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Yeast as Biotechnological Tool in Food Industry

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Review Article

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Abstract

Yeasts are widely spread in nature. Fermentation of sugars by yeast is the oldest and largest application of this technology. Many types of yeasts are used for making many foods: baker's yeast in bread production, brewer's yeast in beer fermentation, and yeast in wine. This work describes the prevalence of yeasts in food products.

Keywords: Yeast; Food processing; Industrial application; Sugar fermentation

Introduction

Yeasts are eukaryotic, single-celled microorganisms classified as members of the fungus kingdom. The first yeast originated hundreds of millions of years ago, and at least 1,500 species are currently recognized [1-3]. They are estimated to constitute 1% of all described fungal species [4]. Yeast sizes vary greatly, depending on species and environment, typically measuring 3–4 µm in diameter, although some yeast can grow to 40 µm in size [5]. Most yeasts reproduce asexually by mitosis, and many do so by the asymmetric division process known as budding. With their single-celled growth habit, yeasts can be contrasted with molds, which grow hyphae. Fungal species that can take both forms (depending on temperature or other conditions) are called dimorphic fungi.

The word "yeast" comes from Old English gist, gyst, and from the Indo-European root yes-, meaning "boil", "foam", or "bubble"[6]. Yeast microbes are probably one of the earliest domesticated organisms. Archaeologists digging in Egyptian ruins found early grinding stones and baking chambers for yeast-raised bread, as well as drawings of 4,000-year-old bakeries and breweries [7].

Yeasts are very common in the environment, and are often isolated from sugar-rich materials. Examples include naturally occurring yeasts on the skins of fruits and berries (such as grapes, apples, or peaches), and exudates from plants (such as plant saps or cacti). Some yeast is found in association with soil and insects [8,9]. The ecological function and biodiversity of yeasts are relatively unknown compared to those of other microorganisms [10]. Yeasts, including *Candida albicans, Rhodotorula rubra*, *Torulopsis* and *Trichosporon cutaneum*, have been found living in between people's toes as part of their skin flora Yeasts are also present in the gut flora of mammals and some insects and even deep-sea environments host an array of yeasts [11-14].

Even if bacteria represent the most studied targets in Food Microbiology (pathogens, starter cultures, probiotics, production of harmful or positive compounds), the official date of birth of Food Microbiology as science is the mid of 19th century, when Pasteur studied alcoholic fermentation, a process executed by yeasts. Also, the useful physiological properties of yeast have led to their use in the field of biotechnology. Many types of yeasts are used for making many foods: baker's yeast in bread production, brewer's yeast in beer fermentation, and yeast in wine fermentation and for xylitol production [15]. Also, in industry, yeasts are commercially used in the production of alcoholic beverages, industrial alcohols, baker's yeast, enzymes and yeast-derived flavour products [16]. Furthermore, yeasts play detrimental role in the spoilage of foods and beverages and some can be pathogenic. Of the yeasts, *Saccharomyces cerevisiae* and related species are widely used in the food and beverage industries. Many species of *Saccharomyces* are safe (GRAS) and the term "yeast" is generally employed as synonymous with *Saccharomyces cerevisiae* [17]. Therefore, this chapter will briefly discuss the beneficial aspects of yeasts in food processing.

Baker's Yeast

Baker's yeast, *Saccharomyces cerevisiae*, is used for bakery and confectionary processes throughout the world [18]. Baker's yeast can be found in different forms like compressed, granular, cream, dried pellet, instant, encapsulated or frozen [19]. One of the most desirable characteristics of baker's yeast strains is high fermentation rate because is priority desired for baker's yeast strains since it is completely connected to dough-leavening. Yeasts at the same time encourage gluten network and generate aromatic compounds [20]. Also, rapidly utilization of maltose, tolerance to high levels of sucrose, enduring freeze-thawing stress and resulting in production of high levels of CO_2 therefore rising dough volume. CO_2 is soluble in water and saturates the aqueous phase. After reaching saturation, all CO_2 produced passes through unsaturated gas phase and permit rising of the volume of bread. Solubilization of CO_2 in water results in decreasing the pH and elevates the acidity of the dough [21]. In addition, CO_2 affects rheological characteristics of fermented dough also producing aroma compounds [20,22]. Aroma compounds are formed widely in the crumb of bread and the most abundant compounds are alcohols, aldehydes as well as 2,3-butanedione (diacetyl), 3-hydroxy-2-butanone (acetoin) and esters [23]. Another desired feature of baker's yeast is using disaccharide melibiose. Baker's yeast should be osmotolerant, able to tolerate chemicals (salt, propionates), maintain a high growth capacity, should not aggregate and must have a good storage capability. In addition, during the drying process and after the addition of dry yeast to flour for dough making, the yeast must have a high rate of vitality [24].

