M. H. Hagemann, K. Bogner, E. Marchioni and S. Braun

Chances for dry-hopped non-alcoholic beverages? Part 1: Concept and market prospects

Consumer habits are changing towards healthier diets also including a decline in consumption of alcoholic beverages in Northern America and Europe. The consumption of premium beverages is increasing, which includes beverages with or without alcohol such as functional drinks, organic or/and regional fermented products and craft beers. Here we reviewed numerous economic reports and scientific findings to estimate the market potential for dry-hopped non-alcoholic beverages in the European and Northern American markets considering hop and (craft) beer production, consumption of alcoholic and non-alcoholic beverages as well as health properties for marketing purposes. The markets for craft beer, for alcohol-free beer and for functional drinks are rapidly growing, thus it seems that the consumer is prepared to a new product type with a bitter but aromatic and complex taste. This could be achieved by dry-hopping as this technique is easy to introduce and the resulting product addresses the consumers demand for alcohol-free beverages and distinct taste of craft beers. Challenges are the sensory properties due to the low alcohol concentration and a resulting lack of "body". Rich hop flavors may cover this to a sufficient extent. In conclusion there is a high potential for dry-hopped non-alcoholic beverages.

Descriptors: functional drink, anti-oxidants, health properties, hop metabolites

1 Introduction

This article introduces the concept and provides market prospects for dry-hopped non-alcoholic beverages. A following article will review the potential health properties of such a beverage and outline target consumer groups.

Global habits of food consumption are constantly changing towards increased demands for healthier food and drinks [1, 2]. While in the 20th century the main concern was to increase the calorie consumption in order to reduce undernutrition [3], a major challenge of the 21th century is to prevent malnutrition caused by unhealthy diets. The recent shift to healthier diets that include higher consumption of fruits and vegetables while consuming less sugar (Table 1) along with the increasing demand for organic food [5] show that especially in the industrialized countries the awareness of food related health problems increases. In agreement with this trend also the consumption of beer is decreasing in Northern America and Europe (Fig. 1).

The beer consumption in Asia, Africa and Latin America the main drivers for the 18 % increase of the global beer production over the last decade [8, 9]. This growth might partly be based on population increase (Fig. 2) and partly result from a currently low consumption compared to Northern America with 78 liters per year and capita or Europe with 68 l. Thus markets could be unsaturated in Asia and Africa as their consumption is as low as 15 l and 11 l, respectively. Considering the decreasing beer production in Europe (Fig. 2) along with the decreasing consumption in Europe and Northern America (Fig. 1), raises the question if there is potential for alternative products.

Increasing consumer awareness of the health and quality aspects of food are plausible drivers for another recent trend; the increas-

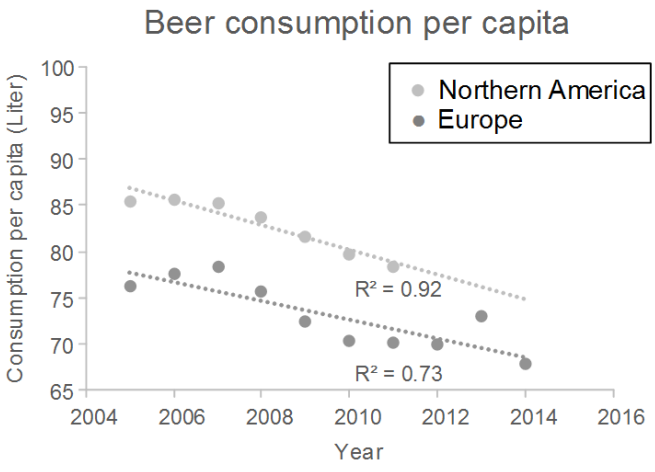

Fig. 1 **Comparison of beer consumption per capita between Northern America and Europe. Data for Northern America [4], Data for Europe [6, 7]**

Authors

Dr. Michael Helmut Hagemann, M.Sc. Kristina Bogner, M.Sc. Susanne Braun. University of Hohenheim, Research Center for Bioeconomy, Stuttgart, Germany, Prof. Dr. Eric Marchioni, Equipe de Chimie Analytique des Molécules BioActives, UMR 7178 – Institut Pluridisciplinaire Hubert Curien Université de Strasbourg, Illkirch, France; corresponding author: Michael.Hagemann@Uni-Hohenheim.de

