Mgr inż. Mateusz BAJERSKI
Mgr inż. Krystian KLIMCZAK
Dr inż. Monika CIOCH-SKONECZNY
Department of Fermentation Technology and Microbiology, Faculty of Food Technology
University of Agriculture in Krakow, Poland
Katedra Technologii Fermentacji i Mikrobiologii, Wydział Technologii Żywności
Uniwersytet Rolniczy w Krakowie, Polska

# APPLICATION OF THE OAK WOOD CHIPS IN BREWING®

## Zastosowanie płatków dębowych w browarnictwie®

*Oak chips are finely shredded oak fragments, which were toasted under strictly controlled conditions. They are produced in various grammages and degrees of toasting. Chips can be divided into natural, light, medium and heavily toasted. Their size affects how quickly ingredients are being released from them. The aim of the article is to present issues related to the application of oak chips in brewing, as an alternative to the oak barrels usage. The description presents information regarding the influence of the oak chips addition on the final profile of the drink and also characterizes the processes that take place during aging.*

**Key words:** oak chips, oak, barrel, beer, aging.

*Płatki dębowe to drobno poszatkowane szczapy dębowe, które zostały upieczone w ściśle kontrolowanych warunkach. Produkowane są w różnej gramaturze i stopniu opieczenia. Wyróżnia się płatki naturalne, lekko, średnio i mocno opiekane. Rozmiar zrębków wpływa na szybkość wydobywania się z nich składników. Celem artykułu jest przybliżenie zagadnień związanych z zastosowaniem płatków dębowych w piwowarstwie, jako alternatywy dla wykorzystania beczek dębowych. W opisie przedstawiono informacje dotyczące wpływu dodatku zrębków dębowych na końcowy profil napoju, scharakteryzowano również procesy zachodzące podczas leżakowania piwa.*

**Słowa kluczowe:** płatki dębowe, dąb, beczki, piwo, leżakowanie.

## INTRODUCTION

Beer has accompanied mankind since antiquity. Its traces can be found all over the world, from Europe, through the Middle East up to China. The production of this beverage became a part of the culture and tradition in many countries, such as the Czech Republic, the United States of America, Germany, Great Britain, Japan, and Poland. Before the advent of stainless steel, barrels were a typical vessel used for storage and transportation for nearly all liquids. The most common tree species, from which wood was obtained for their production was oak. Nowadays, wood barrels are generally made from French and American oak varieties. They gained recognition due to their hardness, durability, and waterproofness. Barrels filled with beer often traveled many kilometers, for example with the Vikings (since about 800 AD) or the British East India Company [7, 16]. Some styles of beer often had to be aged for about 6 – 12 months in wooden tanks, in order to soften their harsh taste. This was the case with the *porter* style. It was invented in England in the 18th century. It quickly gained widespread popularity not only in the originating country but was also a favorite style in the early days of the United States [8].

Wood aging is an old tradition that currently attracts the attention of brewers, looking for new, innovative products. Barrels are frequently used in an attempt to reproduce the original versions of the beers [16, 17]. Although this method is mainly used to obtain a broad range of flavors and aromas from wood, during barrel aging, the compounds extracted from wood also have an impact on color, they improve the properties of the drink and accelerate the maturation of beer. However, the production of these tanks is very expensive, and aging requires long periods of time. A more accessible and cost-effective alternative to the usage of oak barrels is to use fragments of oak wood, commonly known as flakes, shavings, silvers, or chips. Their additional benefit is the usefulness of the entire wood surface, not only 40% of the area inside a barrel [3, 4, 14, 20, 23].