Wine's Yeast

Yeasts are important microorganisms in wine microbiology. *Saccharomyces* able to make biotransformation of grape sugars into ethanol, carbon dioxide and several secondary products. It is a complex process and yeasts are responsible for this conversion [25]. Fast fermentation of grape juice sugars to high ethanol concentrations is essential for wine yeasts. Wine yeasts should exhibit uniform dispersion and produce minimal foam. At the end of the fermentation, sediment should be quickly taken from the wine. It is also important that the yeast should not give slow, sluggish or stuck fermentations [26]. Yeasts also make positive contributions to wine flavour by the synthesis of other minor metabolites that define the flavour, such as esters, acids, alcohols, aldehydes, ketones, polyols, volatile sulphur compounds which directly impact the wine flavour [27,28]. The non-Saccharomyces yeasts, commonly *Kloeckera* spp. and *Candida spp*., dominate at the beginning of the fermentation and affect the characteristics of wine [29]. The other isolated yeasts are *Metschnikowia, Dekkera, Pichia, Kluyveromyces, Issatchenkia, Saccharomycodes, Zygosaccharomyces, Torulaspora, Debaryomyces,* and *Schizosaccharomyces* [29]. The characteristics of wine yeasts must include some properties such as rapid initiation of fermentation, high fermentation effiiency, high ethanol tolerance, high osmotolerance, moderate biomass, high genetic stability, high sulphite tolerance, low sulphite binding activity, low foam formation, compacts sediment, resistance to desiccation, killer activity, genetic marking, proteolytic activity and low nitrogen demand. All these properties are found in *Saccharomyces cerevisiae* [30].

Meat Fermented Food

Yeasts are found on meat and processed meat products. They have also positive effects on fermented meat products and many yeast species such as *Candida, Debaryomyces, Pichia, Trichosporon, Cryptococcus, Rhodotorula* and *Yarrowia* have been isolated from fermented meat products, especially sausages [31,32]. Lipolytic and proteolytic activities, which contribute to flavour due to the production of volatiles, of those yeasts were described [33]. Most frequently isolated yeasts are *Yarrowia lipolytica* and *Debaryomyces hansenii* [34]. *Debaryomyces hansenii* is also used as commercial starter culture in fermented meat products due to its positive contributions on final product [33].

Diary Fermented Food

Yeasts such as *Candidam lusitaniae, Candida krusei*, *Kluveromyces lactis, Debaryomyces hansenii, Yarrowia, lipolytica, Kluyveromyces marxianus*, *Saccharomyces cerevisiae*, *Galactomyces geotrichum*, *Candida zeylanoides* and various *Pichia* species play essential role due to their important functions in dairy-based products such as contributing to the ripening of cheese, speeding up the maturation, improving texture and aroma characteristics of certain milk products, increasing pH of cheese, manufacturing of some metabolites like ethanol, acetaldehyde, CO_2, amino acids and vitamins, removing toxic end-products of metabolism, taking part in some interactions and contributing to the fermentation by supporting the starter cultures, preventing some undesired microorganisms those cause product quality default, inducing the growing of starter cultures by means of the utilization of organic acids, contributing to the flavour characteristic of dairy products due to the strong proteolytic and lipolytic activity, fermenting lactose and utilizing citric acid [35].

Cereal Fermented Food

Cereal and cereal crops are accepted as significant nutrients all over the world. Cereal grains and legumes are utilised as raw material for many foods and beverages in different countries and cultures [36]. Cereal based foods are usually performed by natural fermentations including mixed cultures of yeasts, bacteria and fungi [37]. Sourdough is a significant product for bakeries and it is characterized as combined activity of yeasts and lactic acid bacteria [38]. The most important function of yeasts in sourdough fermentation is metabolizing fermentable sugars for generating CO_2, increasing gas formation capacity, improving flavour and aroma, contributing to the texture of the crumb and the nutritional value [39].