Table 1 Global comparison of the food supply per capita in 2002 and 2011 [4]

Region / Year	Meat		Sugar (Raw Equivalent)		Vegetables		Fruits (Excluding Wine)	
	Value: Food Supply Quantity (kg/capita/year)							
Europe								
2011	76.0	↑	36.3	↓	118.9	↑	91.0	↑
2002	72.7		37.2		110.0		82.7	
America								
2011	86.5	↑	34.2	↓	75.8	↓	107.4	•
2002	82.8		36.3		82.0		107.3	
↘Norther America								
2011	115.1	↓	30.9	↓	113.2	↓	100.3	↓
2002	122.2		33.3		130.3		111.7	
Africa								
2011	18.6	↑	15.6	•	67.0	↑	63.0	↑
2002	16.0		15.4		59.4		60.0	
Asia								
2011	31.2	↑	15.1	↑	168.5	↑	66.0	↑
2002	25.1		14.0		140.2		47.6	
Australia/Oceania								
2011	116.2	↑	37.7	↓	93.4	•	92.0	↓
2002	101.9		39.6		94.2		95.3	

ing consumption of premium beverages over the last years. This includes alcoholic drinks as craft beers, as well as non-alcoholic drinks, including alcohol-free beers (AFB) or functional or relaxation drinks (RD). The aspects “organic” or/and “regional” have also been increasingly important factors for consumers.

1.1 Craft beer

Following the definition of the US-based Brewers Association craft beers are beers of small (≥ 6 million barrels ≙ 7.040.000 hl), independent (< 25 % owned by non-craft brewers), and traditional (or innovative) breweries (alcohol and flavor derives from traditional or innovative brewing ingredients) [11]. The word “craft” shows that focus of these products is on the craftsmanship, thus craft beers are premium products which are produced in small quantities. Craft brewers can be further divided into regional craft brewers (≥ 7.040.000 hl), microbreweries (≥ 17.400 hl), and beer pubs (and contract brewing companies [12], sometimes referred to as “gypsy brewery”.

The recent craft beer trend started in the USA in the 1970s. Therefore, the popularity of craft beer is highest in Northern America compared to other regions of the world. For example, a recent survey among US consumers showed that 24 % [13] of the people asked prefer craft beers over conventional beers. The share of craft beer on the US beer market also has been increasing to 11 % in 2014 according to the Brewers Association [14]. The Global Craft Brewery Survey 2015 lists about 10.000 craft breweries worldwide of which about 4.500 are based in either Northern America or Europe [16]. These high numbers of craft breweries are a result of a constant growth over the last years, whereas the number of breweries more than doubled in the time span from 2006 to 2014 (Fig. 3, see next page). Surprisingly the awarensess about craft beer seems rather low in Europe; A study among Austrian consumers showed that only 26 % knew what the term “craft beer” meant [17]. However, the future perspective for craft beer is positive and the trend is likely to continue to grow, which is particularly good for the hop

