WORLD BEER PRODUCTION AND HOPS USE

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Abstract. *The main raw materials for beer production are beer malt (from barley or wheat), hops (Humulus lupulus L.), water, and yeast. Hop is perennial plant, dioecious plant, which means that each plant carries only male or only females' flowers. Hops help to keep beer fresher, longer; help beer retain its head of foam—a key component of a beer's aroma and flavour and bitterness In the case of dioecious varieties, only female plants shall be taken, while male plants are not desirable. Hops give bitterness to beer and thus affect the aroma, for this reason the quality of hops significantly affects the quality of beer. Beer is a sparkling alcoholic beverage with a characteristic bitter taste and aroma of hops. It is consumed all over the world. It is one of the oldest and most commonly consumed alcoholic beverages in the world. It is also the third most popular drink after water and tea. Europe, in general, consumes the most beer in the world. The country at the top is the Czech Republic, with 143.3 liters consumed (2019) per capita. The aim of this paper is to describe in which countries beer is most consumed and what the main use of hops in beer production is.*

Keywords*: hop, beer, beer production, hop use, world*

INTRODUCTION

Hops (*Humulus lupulus* L.) are a perennial plant that belongs to the Cannabaceae family (ROSSINI, 2016; 2021). Hops originate from southwestern Russia (the area around the Caucasus and the Black Sea). With the great migration of the people, hop cultivation and its use for brewing beer spread to the European continent, and the first records date from the 7th century.

Beer is known to the ancient Egyptians and Babylonians, it was produced by the ancient Celts, Germans, Slavs and Scythians from barley, wheat, oats and buckwheat, and spiced with various spices and honey. Hops are used only in the 8th century. In the Middle Ages, beer was produced in monasteries. Bavarian beer was known as early as the 12th century, and Czech beer in the 13th century.

In the Czech Republic, beer was brewed as early as the 10th century, about which there are written traces. But beer is a much older drink. in Mesopotamia it was cooked as early as the seventh millennium BC. The first beer came about probably by accident. It rained in the bowl where the people kept the grain, the liquid boiled over, and when they remembered that bowl and confided what was in it, there was a pleasant drink there. The oldest written recipe for beer is carved on a stone slab and is more than five thousand years old.

In the beginning, beer was brewed exclusively by women, and only when breweries began to be built did men take over. The oldest brewery that is still in operation is Weihenstephan near Munich, where beer has been brewed since 1040. The first written mention of brewing beer in the Czech Republic dates back to 993, when beer was brewed in the Břevnov monastery.

Beer was bottled in ancient Egypt, bottled, still sporadically, in the 16th, 17th and 18th centuries, and mass use of bottles began only in the 20th century. In the Czech lands, glass was first used as beer packaging in 1841 at the U Křížovníků brewery in the Old Town.

After consuming alcohol, there is no sitting behind the wheel, there is no choir and beer is no exception. The first car accident caused after drinking beer happened two thousand years before Christ in Egypt. A drunken coachman ran over the princess from the temple of the

goddess Hathor. The punishment for the coachman was really cruel – he was crucified at the door of the inn where he got drunk.

Beer is a fermented alcoholic beverage that primarily serves as a refreshing beverage (VAN CLEEMPUT, 2009). There are the four main raw materials for beer production: hops, malt, water and yeast. Today, hops are mostly grown for beer production, but throughout history, a significant role of hops in medicine has been recorded. Beer production grew until 2012, during that year it amounted to about 200 billion liters, since then production of the beer has been stable (GOMES, 2021). Beer is consumed all over the world, it is one of the favorite drinks of most Europeans.

