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THE DEVELOPMENT OF THE CRAFT BEER MARKET, MICROORGANISMS, UNCONVENTIONAL ADDITIVES AND THEIR IMPACT ON THE FINAL PRODUCT

S u m m a r y

Background. The modern brewing industry is currently undergoing enormous and rapid changes in many countries around the world. The growing number of craft breweries and microbreweries is a challenge for large beer companies due to the emergence of new beer styles and interesting additions that give the consumer a much wider choice than classic light lager. The aim of this publication is to present changes taking place in craft brewing in Central and Eastern Europe and further prospects for the development of this sector.

Results and conclusions. This review presents a literature study of key insights influencing the development of craft beer and the transformation of the brewing industry. The history of the global beer revolution and its significance for the development of the craft brewery market in Central and Eastern Europe were briefly presented. This paper also discussed the role of microorganisms and innovative additives used in the production of craft beer , influencing not only its taste, but also the increase in nutritional value and, consequently, greater market interest in this type of beer. Opportunities and prospects for further development of this type of beer, both in Poland and in Central and Eastern Europe, are promising. Craft breweries have made a real revolution on the beer market, influencing consumer preferences, contributing to the improvement of quality and the diversification of the offer on the beer market. When purchasing such a product, the consumer is more aware of the sustainable use of local raw materials in its production.

Key words: craft beer; brewer's yeast; lavender; propolis; polyphenols

Introduction

The craft beer revolution has changed the brewing industry for good. New styles of beer have emerged, with interesting accessories and colorful labels. The consumer now has much more to choose from than just classic light lager.

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As consumers' expectations have grown, so has their awareness, raising standards for traditional industrial microbreweries [81, 83]. These microbreweries, in turn, are responding to the needs of the market, creating corporate beers in the styles associated with the craft beer revolution [81]. However, often these do not gain the acceptance of the craft beer community, whose members are often distrustful of larger breweries. Microbreweries are thought to publish materials that can mislead the consumer. The Polish Association of Craft Breweries has protested against the use of the term "craft" on marketing materials for beer brewed by large breweries with extensive technological facilities, having little in common with craftsmanship [62].

Craft brewing is considered a passing fad by some, while for others it represents a lifestyle. One thing is certain: changes taking place in brewing are irreversible. Along with the craft beer revolution, interest in home brewing, specialty malts, rare yeast strains and new hop varieties has increased [19, 64]. There are increasing numbers of craft beer pubs with large rotating tap lists, specialist stores offering beer from around the world, beer blogs and websites where users can rate beers, such as Untappd, which has eight million users [19, 41, 62, 64, 72].

The craft beer revolution began in the US, where consumers bored with light lager began to demand more interesting aroma and flavor notes [39]. An important event took place on 14 October 1978, when the then-president Jimmy Carter signed a law making home brewing legal [24]. According to the Beer Judge Certification Program (BJCP), 126 beer styles can be distinguished today [6].

The US Brewers Association describes craft breweries as small, independent producers that use traditional methods. They brew less than six million US barrels per year, are less than 25 % owned by non-craft brewers, and most beers are made with 100 % malt [57]. Craft beer sometimes costs several times more than industrial beer, but has an unparalleled taste that is hard to compare with beers brewed by larger breweries [82, 83].

In recent years, there has been a notable decline in the sales of industrial beer, while craft beer shows the opposite [73]. Overall beer consumption, including from craft breweries, in the largest countries in the world is: China recording the highest consumption of 489.9 million hectoliters each year, followed by the United States (241.7 million hectoliters), Brazil (131.5 million hectoliters), Russia (100,1 million hectoliters) and Germany (84.4 million hectoliters) [10, 24].

This article presents a literature study on key insights influencing the development of craft beer and the transformation of the brewing industry in Central and Eastern Europe over the last two decades. The aim of this publication is to present the changes taking place in craft brewing in Central and Eastern Europe and further prospects for the development of this sector.

The Development of the craft beer market in Central and Eastern Europe

The brewing industry in Europe has undergone significant changes in the last twenty years [49]. These changes particularly affect the Eastern European market, where the rolling revolution has led to the loosening of barriers to international companies entering into certain beer markets. As a result of the progressive consolidation of breweries, the number of active breweries in the world has decreased [12, 49].