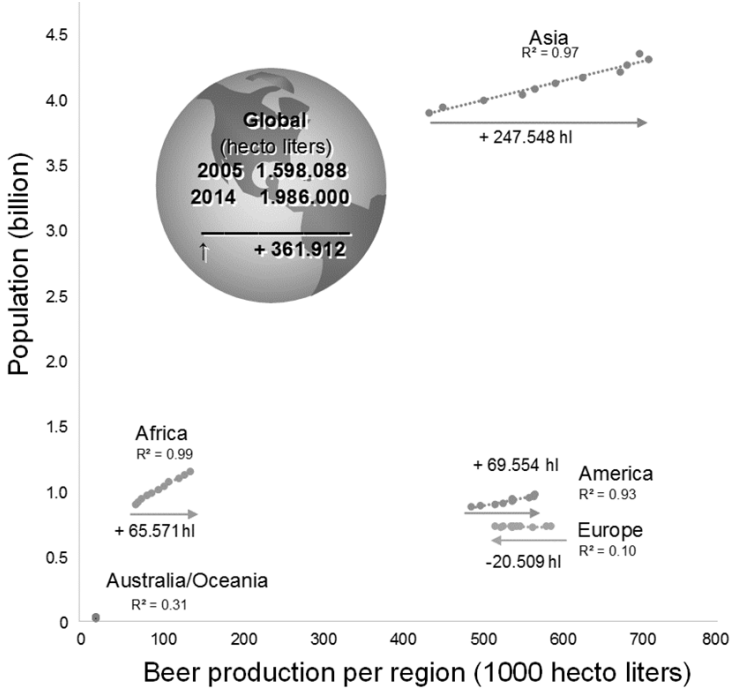

Fig. 2 Global beer production in relation with the population growth from 2005 to 2015. NOTE: Population increase and beer production are positively correlated, except in Europe where the population growth in small and beer production declining. Data on beer production [9], Data on population [10]

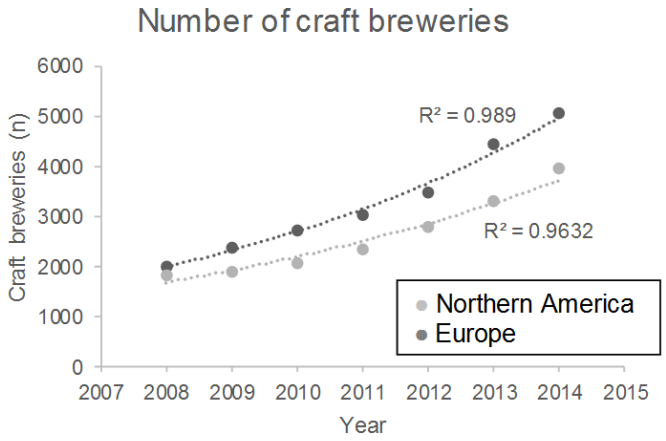

Fig. 3 **Comparison of number of craft breweries in Europe and Northern America (Excluding Mexico and Central America due to data scarcity). Data for Northern America based Brewers Association [14] and Canada Revenue Agency [15]. Data for Europe based on The Brewers of Europe [6,7]**

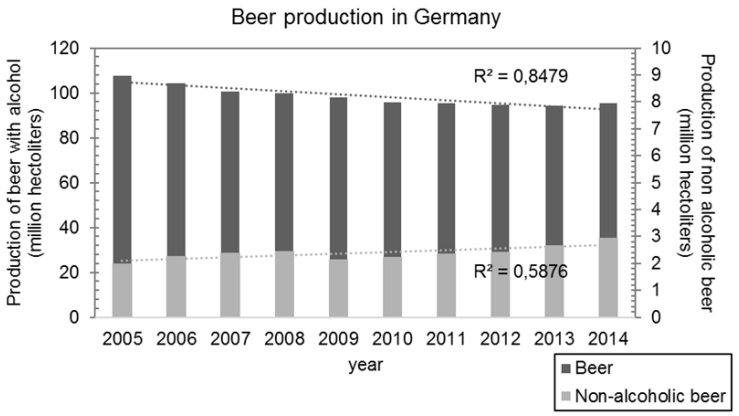

Fig. 4 **Production of alcohol free beer (AFB) in Germany from 2005 to 2014. Data for beer in total from Barth-Haas Group [8,9], and data for non-alcoholic beer from Statistisches Bundesamt [28]**

growers who can now hope for higher prices and to extend their business. The US hop growers trust in the craft beer trend such that they extended the cultivation area for aroma hops from 2015 to 2016 by 2.500 ha [18] as done in the previous years. To date the USA and not Germany is the top producer of hops globally [18]. However, also in Germany the craft beer topic is considered, thus five new aroma (special flavor) hop cultivars have been developed at the hop research center in Hüll in Germany and released within the last three years [19]. These new cultivars, but also established cultivars of the special flavor category, are important for the craft brewers as they can provide exotic aroma for the beer especially if added late in the brewing process [20–23]. The craft beer trend and an increase of beer diversity and tastes as well as the rediscovering of old special beers is certainly good for the image of beer in general and introduces a new beer culture. This includes the before mentioned increase of craft breweries and brew pubs as well as tastings with beer sommelier and culinary considerations as the pairing of certain dishes with the matching beer style [24].