MEDICINAL USES OF HOPS

It is known that plants have been used in medicine throughout history (RANDIĆ, 2003; SMETAN et al., 2018; VITASOVIĆ-KOSIĆ i KUŽIR, 2018; BEICU et al., 2019). People had been trying to figure out how they can use a particular plant to treat certain illnesses. Hops were used for medicinal purposes before being used in the brewing industry (NEVE, 1991). Since the 19th century, hop products are recommended as a mild sedative that helps with sleep and to relieve stress (ROSSINI, 2021.). In his book HUTCHENS (1991) state that hops were used as remedy for silicosis, leprosy, ear infection, pulmonary tuberculosis and in the treatment of many other diseases.

Hops contain the flavonoid compound xanthohumol, which belongs to a group of compounds that contribute to the bitterness and taste of hops. Hops bitterness stimulates the digestive tract: increases the secretion of digestive juices, improves metabolism, increases appetite, eliminates putrefaction processes, soothes diarrhea caused by tension, cures bloating and increases the acidity of gastric juice (VAN CLEEMPUT et al., 2009). Hops, especially in combination with valerian, have been found to have a visible effect as a sleeping agent and as a tranquilizer, also there are more than a hundred different sleeping pill and tranquilizer formulations for sale all over Germany that contain hops (BIENDL, 2009.).

Some research showed that treatment with iso-α-acid was found to mitigate or prevent different illnesses such as fibrosis, inflammation and liver steatosis, also metabolic disorders such as diabetes and obesity. Iso-α-acid is extracted from hops. Some research proved that hop α- and β-acids are also effective against athlete's foot fungi, and they inhibit the growth of bacteria associated with acne and neurodermatitis (BIENDL, 2009.). MILLIGAN et al. (2002) proved that the active substance of hops is responsible for the active substance prenilflavonoid, 8-prenilnaringenine (8-PN). According to MUZYKIEWICZ et al. (2019), hops extracts of hop leaves have antioxidant activity.

Another one medicinal property of hops is estrogenic activity, because hops contain a phytoestrogen. In her paper, ROSSINI et al. (2016) states that estrogenic activity was initially attributed to xanthohumol, but further research has revealed the phytoestrogen, 8-prenylnaringenin (8-PN), phytoestrogen found in the beer and hops. Phytoestrogens can help prevent cardiovascular disease and cancer. Currently, supplements containing hop phytoestrogens are widely used for bone health (potential prevention of osteoporosis), menopausal symptoms and breast enhancement. The loss of naturally occurring estrogen can be replaced by phytoestrogens such as 8PN. BIENDL (2009) reported that some experiment showed that 8PN added into hen's eggs through feeding, can reduced formation of new blood vessels and thus potentially inhibit on the growth of tumors. Due to inhibit the formation of new blood vessels, Xanthohumol has been studied for its chemoprementative properties (BIENDL, 2009.). Essential oils and bitter acids have also been shown to have anticancer effects (ROSSINI, 2021). SREČEC et al. (2011) state that even low micromolar concentrations cause inhibition of metabolic activation of procarcinogens. In vivo trials on mice have shown xanthohumol activity against diabetes (BIENDL, 2009). Some experiments showed that hops extracts of xanthohumol and the lupulones (β-acids) showed inhibitory activities

against all of the acne vulgaris bacteria strains (SREČEC, 2011.). According to MAGALHÃES et al. (2009) found that xanthohumol helps with antioxidant activity and lifestyle-related diseases, anti-infective activity and with antiproliferative/anticarcinogenic activity. Humulone and lupulon are bitter acids that are the main agents of antifungal and antibacterial effects.

OTHER USES OF HOPS

Hops were used as a spice and as a food for many years. Young shoots of hops have a low fat content, also these shots are good source of proteins and dietary fiber (ROSSINI, 2021.). VIDMAR et al. (2009) found that white hop shoots from different cultivars showed a better antioxidant activity than hop cones and leaves. Nowadays there is a growing demand for natural preservatives, hop extract is an effective natural preservative for certain foods (ROSSINI, 2021.).