Modern beer production in the world is under the control of several large brewing groups: Anheuser-Busch InBev (AB InBev, Leuven, Belgium), including SAB Miller (London, UK), Heineken (Amsterdam, the Netherlands) and Carlsberg (Copenhagen, Denmark), Asahi Group Holding (Japan) [39, 10]. Additionally, the Asahi group has significantly influenced the group's beer production market in Eastern Europe. The concern took over from SABMiller in five countries of Eastern Europe the breweries of, among others, Kompany Piwowarska (beers: Tyskie, Zubr and Lech), Czech Pilsner Urquell, Slovak Topvar, Ursus in Romania and Hungarian Dreher [10, 39, 83].

The success of craft beers is influenced by the homogeneity of beers offered by large production concerns. On the other hand, there is a trend towards setting up craft breweries as a response to mass production [10].

In the case of craft beers, the possibility of choosing different varieties of hops, local grain, unconventional starchy ingredients, the addition of local fruit, herbs, spices and vegetables to brew a unique taste and aroma is not without significance for brewing beer [20, 49]. In addition, a recognizable trademark of craft breweries is the production of small batches of beer, which allows for experimenting with ingredients much easier than in the case of industrial production. Production in craft breweries, for example in Slovakia and Poland, is up to 200,000 hl/year, in the Czech Republic 10,000 hl/year, while in the USA 23,848 hl/year [49, 61]. The term craft brewery in the USA means production up to 9,539,200 hl/year, while in the Czech Republic, the terms craft brewery and microbrewery do not differ, it is always a brewery with a production capacity of up to 10,000 hl/year, in which beer is brewed to traditional recipes, unfiltered and unpasteurized [10].

Another change that has influenced the brewing industry is the relocation of beer consumption outside Europe [2, 10]. Beer consumption in Europe is stagnating or even decreasing [10, 49]. The overall consumption in the EU countries amounted to 359 million hectoliters in 2016, of which consumption in the Czech Republic accounted for 15.1 million hectoliters, or 4 % of the total consumption in the EU [10, 49]. The Czech Republic thus has the highest beer consumption per capita in Europe - 144 l, followed by Germany - 107 l, Austria - 104 l, Poland - 93 l, Lithuania - 95 l and Slovakia 73 l [10]. Handicrafts accounts for 3 % ÷ 5 % of total beer consumption in Western Europe and the USA, while in Eastern Europe it is only about 1 %, and in the Czech Republic alone it is estimated to be around 2.5 % [10, 24, 49, 83]. All of the above changes lead to an increase in the number of craft breweries not only in Central and Eastern Europe, but also around the world.

Consumer type and the craft beer market

The low-alcoholic beverage segment is mostly targeted at young consumers aged 18 ÷ 25. Young people are not loyal to brands, which leads to discussions about the effectiveness of large companies' advertising. According to 43 % of young Americans, craft beer tastes better than industrial beer [24, 33], and the craft beer industry is developing thanks to such attitudes. As a result, they pay attention to the price of products they buy [33, 51].

Craft beer is seen by young people as a more sustainable product [33, 51]. To support a history of sustainability, craft beer fans are increasingly looking for basic information about beer, such as its ingredients or history [13, 83]. Moreover, not only young consumers aged 18 ÷ 25 are starting to see the link between local ingredients and sustainability [51]. They make choices based on health considerations, in addition to the ingredients of beer, they also focus on the method of making the drinks. The report [51] revealed that 54 % of consumers buy beer based on advertising about ingredients, and 39 % pay for beer with local ingredients. This is a huge opportunity for breweries, and many of them are responding to these needs with more sustainable processes that help make more planet-friendly brewing practices and norms, and usher in a new wave of more sustainable flavored beers that consumers crave [13, 74] .

A survey by the DSM Global Insights Series [74] of 3,300 craft beer drinkers in seven European and American countries, most of whom (80 %) said they did not believe craft beer was just a passing fad. Craft beer drinkers love the wide range of beers on offer, with 75 % saying the taste of this beer is above all else. It is them who decide about the purchase. Looking ahead, half (50 %) of the consumers surveyed say they think craft beer is more sustainable and a sustainable product more attractive - a trend that will only grow in the coming years [74].

Established artisan breweries thus have a role to play in meeting consumers' growing demand for high-quality, innovative drinks that align with their responsibility to contribute to a better, more sustainable world. This will be essential to capturing the next generation of consumers, as well as future generations [13, 74].