1.2 Alcohol-free beer

Another alternative to conventional beer that attracts attention of the health and quality oriented consumer is alcohol-free beer (AFB). Thereby one has to distinguish between beers that contain less than 0.1 vol%, which are still rare, typical AFB, often with a rest alcohol content of 0.5 vol% or less, and low alcohol beers with less than 3 vol% of alcohol [25]. Following EU regulations, it is only necessary to explicitly state the alcohol content if a food product contains more than 1.2 vol% (EP No. 1169/2011). However, in many countries either the regulation is stricter or the industry typical standard is lower. In the USA a threshold of 0.5 vol% is fixed in the Parliaments National Prohibition Act from 1920. Within Europe the threshold is similar; between 0.5 vol% (e.g. UK, Germany, Switzerland) 1 vol% (Portugal, Spain) [25]. Within Europe, Germany and Spain, are the countries producing most AFB. Based on production of low and non-alcoholic beer Spain is leading the global production with almost 600 million liters in 2012 [26]. Germany leads the global production of solely AFB with about 300 million liters in 2014 [27]. While in Germany in 2005 every 50th beer was alcohol-free, today it is rather every 25th (Fig. 4). The study from Mintel released in 2014 comes to the conclusion that this is a slowly but sustainably growing market [29]. The authors of a similar study conducted by Euromonitor [26] point out that there was a growth increase of low and non-alcoholic beer in the USA from 2007 until 2012 that now is stagnating. However, the level of stagnation especially for low alcoholic beer (< 3 %) nowadays (2012) is several times higher compared to 2007.

More detailed data on the global production or consumption of non-alcoholic or low alcohol beer are scarce. Eurostat started to release statistics only in 2013 and the data comparison of 2013 and 2014 shows a 21 % increase for Europe [27]. The market for AFB is especially interesting considering new consumer groups. Apart from health-conscious people there is another potential consumer group that might further increase the demand for AFB. These are religious groups that do not consume alcohol due to their beliefs as for example several Muslim groups which will be discussed in the follow-up article [29, 30].

1.3 Non-alcoholic functional drinks

Functional drinks cover several beverages including those that are rich in carbohydrates and minerals to regain energy after physical activity, or drinks that contain functional metabolites like caffeine or taurine, further some drinks support relaxation and stress relief, or offer nutritional value and contribute to the prevention of disease evolution [2]. However, due to the lack of a common definition it is difficult to get a comprehensive market overview of this diverse product group [2]. A more abstract criterion to evaluate a market is the launch of products. In the case of functional food and drinks the number has doubled from 2005 to 2009 worldwide, which suggests that this is a rapidly growing sector [31]. The same trend can be seen by evaluation data of single countries. In the USA for example an 32 % increase of retail value has been recorded from 2006 until 2011 [32] a trend likely based on the share of energy drinks within the group of functional drinks. A functional drink that contains hops would fit better in a subgroup called ‘relaxation drinks’. Functional drinks and consequently relaxations drinks (RD) are alcohol-free and are characterized by their provision of a health benefit to the consumer beyond their nutritional value. RDs in particular should relieve stress through various mechanisms including sleep mitigation, muscle relaxation or the reduction of the cortisol levels, the

main stress hormone [33]. The active ingredients found in RDs are typically hormone or hormone-like substances or neurotransmitters as well as vitamins and minerals, which are related to a general stress relief [34].

The consumption of RD is growing, however, solid data are scarce on this rather new and thus still small niche, but currently about 500 products have been released worldwide and the growth perspective is positive [35]. Furthermore, a study on the innovation potential of European food and drink industries show that in particular the sector of non-alcoholic soft and functional drinks shows to be most innovative [36].