**The aim of the article is to present issues related to the application of oak chips in brewing, as an alternative to oak barrels usage. The description presents information regarding the influence of oak chips application on the final sensory profile of beverage, moreover, the processes that take place during the aging were also addressed.**

## OAK WOOD CHIPS AS BEER ADDITIVES

Oaktree (*Quercus sp.*) is by far the most commonly used wood variety for the production of barrels suited to the aging of wines and spirits. The aging process changes the color and taste of the maturing beverage, as well as reduces

**Corresponding author – Adres do korespondencji:** Monika Cioch – Skoneczny, Katedra Technologii Fermentacji i Mikrobiologii, Wydział Technologii Żywności, Uniwersytet Rolniczy w Krakowie, ul. Balicka 122, 30-149 Kraków; e-mail: monika.cioch@urk.edu.pl

both its volume and alcohol content. The time required for the aging of alcoholic beverages varies depending on the characteristics of raw distillate, the origin of wood, size and treatment of the barrel, and the environment. Taste and aroma are affected by modifications in the composition and concentration of the chemical compounds. Such changes can be caused by direct extraction of the wood compounds, breakdown of the macromolecules, reactions between its ingredients and molecules of the beverage, as well as by oxidation, esterification, Maillard reactions, polymerization, or condensation.

However, the production of barrels is very expensive, and aging requires long periods of time. A more economical alternative to using oak barrels is to use pieces of oak wood, commonly known as chips. This practice has been approved and passed by the European Community (EC 2165/2005 and EC 1507/2006), although it is also utilized in some non-European countries, such as Australia and South Africa. The composition of the final product is mainly influenced by the botanical and geographical origin of oak used. During the aging process, parameters such as the size of an oak piece, amount of wood used, and degree of toasting (low, medium, and heavily toasted) are also important [4, 14, 21, 22].

Application of oak chips, especially charred or roasted, accelerates the aging process, and their use is also the easiest method of adding wood-derived compounds. They are more and more often used for the aging of strong liquors, such as Brandy. The utilization of oak chips is a part of the traditional good brewing practices, is legally permitted and prevalent in commercial winemaking. A new technique was introduced in this field - insertion of wood pieces (oak shavings or staves) into the tanks. This offers some distinct and previously unavailable flavor advantages, and also wine modification possibilities. Oak chips in various sizes are available in the market and are used to compensate for a low level of extractable ingredients in the old barrels. They provide an environment resembling one found in the barrel. As wood is put into the wine and not the other way around, the entire surface is usable, not only 40% of the area inside a barrel [2–4, 14].

In the case of higher-quality spirit beverages, the aging process often takes place slowly over several decades. Prolonged periods of aging, along with high prices of the barrels and the need for their maintenance or replacement make the product more expensive. In order to accelerate the changes that undergo in a barrel, alternative systems have been proposed, that mainly rely on rapid aging by addition of oak fragments or extracts into the beverages. It has been found that when using extracts or oak chips, amounts of wood-derived compounds in beverages are very abundant, to the point they are even higher than in cases when distillates are aged in the barrels. Particularly, there is a significant amount of phenol and furan compounds. However, the aging process conducted by the addition of oak chips can be considered incomplete, since oxygen that penetrates through the barrel's staves during long periods of maturation has a significant influence, in sensory and chemical terms. Oak products, such as shavings, cubes, powders, or immersed staves are useful when an alternative to obtaining the flavor and aromas from a barrel is desired. They have become popular in the winemaking industry, thanks to their ability to be used not only in stainless steel tanks but also in barrels, which after repeated use, have a minuscule or no impact at all on the taste of liquor. Alternative oak products could be cost-effective and readily available for most of breweries [4, 14, 16, 20].

## CHARACTERISTICS OF THE OAK BARRELS

Oak is a hard, strong, durable, and waterproof timber. There are hundreds of oak species, which can be divided into two broad categories: red and white. Red varieties are porous and rarely used for barrel production. Nearly all wooden containers used for wine, beer, and spirit beverages are made from white oak. The ones used for wine are typically crafted from French (*Quercus robur*, *Quercus petraea*) or American (*Quercus alba*) oak, although oak wood from Eastern Europe is also used. Barrels are a modern era invention, and they were unknown in ancient times. At that time, clay amphoras were used to store and transport wine. The main stages of barrel production are selection and cutting oaks from the forest, splitting logs into staves, seasoning wood thanks to which it is possible to reduce its high moisture content, and finally assembling the barrels from staves. This last stage involves bending and toasting operations, during which various chemical reactions take place, which leads to the formation of aromatic compounds from neutral wood biopolymers. The aim of the aging process is not only to enhance the organoleptic properties of alcoholic beverages but also to develop other attractive attributes, such as increasing their antioxidant capacity. A number of drinks such as cognacs, whiskey, brandy, vinegar, mescal, and wine increased their antioxidant capacity after they had contact with wood. Prior to the stainless steel, oak barrels were a typical vessel for storing and transporting almost any fluid. Water, beer, wine, olive oil, rum, chili sauces – all traveled the world in wood. Initially, there wasn't a particular intention that it would impart a sensory characteristic to a liquid [2, 16, 20, 22].