The Polish craft beer revolution

Poland ranks third among the countries of Central and Eastern Europe in terms of beer production. In 2018, Polish breweries brewed 39.9 million hectoliters of beer. About 70 % of the Polish market is held by Asahi group and Heineken, with the Carlsberg group coming third [49, 83]. The culture of beer drinking in Poland dates back to the beginning of the tenth century, and today beer is one of the most popular beverages, next to water and tea [62, 81, 82], as a result of this consumers have become more demanding [62]. These rising expectations have created a place in the market for breweries producing craft beer. According to the Polish Association of Craft Breweries, craft beer makes up about 0.4 ÷ 0.5 % of the market [62, 63, 83]. During the Polish People's Republic period (1947 ÷ 1989), beer was pushed to the sidelines and was identified with people from lower social classes, being drunk occasionally when taste and quality were not a concern [49, 82]. By 2005, craft breweries had begun to appear in Poland, initiating the fashion for beers produced without pasteurization [82]. However, this was not enough for more demanding consumers. People started going back to old folk recipes for beer styles that had been long brewed in Poland, as well as to recipes for beer from other parts of the world [63, 82]. There was a breakthrough in 2010 when the brewery in Grodzisk Wielkopolski, after an interruption of over a hundred years, began again to produce Wielkopolska beer, which was traditionally made in Poland from the eleventh century [81, 83]. Almost a year later, on 28 March 2011, the brewery Pinta launched the beer Atak Chmielu; this date is considered the birth of the Polish craft beer revolution [82, 83]. This gave rise to a craft beer revolution, with a sudden increase in the number of small breweries, including brewpubs and business contracting production plants to produce beer ("contract breweries") [62, 72, 82] . Craft breweries specialize in new wave beers, which tend to be ales, in the broad sense of using top fermenting yeast; this distinguishes them from the production of lagers using bottom-fermenting strains, typical of large companies.

There are also websites and beer blogs on social media [41]. In Poland, the most popular beer blogger is Tomasz Kopyra, whose YouTube channel has over 120,000 subscribers. The beer festivals in Poznan, Krakow and elsewhere have also served to popularize of craft beer [41].

Diversity decisively distinguishes craft brewing from large-scale brewing, with about 1,600 new beers appearing in Poland each year [73]. Consumers seem to be bored with the pale "eurolager" style. Industrial beer is positioned through promotion alone, with differentiation usually occurring only in the marketing, and not in the product. On the other hand, innovations are much more common in craft breweries, which primarily focus on ideas, and are thus able to take a risk in terms of their products [73, 82].

Innovative additions used in the production of craft beer

The assortment variety of craft beers depends on the additives used during production. These additives make it possible to obtain beer with a wide flavor and aroma profile, attractive to the consumer [15].

An example of an interesting additions used in the production of some craft beers is ginger (*Zingiber officinale Roscoe*) [77], a herbaceous plant belonging to the *Zingi-*

beraceae family, which is commonly grown in tropical and subtropical regions [76, 77]. The rhizome is the most important part of the plant, often used to improve the taste and aroma of food and for pharmaceutical purposes, due to its high content of bioactive compounds [48, 76]. The distinct aroma of ginger is due to the presence of volatile compounds, such as camphene, geranyl acetate, borneol, geraniol, limonene and terpenes. Nonvolatile molecules are responsible for a sharp, hot sensation in the mouth [32]. This is the main reason for interest in ginger in the food industry, as a raw material for the production of alcoholic beverages, carbonated beverages, soft drinks, bakery products, spices and preserves [48, 77]. Ginger is an example of a spice that was quite popular, even before the craft beer revolution began [77]. It is used both by smaller breweries, which are known for creating new recipes and continuous experimentation, but also by larger brewing concerns. Beer with larger amounts of this spice may have a warming effect, as well as antibacterial and antifungal properties [69]. Ginger also has an anticancer effect [52], which has been confirmed in the prevention and treatment of prostate cancer [84] and breast cancer [86].

Another example is lavender, an interesting herb that brings health properties to beer [44]. Lavender (*Lavandula angustifolia*) is a herb grown in North Africa and Mediterranean mountains, partly for its essential oil, which comes from the distillation of certain lavender inflorescences [34, 80]. It is primarily used in medicine to treat anxiety and fungal infections, and also has applications in dermatology and in the treatment of wounds. Some varieties of lavender have been used as additions to baked goods and dishes [34]. This herb stimulates urine production and improves digestion, reduces emotional stress and anxiety, heals burns and wounds, has a positive effect on sleep and reduces acne [27, 45].