A large amount of plant residues remains in the field after harvesting hops, after cone harvest, because male plants are not desirable in industrial production. A lot of leftover materials after harvest consists leafs and stems. Steams of hop can be reused to make ropes and papers. It is well known that hops are used in the beer and pharmaceutical industries, hops are also used in pest control compounds.

USE OF HOPS IN BREWING

In their ariticle GOMES et al. (2021) state that the addition of hops to the wort can also be done at the end of the boil or during the whirlpool, known as late hopping. Beer production is a complex technological process consisting of malt preparation, main fermentation, post-fermentation and finally finishing. The malt is crushed before being converted into malt. After grinding the malt, the malt is crushed, which is the most important technological operation in the preparation of malt. Malt separation of the beer trope is technologically usually resolved by filtration, with the beer trope serves as a filtration agent. After filtering the wort and rinsing the tropics, further processes in beer production are brewing, hopping, cooling and filtering the wort. During fermentation, the yeast converts glucose into ethanol. Technological last stage maturation is clarification and colloidal stabilization.

Beer is an alcoholic beverage of lower strength, obtained by alcoholic fermentation of malt, produced from barley malt, hops, water and yeast. Malt is the most important ingredient beer represents. It determines the taste of beer, color, density and strength. The process of turning barley into malt, which is rich in sugar, is most important for making beer. Malt can also be made from grains other than barley: wheat, oats or rye can also be used. The technological process of beer production is divided into 4 basic phases: malt production, grinding and cooking of coma, fermentation of coma, filling and shipping of beer.

Malt is a product obtained by allowing pre-soaked barley to germinate under controlled conditions of humidity, temperature and ventilation, and then stop germination and the associated chemical processes (enzyme production, starch saccharification, etc.) by heating to 80-110 ºC. Germination is carried out by stretching soaked barley on the floor of air rooms (hatcheries) or pushing air current through it in rotating drums (GLOVER, 1999). Due to its content of enzymes that break down starch (diastase, amylase) and break down proteins, malt is used to convert starch into sugar in the production of beer, distilled alcoholic beverages, spirits and textile auxiliaries, and for the production of malt syrups, extracts and coffee substitutes.

MOIR (2018) in his work state that hops are considered the basic raw material used in beer production worldwide, hops are also a preservative in beer. Hops are also known to be rich in substances such as α-acid humulone and β-acid lupulone. In addition to α- and β-acids, the lupulin glands of hop flowers also secrete prenylated flavonoids that include phytoestrogenic compounds

that show a wide range of biological activities and have therapeutic potential in humans. SREČEC et al. (2011) that in brewing invention of hop adding into wort was probably one of the most important innovations in history of brewing. The main ingredients in beer production are hop, barley (malt), yeast and water. Beer production is a complex process that allows variation in multiple parameters which influence the quality and type of beer (MAGALHÃESA et al., 2009). The quality of beer depends on the essential oils and resins found in hops, or in the hop cone (ROSSINI et al., 2021.). Hops give bitterness to beer and thus affect the aroma, for this reason the quality of hops significantly affects the quality of beer. Top resins are divided into hard and soft resins. Authors further states that soft resins are more important than hard ones in the brewing process and consist of the α-acids, the α-acids are the source of the bittering agents of beer. In addition to giving bitternest to beer, hops also precipitates proteins from malt and thus contributes to the clarification of beer, promotes foam formation and extended the shelf life of beer (VOGEL, 2006.).

BEER WORLD CONSUMPTION IN THE WORLD

According to Kirin Beer University data on global beer consumption in 2017, China is the country that consumes the most beer in the world (Table 1).