Until the 20th century, most of the beers were delivered to the bars in wooden barrels. Since the 19th century, brewers have worked really hard to elude wood-derived aromas in beer. To accomplish that, new barrels, usually made from oak, were successively filled with portions of boiling water and hydrochloric acid. German, and later American brewers smeared them with tar, minimizing both wood ingredients transfer and possible leakage. Over time, stainless steel containers took over the beer industry. Nowadays, craft brewers, especially in the United States, have once again introduced wooden barrels and their derivatives to the brewery, but this time the goals are completely different. The barrel is no longer an ordinary vessel. A modern brewer ages a beer in wood so that it influences its taste and aroma. We are talking here primarily about oak varieties, however, other tree species are also used. Chestnut, ash, poplar, cedar, acacia, cypress, redwood, cherry, pine, and even eucalyptus have been used with varying degrees of success. When heated and steamed, oak easily bends into barrel staves, and the structure of the wood makes it water-resistant. Oak wood, despite this distinctive attribute, is also porous and has a complex range of flavors that can be brought into beer. In the United States, where oak aging has become common among craft breweries,

the most commonly used barrels are one in which bourbon matured. According to the United States law, whiskey labeled as "Bourbon" must be aged for at least 2 years in new barrels made from American white oak. This implies that barrels can be used only once to mature an authentic Bourbon whiskey, turning an already used one into surplus at the distillery. A common practice in cooperage, considered to be the most important technological step, is oak wood toasting. High temperatures modify wood's physical structure, which is crucial to facilitate the shaping of the staves. What's more important, oak's chemical composition undergoes significant amendment due to thermal degradation of the polymers. Each distillery uses its own blend of oak and degree of charring, which leads to a significant difference in types of flavors, which breweries use to impart desired characteristics to their beers. Whilst most of these barrels are used for the aging of everything, from Scotch whiskey to high-grade tequila to Tabasco sauce, more and more of them end up in the hands of the American craft breweries [2–4, 16, 20].