English lavender is the most commonly used variety. It is grown around the world and fragrant oils of its flowers are used in candles, cosmetics, detergents, massage oils, perfumes, powders, shampoos, soaps and tea [45, 80]. Other lavender species include *Lavandula burnamii, L. dhofarensis, L. latifoliate,* and *L. stoechas* [80]. The lavender herb contains over a hundred ingredients, including linalool, perillyl alcohol, linalyl acetate, camphor, limonene, tannins, triterpenes, cineole and flavonoids [45, 80]. Lavender herb also has cytotoxic properties [26]. It has been shown that caffeic acid, a component of lavender, has an antioxidant effect [6, 70, 80].

As an addition to beer, it can be used in farmhouse styles based on folk brewing recipes [44]. Lavender has an intense floral flavor with a hint of bitterness. The lavender aroma is spicy and slightly floral with shades of mint and lemon, therefore it gives the beer a unique flavor [44]. Lavender can be used as a substitute for hops in so-called gruit beer.

Next interesting addition in the production of beer is bee propolis, a natural product that has great potential as a functional food addition, due to its range of bioactive compounds with many functional properties (including antioxidant, antibacterial, anti-tumor, antifungal, anti-inflammatory, antiviral and anticancer) [19, 78]. Propolis is a sticky and resinous natural product collected by bees (*Apis mellifera*) from harvested plant exudates, leaves and buds; these are mixed with pollen, wax and the salivary enzyme β-glucosidase [79]. The chemical composition of propolis varies with season, geographic origin, botanical origin and a collection mechanism. Over 300 compounds, such as phenolic acids, esters, flavonoids (flavones, flavanones, flavanols, dihydro-flavonols, and chalcone), terpenes, amino acids, caffeic acid, phenyl esters, aromatic aldehydes and alcohols, fatty acids, stilbenes and steroids have been identified in propolis. The variability of propolis composition hampers its functional application and quality control [4]. Overall, propolis consists of 50 % resin and vegetable balm, 30 % wax, 10 % essential and aromatic oils, and 5 % pollen and various other substances, including organic residues [4].

Juniper is an equally interesting additive used in beers. In the Finnish Shahti beers, it is used as a substitute for hops. Juniper is a plant with fungicidal properties but, like hops, is a diuretic [75]. Some other spices and herbs used in the production of beers include garlic, milk thistle, pumpkin, pepper, salt, coriander, Mediterranean herbs and chili [36]. Herbs and spices are also used in some styles of beer [75]. Spices such as allspice, anise, cardamom, cumin, cinnamon, cloves, coriander, gingerbread, blueberries and vanilla beans, as well as herbs like heather and mint, can be used to enhance the flavor of infusions [75, 36]. For example, Belgian Witbier uses coriander, and certain traditional English beers are made with honey and spices – with pepper [3, 17, 38, 43, 75].

Fruit and vegetables are also a valuable addition to craft beers. Fruit (as whole or in the form of juice) is among the most studied supplements and is already present in many commercial products [17, 54]. For example, in Poland Cornelian cherry (cv. Podolski) is a popular addition to beer brewing. They cause an increase in the content of polyphenols in beer and their antioxidant activity. They give beer a sour taste [1, 42]. On the other hand, in Croatia, the Chestnut beer additive used increases the alcohol content in the product and deepens its color. Whereas, eggplant (cv. Classic) peel extract is a vegetable used to brew beer in Romania [35]. Its addition has the effect of increasing antioxidant activity, phenolics and flavonoids content, and obtaining reddish color due to the release of anthocyanins [35]. The region of Central and Eastern Europe, however, despite the developing sector of the production of craft beers, is relatively little known in terms of specific additives. There is no extensive literature data on this subject.

More than yeast

Human activity resulted in the domestication of *Saccharomyces cerevisiae* yeast, specifically adapted for beer production [29]. The use of different yeast strains contributes to obtaining insights into beer products with diverse sensory characteristics [23]. The choice of wort fermenting yeast strains and beer conditioning is crucial, as the abundancy of many aroma-active compounds in beer is directly linked to the yeast strain applied [7, 60]. Every brewing yeast produces relevant aroma components, i.e. higher alcohols and esters. The levels of each of these compounds found in beer depend not only on the fermentation conditions but also on the yeast strain [75]. The item of the use of specific yeast types is to increase fermentation efficiency, to develop new beer characteristics, and especially to enhance the sensory complexity of the final beer produced [5]. Depending on the style of beer, temperature and flocculation ability, yeast is divided into two main groups [17].