1.4 Dry-hopping

Technically dry-hopping is a cold-extraction of hop cones or pellets in water and alcohol [37]. The hops are added after the wort has been cooled and while the beer ferments [38] during the lagering or just before packaging [39]. Because following this technique hops are added after the wort boiling the bitter acids from dry-hopping do not isomerize as the necessary temperatures are not reached. However, the aroma, i.e. the volatile terpenoids and other fractions of the hop metabolites, enrich the beer with flavor and taste [39]. Generally, the flavor deriving from the dry-hopping is very sensitive and can alter due to the picking date of the used hop material or due to the location the hops have been picked from [37]. While above 500 g/hl saturation of the dry-hopping flavor is reached in craft brewing, extreme hopping additions in total of about 500–800 g/hl are applied [37]. The amount, the type and the quality of hops used for dry-hopping can influence the resulting beer flavor [22]. Additionally, physical absorption as well as enzymatic and chemical reactions can alter the flavor over time [40]. This flavor is largely based on the composition of monoterpene alcohols, their derivatives, several esters, and polyphenols [22, 40]. Further, sulfur compounds can contribute substantially to the beer flavor [41, 42]. Dry-hopping can also lead to the enrichment of certain bioactive compounds [43]. In conclusion, dry-hopping can be used to substantially change and enrich the flavor of a beverage, thus it is an interesting technology for the production of new styles of AFBs or RDs.

The increasing growth of the AFB and RD sector, in the context of (1) a growing interest in craft beer (indicating higher willingness to pay for premium products) along with (2) the increasing demand for healthy food and drink products suggests that a fermented dry-hopped beverage has a good marked potential with basically two major selling strategies as alcohol-free craft beer or as relaxation drink.

2 Materials and methods

The data foundation of this article are statistics as released by national and international governmental institutions and hop growers or brewer's associations. The data have been gathered, converted where necessary and used for trend analysis. Trend analysis is presented only if the p-value of the regression was significant (p-value > 0.05). The coefficient of determination is presented (R^2).

3 Results and discussion

The increased consumption of craft beer is of significant importance for the brewers, as this premium product might compensate partly for the declining revenues due to decreasing consumption of beer, especially in Northern America and Europe [4,6,7]. Therefore, it is suggested that also an alcohol-free craft beer is likely to have great market perspective.

3.1 Alcohol-free craft beer

The key value proposition of alcohol-free craft beer clearly is the absence or low amount of ethanol and the additional value deriving from the term "craft". This requires the product to have certain properties as stated in the introduction. Thus the additional value of an alcohol-free craft beer compared to the conventional counterpart is flavor-richness and a superior taste. This is where AFBs often have sensory deficits, which can be a "lack of body", low aromatic profiles, or off-flavors [44]. Most regional craft brewers and microbreweries are unlikely to be able to invest in advanced equipment for the physical removal of ethanol, thus the biological approach, i.e. to stop the fermentation, would be the choice for small breweries. Especially these approaches have shown to lead to greater problems with the product and can only be partly overcome with special yeasts and brewing recipes [44]. The undesired sensory properties of AFBs, however, can be substantially improved by dry-hopping as it would improve the product by adding hop flavors. Especially if beer styles are used that require an abundance of hops, as for example India Pale Ale, the product would have distinct and strong aroma profiles and a higher bitterness levels. Currently only few products are on the market that belong to the category alcohol-free craft beer.

3.2 Dry-hopped relaxation drinks

A functional drink with positive health benefits is expected to be alcohol-free or at least to have a very low alcohol content. The product consequently has to be advertised for its health beneficial function, i.e. for its compounds like vitamins, minerals, anti-oxidants or other positively connoted substance groups. In the case of a RD the relaxation promoting properties need to be highlighted. The secondary metabolism of the hop plant bears a high and still growing number of compounds, many of which are discussed to have positive health effects [25, 45]. In combination with other herbs hop is a traditionally and well-known ingredient for mild-sedative medicines or teas, thus a good candidate for RDs. The growing sales of the few RDs already on the market, e.g. in Germany, show that there is a potential for such anti-stress drinks [46].

AFBs have been reported to "lack body" as results of a low ethanol concentration [44]. This interpretation is based on the consumers taste experience would expect the taste of a AFB to be similar to the taste of conventional beer. Producing a RD the consumer does not have such a clear taste in mind, thus a RD can be created more freely compared to a AFB – with or without a strong "body". Indeed, the increasing sales of flavoured water [47] show that this "body" is not an essential element of a successful beverage. Alternatively relaxation drinks can be produced using fruit juices or additional sugars, which are able to achieve the sensory property

