushroom producer and exporter. The value of the total mushroom yield ranks sixth of the world, superceded only by grain, cotton, oil, fruit and vegetables, and exceeding tea, silk and other traditional economic crops. In this rapidly developing area, mushrooms have already become the buttress or main industry of local rural economics.

Some mushrooms have highly nutritional and/or medical value, and scientific research has shown them to be rich in protein, essential amino acids and bioactive polysaccharides, and to have a low fat content. Hence, mushrooms have numerous functions including enhancing immunity, restraining tumors and reducing blood fat. They have been widely exploited and applied as functional foods. However, the technology for extensive processing of mushrooms is still relatively elementary. Mushrooms are mainly made into dry products as food for consumption at mealtimes. Only a few parts of the mushroom are converted into healthy food or medicinal materials through traditional technology. Since the effective elements are either destroyed or altered during processing, the content of the active components are reduced and the healthy function poor. Modern separation and recombination technology is recommended to produce high quality mushroom functional food.

2 The Concept and Important Effect of Separation and Recombination Technology

2.1 Separation technology

The natural world is highly complex. Inorganic mineral substances and organic elements combine together in nature to form complex compounds. Some of these compounds can be used directly, while the functions of others are expressed or enhanced only after being separated or reorganized. Separation technology is a scientific technology that studies how to separate a single component or several kinds of substances from a mixture. Separation includes mass transfer and non-mass transfer substance separation technology. Heterogeneous separation, including filtration, sedimentation, centrifugation and cyclone separation does not involve mass transfer and is an example of non-mass transfer separation technology. Mass transfer separation technologies can either be homogeneous or heterogeneous. However, most are homogeneous systems such as flash evaporation, extraction, rectification, adsorption, absorbance, ion exchange, crystallization, foam separation, reverse osmosis, ultrafiltration and electrophoresis. Each separation technology appeared at a different time, and the history of application has also been very different. Some separation technologies appeared early and belonged to traditional operational processes such as rectification, absorbance, extraction and crystallization. They have a long history in unit operations and have been widely applied in food engineering. Other new separation technologies in food engineering were only developed within the last 20-30 years, and include membrane separation, large-scale industry chromatography separation, supercritical fluid extraction and molecule distillation. However, they have advantages in terms of, for example, high efficiency, selectivity, energy saving and environment protection. They are designated modern separation technologies and represent future applications in modern food processing.

2.2 Recombination technology

Recombination technology is the redistribution of the components of mixture according to percentage, or the alteration of the structure or nature of some components of a mixture in order to satisfy the requirements of the end product(s). Mixing, stirring, pinching and molding are traditional recombination technology. They can only recombine and make uniform the components of the system and cannot change the structure and nature. Extrusion technology is a process for exposing food materials to high temperature and pressure, and for rapidly releasing the materials back to normal conditions such that the structure and nature of the food will be changed. Extrusion technology is a new and developing technology, so more and more food manufacturers are paying it great attention.

2.3 Role of modern separation and recombination technology

New technologies are the base of the modern food industry. They can improve the level of integrated use, retain food nutrition and flavor, and satisfy hygiene standards. Furthermore, these technologies can also improve the production vision in the food field.

3 Applications of Modern Separation and Recombination Technology to Studies on Mushroom Functional Foods

3.1 Technique flow chart

A technique flow chart indicating the various modern separation procedures is shown in Figure 1.