Fermented foods and beverages have been an important part of our lives in all over the world. Their production is one of the oldest manufacturing and preservation methods, dating back to ancient times. Yeasts, mainly *Saccharomyces cerevisiae*, and lactic acid bacteria have long been used for the production of many fermented products. In food industry, yeasts have an important role in the production of alcoholic beverages, bioethanol, baker's yeast and yeast-derived products. Lactic acid bacteria also have a fundamental effect on the production of some food products such as yoghurt, fermented vegetables, sour-dough bread and others [40]. Yeast plays a vital role in the production of all alcoholic beverages. Yeast plays a vital role in the production of all alcoholic beverages and the selection of suitable yeast strains is essential not only to maximize alcohol yield, but also to maintain beverage sensory quality [41]. In wine fermentation, strains with specific characteristics are needed, for instance, highly producers of ethanol to reach values of 11–13%v/v, typically found in this beverage. Yeasts are largely responsible for the complexity and sensory quality of fermented beverages. During fermentation, yeast cells convert cereal-derived sugars into ethanol and CO2. At the same time, hundreds of secondary metabolites that influence the aroma and taste of beer are produced. Variation in these metabolites across different yeast strains is what allows yeast to so uniquely influence beer flavour [42]. Although most breweries use pure yeast cultures for fermentation, spontaneous or mixed fermentation is nowadays used for some specialty beers. Traditional ciders are produced from spontaneous fermentation of juice carried out by autochthonous yeasts, cerevisiae strains are also commonly used to carry out alcoholic fermentation. This ensures consistent quality of the finished products [43]. Some other non-*Saccharomyces* yeast species are involved in spontaneous fermentation of apple juice for cider production. However, these yeasts contribute at a lesser extent than *Saccharomyces* and can be producers of off-flavours [44].

Bread Fermentation

In addition to these three worldwide-famous fermented beverages, the fermentative yield of yeast cells during this fermentation is crucial and determines the final quality of the bread. Yeasts not only produce CO_2 and other metabolites that influence the final appearance of the dough, volume, and texture, and of course, the taste of the bread. Commercial bread producers currently produce various types of dough such as lean, sweet or frozen dough. Depending on the type of dough, and to obtain optimal fermentation rates, it is recommended to use suitable yeast strains with specific phenotypic traits [45].

Coffee Fermentation

Yeasts play an important role in coffee production, in the post-harvest phase. Its performance can be done in two phases. On the one hand, aerobically, in which the berries just collected are deposited in a tank and the yeasts are allowed to act. This process is carried out under control of basic parameters, such as time and temperature. This second process is more homogeneous and easy to control than the aerobic. Sometimes, coffee beans are even fermented in a mixed process, first in an aerobic and finally anaerobic manner [45].

Chocolate Fermentation

Raw cacao beans have a bitter and astringent taste, because of high phenolic content. Anthocyanins are one group of these polyphenols, and it both contributes to astringency and provides the reddish-purple color. Fermentation allows the enzymatic breakdown of proteins and carbohydrates inside the bean, creating flavour development [45].

Food spoilage

Although the yeast is having a lot of bifacials for food but it can spoilage food too. Yeasts are able to grow in foods with a low pH (5.0 or lower) and in the presence of sugars, organic acids, and other easily metabolized carbon sources [46]. During their growth, yeasts metabolize some food components and produce metabolic end products. This causes the physical, chemical, and sensible properties of a food to change, and the food is spoiled [47]. The growth of yeast within food products is often seen on their surfaces, as in cheeses or meats, or by the fermentation of sugars in beverages, such as juices, and semiliquid products, such as syrups and jams [48-50]. The yeast of the genus Zygosaccharomyces have had a long history as spoilage yeasts within the food industry.

Conclusion

Yeasts have been known to humans for thousands of years as they have been used in fermentation processes like wine, beer and bread making. Today, yeasts are also used as alternative sources of high nutritional value proteins, enzymes and vitamins, and have numerous applications in the health food industry as food additives, conditioners and flavouring agents, for the production of microbiology media and extracts, as well as livestock feeds. Modern scientific advances allow the isolation, construction and industrial production of new yeast strains to satisfy the specific demands of the food industry. *Saccharomyces cerevisiae* strains, the most common and commercially available yeast. They are well known for their fermentative behavior and technological characteristics which allow obtaining products of uniform and standard quality. Many other important industrial products are the result of fermentation, such as yogurt, cheese, bread, coffee. Yeasts also play a key role in wastewater treatment or biofuel production.

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