Oak itself brings many flavors, which differ vastly depending on the species, area of cultivation, and the way the wood was processed. The compounds within oak wood contribute to the improvement of aroma, taste, and color, as well as enhance the "palate fullness". Oak barrels are commonly used for wine aging because they improve quality, increase color stability, induce spontaneous clarification, modify its composition due to the compounds obtained from wood, and are responsible for a more complex aroma. Oak wood consists mainly of three large insoluble polymers – cellulose, hemicellulose, and lignin. It also contains other compounds characterized by a lower molecular weight, such as volatile and non-volatile acids, sugars, steroids, terpenes, volatile phenols, and lactones. Many compounds called lactones derived from lipids are responsible for a considerable number of aromas and flavors which are associated with oak. In lower concentrations, lactones are simply perceived as "oaky" and pleasantly herbal, at a higher level their aroma can become rose-like, and in the highest, they give a strong coconut impression. A secondary perceivable trait is the vanilla flavor, derived from a mixture of vanillin and syringaldehyde, which may be pleasant at a lower concentration, but can easily dominate other tastes and aromas. The mild heat applied to the barrels during their toasting promotes the conversion of lignin compounds into vanillin and syringaldehyde [10, 20, 21]. Hemicelluloses, polymers composed of several simple sugars, are another component of the wood structure. When heated, they break down into constituent sugars, which subsequently caramelize into furfural, maltol, and cyclotene, which bestow flavors ranging from bitter almonds to sweet caramel and burnt sugar. Maltol, which has caramelized flavor, reminiscent of freshly baked bread is also a flavor enhancer and may intensify the perception of sweetness in a beer. Furfural contributes to imparting it a character of dried fruits, and in contact with yeast, it can be converted from the taste of roasted almond into a smoky and leathery, which is desirable in some aging beers. In addition, volatile phenols, such as eugenol (clove) and 4-vinylguaiacol (cinnamon-like) along with flowery, fruity terpenes are present [11, 15, 20]. Oak also contains tannins, which in beer undergo hydrolysis and get broken down into other compounds. They may impart tartness, however, this is prevented by their decomposition during toasting of the barrels, mostly during charring. Tannins are also a potent antioxidant. Oak wood is the only known source of roburins. Their main source in a human diet comes from the consumption of wine and spirits (cognac and whiskey), traditionally matured and stored in oak barrels [3, 12, 15, 16, 18, 19, 21]. Since craft breweries became more popular, especially in the United States, many of them were looking for new and unique methods to improve the flavor of their beers. They soon found out that using spent oak barrels, that once kept bourbon, whiskey, wine, or to a lesser degree brandy, sherry or port could produce a distinct flavor. Bourbon and whiskey barrels are most commonly used for beer types such as a stout or barley wine. Barrel type and maturation time are the two variables, equally important for the quality of the final product. Both of those aging parameters in whiskey and cognac production are defined according to the international or local legislation regarding product name. According to the European countries tradition, brandies are stored for at least two years (sometimes for several decades), in different wooden barrels. New, unused barrels can also be used for beer aging, however, they are unpopular due to the high cost. Flavors, which a new oak can contribute are wooden, vanilla, dill, or toast. After acquiring used bourbon or whiskey barrels, breweries can rinse them or pour beer directly into the remaining liquid. Rinsing or cleaning the barrel leads to attaining softer, more subtle flavors. However brewers often pour beer directly into the barrel, disregarding cleaning, and even if there is still a liter or two of the previous liquor, it comes with sanitary benefits, especially if the previous product was a whiskey. Since barrels contain a finite pool of extractable material, the amount of volatile compounds available for extraction decreases over time. As a result, most of the barrels are withdrawn from operation after 5 or 6 years [4, 6, 12, 16, 20].

Breweries utilizing wine barrels often use them in combination with "wild" *Brettanomyces* yeasts and bacteria, such as *Lactobacillus* and *Pediococcus*. In some cases, brewers might want to extract from wood the remaining small amount of oak taste and tannins. There is also a possibility of trying to obtain any remaining qualities of wine and other liquors, which may remain in the wood. Finally, brewers use wooden barrels as a place to store microflora, such as *Brettanomyces*, *Lactobacillus,* and *Pediococcus*. Even though they are considered as the bane by the majority of brewers and winemakers, they are essential in creating many styles of sour beers, inspired by the Belgian tradition. Beer without the aforementioned yeasts and bacteria is more vulnerable to oxidation because secondary fermentation which ensures a protective barrier of carbon dioxide in the barrel does not take place. Micro-oxygenation is a slow and steady penetration of oxygen into beer through porous wood in the barrels and has many advantages. Brewers as well as winemakers can choose barrels from French or American oak. French varieties are more porous than American ones, which allows for greater diffusion of oxygen through the wood itself. Micro-oxygenation of beer has an immediate effect on acetic bacteria growth (*Acetobacter)* in sour beers. *Acetobacter* requires oxygen for its growth, and the more of this chemical element means the more acetic (vinegar-like) nature of the drink is, which may or may not be desired. Barrels, which are not full (leaving the empty space) may also lend a vinegar feel to the beer. Aging

alcohols using oak chips can be considered incomplete. When added, oak chips start to soak up and release oxygen adhered to their surface. It isn't considered as oxygen originating from wood, as it is not trapped in its porosity. When the liquid starts to fill the empty spaces inside the barrel's wood structure (wood porosity), the air contained in it can begin to seep into the liquid [1, 9, 13, 14, 16].

Similarly to winemakers, brewers also have to take into the consideration size of the barrel. Most of them regard barrel capacity of 219–227 liters to be the standard size. Smaller barrels may provide a larger oak surface area to contact beer. This results in more abundant flavor, but can also lead to excessive diffusion of oxygen. Large oak containers provide a smaller oak area, and may potentially protect the beer from too much oxidation. However, most brewers decide to use more standard-sized barrels, to provide more mixing capabilities. Standard-sized barrels are also easier to acquire [6, 16].