The first group includes those belonging to the spec *S. cerevisiae*, which are suitable for top-fermented beers, where the process takes place at higher temperatures (16 ÷ 22 °C), have flocculation properties or may show the ability to aggregate at the top of the vessel after the end of fermentation. In the second group, there are natural hybrids, known as *Saccharomyces pastorianus* (syn. *S. carlsbergensis*), suitable for the lager style; they ferment at lower temperatures (6 ÷ 16 °C) and settle at the bottom of the vessel at the end of fermentation [17, 58]. These two styles also require different maturation periods: lager beers undergo a long, low-temperature maturation period (aging), while but beers mature more quickly [17, 58].

Recently, it has been shown that present-day industrial beer yeast has originated from a handful of domesticated ancestors. The genetic analysis performed showed that most strains of *S. cerevisiae* used in the production of ale-type beers was genetically distinct from the wild strains and mainly grouped into two independent lines, called Beer 1 (which consists of three separate strains from Belgium/Germany, Great Britain and the United States) and Beer 2 (which contains yeast from Belgium, Great Britain, the United States, Germany and Eastern Europe) [29, 37].

S. pastorianus are descendants of natural hybrids between the mesophilic species *S. cerevisiae* and the cryotolerant parent of *Saccharomyces non-cerevisiae* [37]. The origin of these lager-brewing hybrids has been a subject of dispute for decades [65]. Some studies have confirmed an association between parental strains other than *S. cerevisiae* and genetically complex species of *S. bayanus* [37, 65], a heterogeneous group of cold-resistant strains, including *S. bayanus* and *Saccharomyces uvarum*. In 2011, Libkind et al. [46] for the first time described the cryotolerant species *S. eubayanus*, the genome which matched the subgenome of lager strains. The reconstruction of hybrid lager genomes showed that *S. pastorianus* was formed around 500–600 years ago as a result of the hybridization of various strains influenced by socio-cultural changes taking place in the Middle Ages in Central Europe [37].

The most important change in the evolution of bottom-fermenting yeast was made in 1516 in Bavaria with the introduction of the Reinheitsgebot Edict, the Beer Purity Act, which mandated the production of beer during the winter months (September 29 to April 23) [29]. This ensured greater stability and less bacterial contamination of brewed beers. At the same time in the Czech Republic, brewers tried to store beer in cool mountain caves to improve the taste of beer [36]. The necessity to conduct fermentation at a lower temperature favored interspecies hybrids of *S. cerevisiae* × *S. eubayanus* over parent populations. It was believed that *S. eubayanus* was initially a wild contaminant in the brewing process with a selective advantage over native yeast but growing better at lower temperatures [37]. However, strains of *S. eubayanus* have so far only been isolated in the wild, but not in the brewing community, and have never been found in Europe. Further genetic studies showed that *S. pastorianus* strains are divided into two distinct lines corresponding to the geographical distribution of the breweries: Saaz lager yeast (hybrid group I or *S. carlsbergensis*), Frohberg type lager yeast (hybrid group II) [37].

An example of a European region where traditional yeast cultures are still being used is western Norway, where a number of farmhouse brewers have maintained the traditional yeast types of this region, some reportedly for hundreds of years [16, 64]. Norwegian farmhouse ale is produced predominantly from malted barley and is typically hopped, and also infused with juniper branches [60, 64]. Until recently, the yeast cultures, referred to as kveik, a dialect term for yeast in this region, were geographically isolated and maintained only locally by traditional farmhouse brewers [17, 64]. It is hypothesized that kveik yeast is domesticated, as beers produced using this type of yeast are reported to be free of phenolic off-flavors (POF) and this yeast is potentially capable of rapidly fermenting malt-derived sugars due to the reported short fermentation times where the temperature range of the process is 25 ÷ 40 °C with an optimal range of 35 ÷ 40 °C [64].