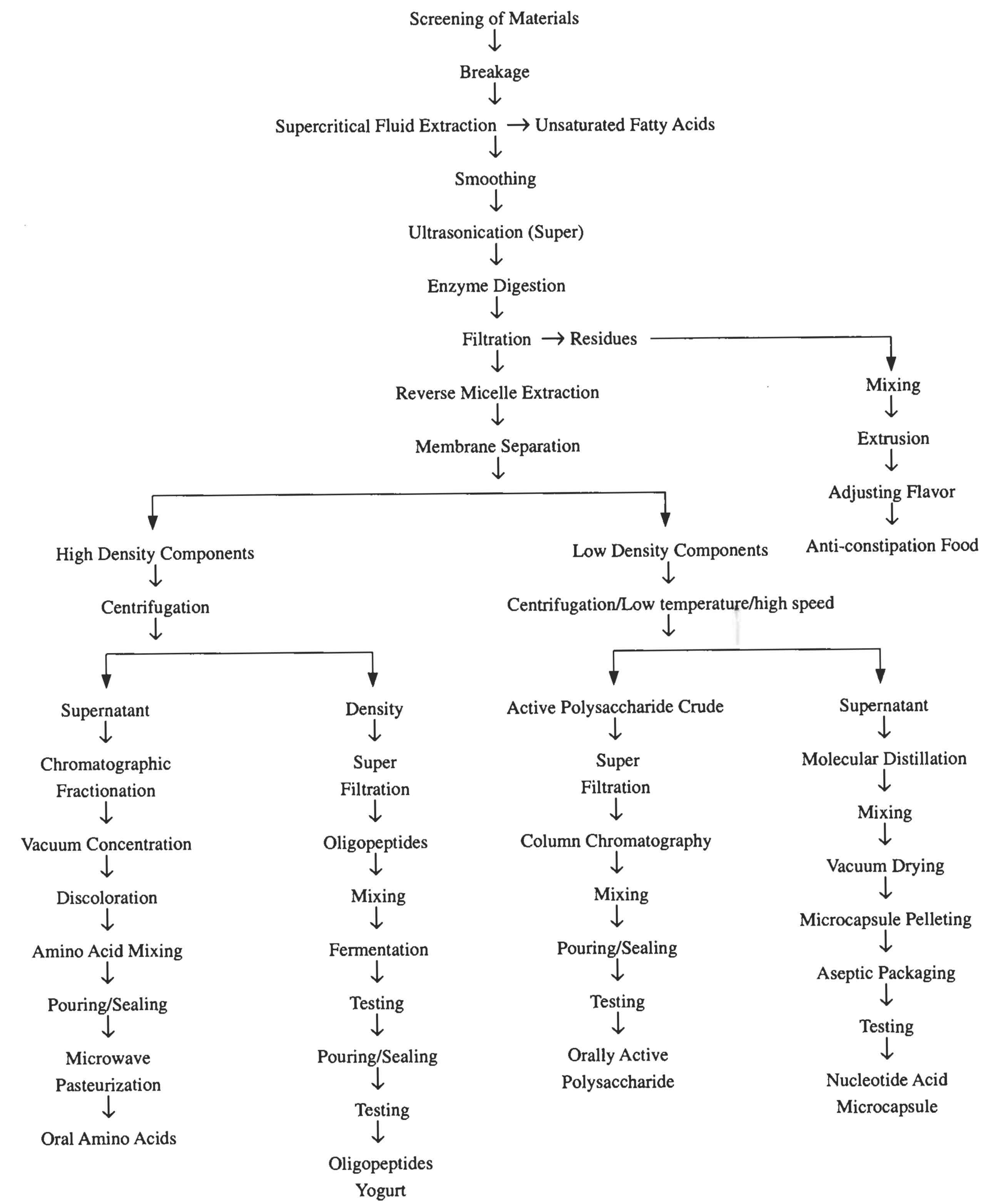

Figure 1. A technique flow chart indicating the various modern separation procedures

3.2 Technology characteristics

3.2.1 Supercritical Fluid Extraction is based on fluids with the nature of liquid and gas under the supercritical state and, by using the supercritical fluid as extraction agent, the soluble components in the mixture can be separated. The technique is also known as Gas Extraction or Dense-Gas Extraction. Since the course of Supercritical Fluid Extraction is between distillation and solvent extraction, it has double merit. It provides for convenient manipulation, good selectivity, a high degree of efficiency, removal of discolouration and bad smells, and elimination of rudimentary extraction agent. This technology can improve the rate of production, purity, and quality, and also saves time and energy. It is advantageous for unsaturated fatty acid extraction from edible fungi. The hydrophobic property of materials can be decreased after supercritical fluid extraction, and the swelling property is improved. The extraction rate of the soluble components is also improved.

3.2.2 Ultrasonication is a shear-based breakage method. The dense cell wall is loosened and made fragile under the cavitation effect of the ultrasound. This can improve the rate of movement of soluble components into cells, and the efficiency of enzymatic reactions. Product activity and also productivity are improved by using the technique of ultrasonic destruction of the cell wall.

3.2.3 Reversed Micelle is a kind of nano-scale mass where surfactant is scattered in a continuous organic phase. Reversed Micelle Extraction has the merits of low cost, high rate of extraction, and repeated use of extraction solvents. Nucleic acids, amino acids and polypeptides can be resolved smoothly in reversed micelles, and the bioactivity of extracted materials is maximised.

3.2.4 Membrane Separation technology usually works under normal temperatures, so that the original properties of the separated substances, such as color, flavor, nutrition and texture, are retained. This method has high selectivity, preserves good product quality, and effectively maintains the active properties of the separated materials. Different membranes, pressure differences, membrane fluxes and concentrations can be adopted in order to separate the corresponding desired products from the mixture.

3.2.5 Mushrooms can be treated with high vacuum, low temperature molecular distillation and vacuum drying in order to avoid or reduce the possibility of thermolysis and polymerization, and retain the biological activity of the products.

3.2.6 Various mushroom components have stronger biological activity, and homologous healthy functions or curative effects, only in a pure form. Chromatographic separation is the most efficient technology adapted for separating the valid components, acquiring highly purified products, and reclaiming the maximum amounts of the target product. In particularly, combined low temperature ultrafiltration and column chromatography separation can be used to purify products, and lead to improved results, to a degree that other methods cannot compare.

3.2.7 Extrusion can break or recombine chemical bonds, and change the construction and chemical composition of materials under conditions such as friction, shearing, fusion, mixture and transportation. There is a lot of cellulose and lignin in mushrooms. The cellulose macromolecule becomes high-quality dietary fiber with special healthcare functions following extrusion. Because they are folded, broken down and recombined, the crystalline structure of cellulose becomes loose, the large molecule undergoes conformation changes, the molecular weight decreases, branched chains are formed, and the content of hydrophilic radicals and soluble components is increased. Furthermore, during extrusion, a stable cubic microcrystalline net construction is formed, and the water absorption and retention capacity is increased.

4 Conclusion

A series of mushroom functional foods can be prepared from fresh or dried mushrooms using new technologies such as supercritical fluid extraction, high vacuum and low temperature molecular distillation, extrusion, ultrafiltration and chromatography. These kinds of food maintain the bioactive components and maximal biological activity, and compete very effectively in market terms. Furthermore, there is full utilisation of the materials present in the mushroom feedstock.