"body". However, the latter approach will increase the amount of nutritional energy (kilojoules, kJ) and thereby partly compromise the health-beneficial properties. Looking at the energy of AFB in comparison to AFB mixed with lemonades or juices and compared with conventional beer shows that AFB are low on energy while the energy of AFB mix drinks depends on the added component, while both beverages have less energy than conventional beer. A conventional beer, lager or pilsner, contains around 172 kJ*100 ml^{-1}, while wheat beer has about 188 kJ*100 ml^{-1}. In comparison AFBs typically have around 84 kJ*100 ml^{-1} while AFB mix drinks range between 109 and 146 kJ*100 ml^{-1}. In summary, the RD producer can choose between a product that is produced mainly for the health benefits and is presumably less tasty and has less "body", but a higher energy concentration due to higher fruit sugars and is thus less healthy but has a sweeter taste.

4 Conclusion

The hypothesis presented is that there is a high potential for dry-hopped alcohol-free craft beer as well as for dry-hopped relaxation drinks. This has been corroborated by drawing parallels between the products and similar beverage groups (beer, AFB and functional drinks). The growing markets of AFB and functional drinks indicate that the target market for a dry-hopped alcohol-free beverage is to be found within Europe and Northern America. Now it is time to take action and develop pilot products. In order to be most effective, the development needs to be closely connected to basic and applied research. To overcome technical production hurdles might be as important as investigating health chances and concerns or marketing considerations, thus the successful product development is in this case a multi-disciplinary team effort. The resulting product might close the gap of sales deriving from decreasing beer consumption in some global regions and support the development towards increased well-being of people without sacrificing taste.

Acknowledgement

The authors thank the team of the Hohenheim research center for bioeconomy for their support and contribution to this report, particularly Benjamin Biesdorf and Verónica Schmidt-Cotta for their editorial work.

5 Literature

1 Ozen, A. E.; Pons, A. and Tur, J. A.: Worldwide consumption of functional foods: a systematic review. Nutrition Reviews, **70** (2012), no. 8, pp. 472-481.

2 Corbo, M. R.; Bevilacqua, A.; Petruzzi, L.; Casanova, F. P. and Sinigaglia, M.: Functional Beverages: The Emerging Side of Functional Foods. Comprehensive Reviews in Food Science and Food Safety, **13** (2014), no. 6, pp. 1192-1206.

3. Kearney, J.: Food consumption trends and drivers. Philosophical Transactions of the Royal Society of London. Series B, Biological Sciences, **365** (2010), no. 1554, pp. 2793-2807.

4. Food and Agriculture Organization of the United Nations (FAO): FAOSTAT database, Food Balance Sheets (accessed 31 Mar 2016), (2016) http://faostat.fao.org/

5. International Federation of Organic Agriculture Movements (IFOAM): The World of Organic Agriculture. Das Forschungsinstitut für biologischen Landbau (FiBL) and IFOAM, Bonn, Germany, 2015.

6. The European Brewers Association: Beer Statistics 2010 ed. The Brewers of Europe, Brussels, Belgium, 2010.

7. The European Brewers Association: Beer Statistics 2015 ed. The Brewers of Europe, Brussels, Belgium, 2015.

8. Barth-Haas Group: The Barth Report, 2005 ed., Joh. Barth & Sohn GmbH & Co KG. Nuremberg, Germany. 2005.

9. Barth-Haas Group: The Barth Report, 2015 ed., Joh. Barth & Sohn GmbH & Co KG. Nuremberg, Germany. 2015.

10. United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2015 Revision, United Nations, Population Division, New York, USA, 2015.

11. Brewers Association: Statistics, craft brewer defined. (accessed 30 Jul 2016), (2016) https://www.brewersassociation.org/statistics/craft-brewer-defined/

12. Brewers Association: Statistics, craft beer industry market segments. (accessed 30 Jul 2016), (2016) https://www.brewersassociation.org/statistics/market-segments/

13. Public Policy Polling: Press release, More on Americans' attitudes toward food. Published on 27 Feb 2013, (accessed 31 Mar 2016), (2016) http://www.publicpolicypolling.com/main/2013/02/more-on-americans-attitudes-toward-food.html

14. Brewers Association: Statistics, insights and analysis. (accessed 30 Jul 2016), (2016) https://www.brewersassociation.org/category/insights/