Thus, the fermentation process plays a key role in the production of aromatic alternative ingredients, as yeast metabolism strongly influences not only the alcohol yield from maltose and maltotriose, but also the flavor and aroma of the brewed beer [22, 47]. Pyruvate produced in the yeast glycolysis process provides carbon for the synthesis of amino acids that are involved in the production of diketones and several aromatic compounds, such as sulfur-containing compounds, esters and higher alcohols [22]. Additionally, yeast can modify phenolic compounds present in wort, releasing volatile organic compounds. Therefore, the fermentation process offers a wide range of possibilities for the diversification of beer during the brewing process [37]. Thus, there is a growing demand for innovative starter cultures for beer brewing, cultures that can give "character" and "content" to end products. The definition of microbial terroir, well known in wine production, only becomes important in the production of craft beers [17]. In brewing, microbial terroir may be associated with the use of native microbes, isolated from traditional beer ingredients, but also with strains isolated from other indigenous biological resources. In fact, various research trends have focused on improving the microbial biodiversity useful for beer production, including investigating the brewing potential of different groups of microorganisms, such as Saccharomyces strains isolated from other fermented food and beverage hybrids of the *Saccharomyces genus* and non-*Saccharomyces species* [14, 17, 37].

An example of the use of various unconventional yeast types in the process of producing craft beers is the research of Mulero-Cerezo et al. [53] where the probiotic *Saccharomyces cerevisiae var. boulardii* was used as a single yeast starter. The research produced beer with higher antioxidant activity, lower alcohol content, similar sensory properties and higher yeast survival after 45 days than beer obtained with the use of the commercial *S. cerevisiae* strain, commonly used in the brewing industry [53]. Another example of non-Saccharomyces species that was tested in the production of craft beer in Slovakia was the *Lachancea thermotolerans* MN477031 strain isolated from grape must. The brewed beer was characterized by a low production of lactic acid [17, 85].

Therefore, screening existing microbial collections to assess the extent to which they are reservoirs of potential brewing microbes is an emerging field that may improve the relationship of craft beer to specific geographic origins [17, 37]. In addition, the development of complex microbial starters, consisting of different strains of microbes in fermentation, may be one of the main challenges in beer research aimed at regionalization and market segmentation [8, 17, 37].

Until now, commercial yeast strains with well-known fermentation abilities have been used in the production of craft beers in Central and Eastern Europe. However, these strains are not fully related to the region where beer is produced.

Methods of preserving craft beer

For beer to be microbiologically safe, it must be properly preserved [18]. There are several methods of preventing beer spoilage during storage, so that the entire range of its flavor and health benefits can be appreciated by the consumer [11]. It should be mentioned, however, that the properties of beer prevent the development of pathogenic microorganisms. These include low pH (4.3 ÷ 4.6), the presence of alcohol, the lack of oxygen, the presence of aseptic bittering substances derived from hops, and the low nutrient levels. However, microorganisms adapted to these conditions have developed, and can be harmful to beer. Such microorganisms can multiply and excrete their metabolic by-products into the beer, hence it is important to keep microbiological stability in mind throughout the beer production process. First, the brewing equipment must be kept hygienic with proper disinfection and washing, and appropriate air and water treatment is needed (e.g. with chlorine dioxide). Microorganisms that can be harmful to beer include *Lactobacillus, Pediococcus* and *Micrococcus* [11].

The development of brewing procedures introduced filtration and colloidal stabilization as key elements in beer preservation and stability [56, 59]. The colloidal stability of beer is the most important factor in beer quality. Colloidal particles significantly shorten beer's storage time, but most importantly, also influence its appearance. Colloidal stabilization involves one or more procedures that are applied at different stages during production and result in colloidal stability of the final product [59]. Beer is considered to be colloidally stable if it can be stored for several months at 25 °C without exhibiting any changes in composition or other properties; specifically, beer has to be able to remain clear without any signs of precipitation. Since colloidal stability is of primary importance for the consumer, retail requirements have resulted in many solutions for this issue. Stabilization agents have to be reliable during the filtration and stabilization processes [59].

Beer preservation methods include the use of PVPP polymer, filtration, antioxidants, pasteurization and microfiltration. The use of cross-linked PVPP polymer can improve the clarity of beer – its colloidal stability. Reactions between polyphenols and proteins in beer lead to the deterioration of beer stability. Too many of these compounds cause haze that can be seen with the naked eye, which in turn reduces the shelf life of beer. Thus, limiting the presence of one or both groups of compounds through the use of stabilization will extend the beer's physicochemical stability. This can be achieved by using polyvinylpyrrolidone [3, 59].