## TYPES OF OAK CHIPS

Oak chips are finely shredded oak fragments, which were toasted under strictly controlled conditions. They are produced in various grammages and degrees of toasting. Chips can be divided into natural, light, medium and heavily toasted. Their size affects how quickly the ingredients are being released from them. Much faster extraction of aromas in smaller chips allows for their usage as early as in the beverage fermentation process. Bigger chunks work well in the aging process of beers/wines. Different degrees of toasting affect the nature of aromas released.

### American oak chips

American oak imparts the liquids with a strong flavor, which is additionally emphasized by the usage of charring inside the barrel. In America, *Quercus alba* oak is widely used, the wood of which is richer in lactones than European varieties. It is intensely aromatized, hence it's sparingly used in wine production as it can overwhelm the aroma of the beverage itself. Nevertheless, it's one of the most popular types of wood. Lactones tend to impart a coconut flavor, which is particularly noticeable in this variety. Aging the wine spirits in contact with this oak variety improves the quality of alcohol [4, 5, 16, 20, 21].

### French oak chips

In Europe and France, *Quercus petraea* (known as sessile) and *Quercus robur* (also known as pedunculate) oak varieties are used. French oak is famous for its delicate mellow character and is preferred by many wine producers, as its contribution to flavor appears to be very refined and balanced. This wood is dense, and as a result, it is also much more expensive as compared to an American oak. In Belgium, breweries that produce *lambic* beers have always bought used French wine barrels for beer aging. Furthermore, oak wood, especially from the French Limousin region (mainly *Quercus robur* L.) is traditionally used to age wine spirits, including those most recognizable in the world: cognac and armagnac [2, 4, 5, 16, 20, 21].

## CONCLUSION

Wood aging is an old tradition, which currently attracts the interest of brewers looking for new, innovative products. This method is mainly used in order to acquire a broad spectrum of flavors and aromas from wood. During barrel aging, compounds extracted from wood also influence color, improve beverage characteristics and accelerate beer maturation. However, the manufacturing of these containers is very expensive, and aging requires long periods of time. A more accessible and cost-effective alternative to the usage of oak barrels is to use fragments of oak wood, commonly known as chips. They are made from two main species of oak, but even within a given species, there is a wide variety regarding the properties of wood. Additionally, mixing shavings allows achieving a rich, complex flavor effect that cannot be obtained in a barrel, even after many months of aging. A definitive advantage of oak chips, in comparison to barrels, is the utilization of their entire surface, which is directly related to a shorter time needed for permeating flavors into the beverage. On top of that, they are more convenient to use than barrels, ecological, and low-priced.

## PODSUMOWANIE

Leżakowanie w drewnie to stara tradycja, która aktualnie cieszy się zainteresowaniem piwowarów poszukujących nowych, innowacyjnych produktów. Metodę tą stosuje się głównie w celu uzyskania szerokiego spektrum smaków i aromatów z drewna. W trakcie dojrzewania w beczce, ekstrahowane z drewna związki wpływają na kolor, poprawę właściwości napoju oraz przyspieszają starzenie się piwa. Produkcja tych zbiorników jest jednak bardzo kosztowna, a leżakowanie wymaga długich okresów. Łatwiej dostępną i bardziej ekonomiczną alternatywą dla stosowania beczek dębowych jest używanie fragmentów drewna dębowego, zwanych potocznie płatkami. Wykonuje się je z dwóch głównych gatunków dębów, ale nawet w obrębie danego gatunku, występuje duże zróżnicowanie pod względem właściwości drewna. Dodatkowo, mieszanie wiórów pozwala na uzyskanie głębokiego, złożonego efektu smakowego, jakiego w beczce uzyskać się nie da, nawet po wielu miesiącach leżakowania. Zdecydowaną zaletą płatków dębowych, w przeciwieństwie do beczek, jest wykorzystanie całej ich powierzchni, co wiąże się bezpośrednio z krótszym czasem potrzebnym do przenikania substancji smakowych do napoju z drewna. Oprócz tego, że są one wygodniejsze w użyciu niż beczki, są również ekologiczne i tanie.

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