15. Canada Revenue Agency: Data on Beer Canada. (accessed 30 Jul 2016), (2015) from http://www.cra-arc.gc.ca/

16. Alltech: Press release, Global Craft Brewery Survey. Published on 9 Nov 2015, (accessed 30 Jul 2016), (2015) http://www.alltech.com/news/news-articles/2015/11/09/alltech-releases-first-global-craft-beer-survey-against-backdrop-ab

17. MindTake: Press release, Craft beer in Österreich noch weitgehend unbekannt. Published on 12 Nov 2015, (accessed 30 Jul 2016), (2015) http://research.mindtake.com/de/craft-beer-osterreich-noch-weitgehend-unbekannt

18. International Hop Growers` Convention: Summary Report of the Economic Commission of the International Hop Growers` Convention. Paris, France, April (2016), p. 2.

19. Seigner E.: List of world hop varieties of the International Hop Growers` Convention (IHGC). (accessed 30 Jul 2016), (2015); http://www.lfl.bayern.de/mam/cms07/ipz/dateien/hopfen_ihgc_list_-_hop_varieties_2015-aktualisiert.pdf

20. De Keukeleire, D.: Fundamentals of beer and hop chemistry. Química Nova, **23** (2000), no. 1, pp. 108-112.

21. Takoi, K. and Koie, K.: Biotransformation of hop-derived monoterpene alcohols by lager yeast and their contribution to the flavor of hopped beer. Journal of Agricultural and Food Chemistry **58** (2010), pp. 5050-5058.

22. Takoi, K.; Tokita, K.; Sanekata, A.; Usami, Y.; Itoga, Y.; Koie, K.; Matsumoto, I. and Nakayama, Y.: Varietal difference of hop-derived flavour compounds in late-hopped/dry-hopped beers. BrewingScience, **69** (2016), no 1, pp. 1-7.

23. Kankolongo Cibaka, M.-L.; Gros, J.; Nizet, S. and Collin, S.: Quantitation of selected terpenoids and mercaptans in the dual-purpose hop varieties Amarillo, Citra, Hallertau Blanc, Mosaic, and Sorachi Ace. Journal of Agricultural and Food Chemistry, **63** (2015), no. 11, pp. 3022-3030.