Another method of fixation is filtration, the purpose of which is to separate suspended solids that contribute to the formation of turbidity and opalescence, and to impart proper clarity. As a result of filtration, the number of yeast cells is reduced to 5 cells per 100 ml, the clarity will be less than 0.5 EBC, though there is usually some slight oxygenation (less than 0.02 mg/L) [21]. Filtration techniques can be divided into surface and depth filtration techniques [28]. The second approach, also referred to as spreading, is used by most breweries in Poland and around the world. Depth filtration uses auxiliary agents, such as perlite or diatomaceous earth. Candle filters are the most popular devices used in the filtration process; these devices guarantee the high microbiological stability of beer and are simple to operate and easy to clean. These advantages, when coupled with electronic process control and almost perfect filter design, facilitate the complete optimization of the filtration process [28, 84].

In deep microfiltration (with particles smaller than 1 micrometer, to filter out yeast and bacteria), the commonly used material is a membrane. The "cross-flow" technique makes it possible to obtain beer from post-fermentation yeast. After fermentation, yeast is removed from fermentation tanks. Beer, which is 50 % of this yeast volume, can be recycled in the production process, significantly reducing beer losses. Ceramic membranes are inferior to polymer membranes, as their production cost is high, and they have low resistance to thermal shock. On the other hand, regularly washing them in the appropriate manner ensures long-term failure-free operation; they are characterized by high endurance [68, 71].

The addition of antioxidants, for example fruit [30, 35], vegetables [54] such as vitamin C, phenolic acids, carotenoids and anthocyanins and sodium sulfite [31], also serves to extend the shelf life of the finished product [3, 35, 54]. Antioxidants have a different mode of action to preservatives, which work by stopping the growth of microorganisms. Antioxidants instead inhibit the rate of oxidation, which prevents the decomposition of free radicals into volatile products and the inactivation of enzymes [3, 30, 76].

The excessive use of advertising slogans promoting allegedly unpasteurized beer claims can falsely suggest to consumers that pasteurization of beer is an unnecessary process to preserve durability of beer. This claim is also used by large brewers as a marketing gimmick in the continuing trend for less-processed and fresh produce [21, 71]. Pasteurization involves heating beer to less than 100 °C, most often to a temperature in the range of 65 ÷ 85 °C for long-term pasteurization. Its aim is to destroy the vegetative forms of microorganisms. Pasteurization inactivates enzymes and reduces the number of residual microflora [21, 71].

Classic beer is considered to be a drink with high microbiological stability due to technological procedures used (pasteurization) and care for the hygiene of a brewery [40, 67]. However, the risk of microbiological contamination of craft beers has increased primarily for unpasteurized, instant pasteurized, cold sterilized, low alcohol or non-alcoholic beers. Oxygen-reduced beers are also a problem. Moreover, the use of innovative beer ingredients such as fruit and vegetables is an additional cause of microbial contamination. The spoilage microorganisms are a big challenge for the production of this type of beer. *Pectinatus spp.* and *Megasphaera spp.* are gram-negative, anaerobic bacteria found mainly in beers where the environment has been modified (reduced oxygen content, low alcohol beers) [55, 66, 67]. They cause spoilage of packaged beer, and the visible turbidity of the beer is accompanied by a taste reminiscent of rotten eggs [55, 40, 66, 67].

Difficulties for craft breweries

Craft breweries face a number of difficulties that result from the high production costs of their product, and the high price of the finished beer [63]. This is craft beer's greatest obstacle in reaching a wider audience, with a large part of society considering craft beer a luxury product. Craft breweries also struggle in keeping the quality of their beer constant, given that they are operating with less automation, usually lacking a laboratory and professional bottling equipment, and face a greater risk of human error. Another obstacle is the shortage of specialized raw materials, including imported hops. Additionally, building a production brewery is costly [18, 41, 63].

Growing awareness of climate change is another problem, leading to the need for brewers to invest in the emerging needs of the environment [13, 50, 63, 74]. At the Congress of Brewing Industry Employees, issues such as a returnable bottle, ecological packaging, low alcohol beer, and the stability of the regulatory environment were raised [9]. The last of these concerns an increase in the costs of water, energy, raw materials, and labor, as well as increases in excise; these, in turn, will be associated with an increase in beer prices and consumer dissatisfaction. The process of returning used bottles also needs to change in Poland, as it currently requires the consumer to keep the purchase receipt for beer. The withdrawal of this requirement could lead to an increase in the number of glass bottles that are returned for recycling [9, 13, 82, 83].