Table 1

World beer consumption by country
(Source: https://www.kirinholdings.co.jp/english/)

Ranking, 2017.	Country	Total Consumption (thousand kl)	Global market share (%)	Growth Rate 2016-2017
1	China	40,143	21,5	-3.9%
2	United States	23,956	12,8	-1.2%
3	Brazil	12,565	6,7	-0.7%
	Mexico	8,532	4,6	6.8%
5	Germany	8,218	4,4	-2.3%
6	Russia	8,008	4,3	-4.7%
7	Japan	5,116	2,7	-2.6%
8	United Kingdom	4,405	2,4	0.7%
9	Vietnam	4,356	2,3	5.8%
10	Spain	4,050	2,2	3.6%

China is at the top of the list (Table 1.). Global beer consumption in 2017 amounted to approximately 186.72 million kiloliters, which is 0.2% less than in the previous year (WORLD POPULATION REVIEW).

Asia is the leading beer-consuming region with 33, 7% global market share (Table 2). Beer consumption in Africa grew in 2017 compared to 2016 (WORLD POPULATION REVIEW). In last decade, Europe is dominate in the craft beer industry. The global craft beer market is highly fragmented, dominated by local microbreweries and medium-sized regional breweries, especially in developed markets such as Europe. The craft beer industry is one of the oldest in the world. The most important craft breweries are still independent.

The global craft beer market by 2022 will record moderate cumulative annual sales growth. Craft beer retailers are focused on originality and increasing added value. It is expected that this, in addition to the previously mentioned factors, will have the greatest impact on the development of the craft beer market in the next five years.

Table 2

World beer consumption by region
(Source: https://www.kirinholdings.co.jp/english/)

Region	2017. Total Consumption (thousand kl)	Global Market Share (%)	633 ml Bottle Equivalent (million bottles)	Growth Rate 2016-2017
Japan	5,116	2,7	8,081.5	-2.6%
Asia (excluding Japan)	57,831	31,0	91,359.6	-0.7%
Asia Total	62,946	33,7	99,441.1	-0.8%
Europe	48,633	26,0	76,829.1	0.0%
Central and South America	32,175	17,2	50,829.9	1.3%
North America	26,026	13,9	41,114.8	-1.2%
Africa	13,540	7,3	21,390.7	0.5%
Oceania	2,196	1,2	3,469.5	0.3%
Middle East	1,207	0,6	1,907.1	4.0%
Global Total	186,726	100,0	294,982.1	-0.2%

In European countries, most beer is consumed per capita per year. The Czech Republic consumes the most beer per capita (Table 3). The Republic of Croatia is among the top twenty countries that consume the most beer per capita. In 2017 the top five countries with the highest consumption of beer per capita in 2019 are: Czech Republic, Namibia, Austria, Germany and Poland.

Table 3

World beer consumption per capital
(Source: https://www.kirinholdings.co.jp/english/)

Ranking, 2017.	Country	Consumption Volume (L)	633 ml Bottle Equivalent
1	Czech Republic	183.1	289.3
2	Austria	106.6	168.4
3	Germany	100.1	158.1
4	Poland	99.4	157.1
5	Romania	95.2	150.4
6	Ireland	94.9	149.9
7	Spain	87.3	137.9
8	Namibia	83.2	131.4
9	Slovakia	81.1	128.1
10	Estonia	80.5	127.1

CONCLUSIONS

Beer is one of the most popular drinks in the world. Hops are a plant that is one of the most important ingredients for beer production, also hops are used in medicine in various aspects. Beer is a sparkling, refreshing alcoholic beverage with a low, medium, or high percentage of alcohol. It has a bitter taste, but the bitterness may be less or more pronounced. The beer has a typical malt taste and its hop aroma is characteristic.

Beer is an alcoholic beverage that is consumed in large quantities all over the world, and mostly in Europe. China is the country that consumes the most beer in the world, followed by the United States, Brazil and Mexico. In most countries, in 2017, the total consumption of beer in the world and the total consumption of beer per capita decreased compared to 2016. According to the latest data, from 2019, the consumption of beer per capita is growing in African countries, while in the Czech Republic that number has decreased compared to 2017. Although beer consumption per capita in the Czech Republic has decreased, it is still the country that consumes the most beer per capita.

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