24. Brewers Association: Attachments, Brief beer and food matching chart.

(accessed 30 Jul 2016), (2016) https://www.brewersassociation.org/attachments/0000/2095/Beer_and_Food_Flyer_MDC.pdf
25. Preedy, V. R.: Beer in Health and Disease Prevention. 2011 ed., Elsevier, London, UK, 2011. p. 62.
26. Euromonitor: Press release, As good as it gets, Low/non-alcoholic beer in mature markets. Published on 20 Nov 2013, (accessed 30 Jul 2016), (2013) http://blog.euromonitor.com/2013/11/as-good-as-it-gets-lownon-alcoholic-beer-in-mature-markets.html
27. Eurostat: Produktion von alkoholfreiem Bier in der Europäischen Union nach Ländern im Jahr 2014 (in 1.000 Liter). Eurostat database, Statistische Amt der Europäischen Union, Luxemburg 2015. (accessed 30 Jul 2016), (2015) http://ec.europa.eu/eurostat/de
28. Statistisches Bundesamt: Produktionswert von alkoholfreiem Bier in Deutschland in den Jahren 2005 bis 2014. (accessed 31 Mar 2016), 2015 https://www.destatis.de/DE/Startseite.html
29. Mintel: Press release, Lightweight lager? Europeans embrace the non-alcoholic beer boom. Published on 14 Nov 2014, (accessed at 31 Mar 2016), (2014) http://www.mintel.com/press-centre/food-and-drink/lightweight-lager-europeans-embrace-the-non-alcoholic-beer-boom
30. The Economist: Press release, Brewers in the Middle East - Sin-free ale. Published on 3 Aug 2013, (accessed 31 Mar 2016), (2013) http://www.economist.com/news/business/21582531-non-alcoholic-beer-taking-among-muslim-consumers-sin-free-ale
31. Sorenson, D. and Bogue, J.: Consumer-oriented development of functional beverages. In: Paquin P, editor. Functional and specialty beverage technology. Woodhead Publishing Limited and CRC Press LLC., Cambridge, UK, 2009, pp. 421-450.
32. Baird: Market Analysis, Health, Nutrition & Fitness Report. Baird, Milwaukee, USA, 2012, p. 6. (accessed at 11 Aug 2016) https://images.indiegogo.com/medias/980312/files/20130811072017-Health_Nutrition___Fitness_Growth_Opportunities.pdf?1376230819
33. Zenithinternational: Press release, Alertness and Relaxation Drinks Report. (accessed at 11 Aug 2016), (2011) http://www.zenithinternational.com/reports_data/139/Alertness%20and%20Relaxation%20Drinks%20Report%202011
34. Lucot, M.: Press release, Relaxation drinks. (accessed at 11 Aug 2016), (2016) http://www.ingredia-nutritional.com/static/download.htm?doc_id=148
35. IBISWorld: Market research report, Relaxation drink production in the US. Published in Sep 2014 (accessed 31 Mar 2016), (2014) http://www.ibisworld.com/industry/relaxation-drink-production.html
36. FoodDrinkEurope: Report, Data and trends of the European food and drink industry 2014-2015. FoodDrinkEurope, Brussels, Belgium, 2015. p. 10. (accessed at 11 Aug 2016) http://www.fooddrinkeurope.eu/uploads/publications_documents/Data__Trends_of_the_European_Food_and_Drink_Industry_2013-20141.pdf
37. Schönberger, C. and Kostelecky, T.: 125th Anniversary Review: The Role of Hops in Brewing. Journal of the Institute of Brewing, **117** (2011), no. 3, pp. 259-267.
38. Billovits, M. J.; Hanson, L. G.; Gutiérrez, M.-J.; Snider, M. L.; Miranda, G. and Lewis, M. J.: The Microbiology of Dry-Hopping. MBAA Technical Quarterly, **27** (1990), pp. 83-89.
39. De Keukeleire, D.: Fundamentals of beer and hop chemistry. Química Nova, **23** (2000) no. 1, pp. 108-112.
40. Forster, A. and Gahr, A.: On the fate of certain hop substances during dry hopping. BrewingScience, **66** (2013), no. 7-8, pp. 93-103.
41. Lermusieau, G.; Bulens, M. and Collin, S.. Use of GC–olfactometry to identify the hop aromatic compounds in beer. Journal of Agricultural and Food Chemistry **49** (2001), pp. 3867-3874.
42. Vermeulen, C.; Lejeune, I.; Tran, T. T. H. and Collin, S.: Occurrence of polyfunctional thiols in fresh lager beers. Journal of Agricultural and Food Chemistry. **54** (2006), pp. 5061-5068.
43. Henley, T.; Reddivari, L.; Broeckling, C. D.; Bunning, M.; Miller, J.; Avens, J. S.; Stone, M.; Prenni, J. E. and Vanamala, J.: American India Pale Ale matrix rich in xanthohumol is potent in suppressing proliferation and elevating apoptosis of human colon cancer cells. International Journal of Food Science and Technology, **49** (2014), no. 11, pp. 2464-2471.
44. Brányik, T.; Silva, D. P.; Baszczyňski, M.; Lehnert, R. and Almeida e Silva, J. B.: A review of methods of low alcohol and alcohol-free beer production. Journal of Food Engineering, **108** (2012), no. 4, pp. 493-506.
45. Farag, M. A.; Porzel, A. and Wessjohann, L. A.: Comparative metabolite profiling and fingerprinting of medicinal licorice roots using a multiplex approach of GC–MS, LC–MS and 1D NMR techniques. Phytochemistry, **76** (2012), pp. 60- 72.
46. Schleiss, M.: Press release, Anti Energy Drinks: Geschäftsideen, die beruhigen. Published on 23 Mar 2015, (accessed 31 Mar 2016), 2015 https://www.fuer-gruender.de/blog/2015/03/geschaeftsideen-relaxation-drinks/
47. Research and Markets: Report ID: 3292773, Global market study on flavored and functional water. Published on Aug 2014, (accessed on 31 MAr 2016), 2014 http://www.researchandmarkets.com/research/fhp4tx/global_market

Received 26 June 2016, accepted 14 August 2016