Prospects

Poland is the third largest producer of beer in Europe, with about 320 breweries in the country [49, 83]. There is a similar number in the Czech Republic, but while Poland has a population of 37.48 million, the Czech Republic has only 10.65 million [10, 49, 83]. A total of 1,408 breweries operate in Germany, for a population of about 82 million [9, 10, 33, 83]. In the wine countries of Italy and France, the number of breweries is 1,000 and 1,600 respectively [83]. Beer produced in Poland comes mainly from the largest breweries. Given the number of breweries in other European countries, there is likely room for more in Poland; the number of these can thus be expected to increase, considering the potential of the craft brewing segment [73, 74, 83].

The growing interest in beer produced by craft methods may also result from the growing demand for environmentally friendly, with "clean" labels and made to small-scale recipes [85]. Today's consumers more often buy local food and show a desire to support the development of the Polish economy [63]. This trend will probably continue [81, 83, 85].

The preferences of where to drink beer are also changing - young people prefer fresh air, and for them beer is not only a taste and aroma, but also an excuse to meet and have fun together, at a concert or by the pool [51]. On the other hand, the younger generation drinks much less than the older consumers in the privacy of their homes. Perhaps that is why another revolution awaits us soon - a great return of beer stalls in the new version, in places of rest for city youth on warm days.

Craft breweries and their consumers have revolutionized the world beer markets in the last two decades [86]. Both the production and consumption of craft beer in Europe continues to grow, and the number of active microbreweries has already exceeded

7,500. These breweries supply traditional and innovative craft beers throughout the region. The analysis carried out by Goldstein Market Intelligence forecasts that the European craft beer market will grow by a CAGR (Compound Annual Growth Rate) of 9.1 % in the period of 2017 ÷ 2030, which will be influenced by the future generation of consumers [25].

Conclusions

The development of craft breweries has brought many benefits to the beer market itself, and they continue to grow in popularity, both at home and abroad. The number of small beer producers is constantly growing, and consumers value the diversity, quality and local nature of these products. Their impact on the brewing industry is enormous and the development prospects are promising. Thanks to their attention to quality and authenticity, craft breweries are gaining more and more consumers.

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ROZWÓJ RYNKU PIW RZEMIEŚLNICZYCH, MIKROORGANIZMY, NIEKONWENCJONALNE DODATKI I ICH WPŁYW NA PRODUKT KOŃCOWY

S t r e s z c z e n i e

Wprowadzenie. Współczesny przemysł piwowarski przechodzi obecnie ogromne i szybkie zmiany w wielu krajach świata. Rosnąca liczba browarów i mini browarów rzemieślniczych stanowi wyzwanie dla dużych koncernów piwnych, ze względu na pojawienie się nowych stylów piwa i ciekawych dodatków, które dają konsumentowi znacznie szerszy wybór niż klasyczny jasny lager. Celem niniejszej publikacji jest przedstawienie zmian zachodzących w browarnictwie rzemieślniczym w Europie Środkowo-Wschodniej oraz dalszych perspektyw rozwoju tej branży.

Wyniki i wnioski. W niniejszym przeglądzie przedstawiono studium literaturowe dotyczące kluczowych spostrzeżeń wpływających na rozwój piwa rzemieślniczego i transformację branży piwowarskiej. Pokrótce przedstawiono historię światowej rewolucji piwnej i jej znaczenie dla rozwoju rynku browarów rzemieślniczych w Europie Środkowo-Wschodniej. Omówiono rolę mikroorganizmów i innowacyjnych dodatków stosowanych w produkcji piwa rzemieślniczego, wpływających nie tylko na jego smak, ale także na wzrost wartości odżywczej, a co za tym idzie, większe zainteresowanie rynku takim rodzajem piwa. Możliwości i dalsze perspektywy rozwoju tego sektora produkcji piwa rzemieślniczego zarówno w Polsce, jak i w Europie Środkowo-Wschodniej są bardzo obiecujące. Browary rzemieślnicze dokonały prawdziwej rewolucji na rynku piwa, wpływając zarówno na preferencje konsumentów, jaki i przyczyniając się do poprawy jakości i dywersyfikacji oferty na tym rynku. Kupując taki produkt, konsument jest bardziej świadomy zrównoważonego wykorzystania lokalnych surowców w produkcji tego rodzaju piwa.

Słowa kluczowe: piwo rzemieślnicze; drożdże piwowarskie; lawenda; pierzga; polifenole