

M. H. Hagemann, V. Schmidt-Cotta, E. Marchioni and S. Braun

# Chance for Dry-hopped Non-alcoholic Beverages?

## Part 2: Health Properties and Target Consumers

**Alcohol-free beer and functional drinks are two strongly growing markets within the beverage sector. The success of alcohol-free beer and functional drinks with relaxing, stress reducing properties might be largely based on their health-beneficial properties. Additionally, exotic flavors along with a high product quality are also key value propositions of these products. In the following, the main potential health beneficial properties of alcohol-free dry-hopped beer and dry-hopped relaxation drinks will be reviewed and the main target consumer groups will be described. The concept and market prospects of dry-hopped non-alcoholic beverages have been discussed in an earlier article by the authors.**

Descriptors: dry-hopping, functional drink, healthy diets

### 1 Introduction

The decrease of beer consumption in North America and Europe [1–3] is likely caused by the increasing global awareness and demand for healthier food and drinks [4,5]. Along with this health trend also consumption of premium beer (i.e. craft beer), alcohol-free beer (AFB), and relaxation drinks (RD) is increasing [6]. Craft beer refers to beer produced in (relatively) small quantities with traditional or innovative brewing techniques [7]. AFB is defined as beer with an ethanol concentration of 0.5 vol% or less [8]. RDs are non-alcoholic functional drinks characterized by their provision of health benefits beyond their nutritional value, which are stress relief and anxiety reduction [5,9,10]. This article introduces the health properties and target consumers for dry-hopped non-alcoholic beverages, such as alcohol-free craft beers (AFCB) and dry-hopped relaxation drinks. The concept and market prospects have been discussed in a previous article [6].

### 2 Health aspects of alcohol-free beer

In general, the multiple health aspects of AFB are similar to normal beer without the negative effects of ethanol on the liver and other organs [11]. The small amount of residual ethanol in some AFB types is considered to be safe from a medical point of view as shown, e.g. by studies concluding that the consumption of AFB is even safe when breastfeeding or being pregnant [11,12].

<https://doi.org/10.23763/BrSc17-10Hagemann>

#### Authors

Michael Helmut Hagemann, Verónica Schmidt-Cotta, Susanne Braun. University of Hohenheim, Research Center for Bioeconomy, Stuttgart, Germany; 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

However, from a physiological or neurophysiological perspective, AFB should not be consumed by former alcohol addicts due to the danger of relapse [13].

AFB could be used as part of a healthy diet, especially as alternative to energy-rich beverages, which are associated with obesity [14]. This disease is a growing health concern, especially in Europe and North America [15]. Due to the relatively low energy concentration of AFB, typically about 84 kJ\*100 ml<sup>-1</sup>, compared to soft drinks and juices, which range from 155 to 226 kJ\*100 ml<sup>-1</sup>, AFB might be a valid alternative with additional health properties as it is rich in vitamins and minerals. Furthermore, some AFBs are close to or advertised as isotonic, i.e. the beer is brewed such that the mineral and osmotic properties are similar to human blood [8,16]. It is important to note that yeast clouded AFBs contain more minerals and are therefore closer or in the range or isotonic compared to clear AFBs [16]. Generally, the mineral composition of AFB is considered to be balanced with high amounts of potassium (500–600 mg\*l<sup>-1</sup>) and magnesium (100–110 mg\*l<sup>-1</sup>) as well as with low amounts of sodium (30–32 mg\*l<sup>-1</sup>) and calcium (35–40 mg\*l<sup>-1</sup>) [17]. These minerals and other compounds in AFB can help to recover after physical exercises [18], to reduce inflammation, and to reduce the chance of getting respiratory illnesses after intensive physical exertion, respectively [19,20]. Indeed, sportsmen seem to appreciate the properties of AFB which is reflected by an increased consumption of sports drinks and AFB over the past years [21,22]. The minerals in beer and AFB derive mainly from barley (75%) and water (25%), thus the mineral content of beer depends on the origin of the raw materials [17]. Additionally, beer and AFB are a source of mineral micronutrients, such as selenium [23] or highly bioavailable orthosilicic acid [24,25] which is considered important for bone and tissue growth [26]. Besides minerals also dietary fiber is an important part of a healthy diet [27]. However, despite the high level of 2 g\*l<sup>-1</sup> compared to many other beverages [28] the food composition tables on beer bottles often lack information on the concentration of dietary fiber. The American Dietetic Association recommends an intake of 14 g dietary fiber per 4,184 J of food

consumed. The dietary fiber in beer derives from barley and is a complex of indigestible carbohydrates, polyphenolic compounds and indigestible protein. In contrast to digestible carbohydrates (10%), which are responsible for the calorific value of beer, indigestible carbohydrates (90%) can lower blood cholesterol [28,29].

Beer and AFB are also rich in vitamins, especially from the class of B vitamins [30]. Regarding the bioavailability of vitamins AFB and ethanol-containing beer differ; due to the antagonistic effect of ethanol on the bio-utilization of vitamins [11]. B vitamins in beer partly derive from the malted barley and partly from microorganisms [8]. In particular vitamin B12 has been suggested to derive from yeast [8,31], but lactic acid bacteria are further possible B vitamin sources. Lactic acid bacteria can be naturally present in a raw material or additionally added for fermentation or other food processing techniques [32,33]. In beer, depending on the species and strain, lactic acid bacteria can be either unwanted spoilage organisms or wanted for adding a sour flavor and microbiological stability to certain beer styles [34–36]. However, the bioactive compounds of hop (*Humulus lupulus* L.) can inhibit growth of these bacteria [34] and therefore the actual vitamin contribution to the final product largely depends on all aspects of the particular brewing process.

Hops contribute to the bitter taste of beer but also have interesting health-related properties. In particular, the bitterness is based on the bitter acids and their isomerization products; humulone (alpha acid) and lupulone (beta acid). Studies on the potential medical uses of these metabolites have demonstrated anti-carcinogenic properties [34], possible pharmacological effects against obesity [35], liver-protective effects [36] and inhibition of bone resorption [11]. However, these results mostly derive from pharmacological research studies based on experiments with tissue culture, model organisms or early medical trials, thus it should not be assumed that these health effects can be achieved by beer consumption.

Iso-alpha acids, typically ranging from 8–28 mg<sup>l</sup><sup>-1</sup> depending on the beer type [37], as well as prenylflavonoids and myrcenol are responsible for the sedative effect of beer and AFB consumption. Especially, the AFB consumption can induce better sleep and relieve stress [38], as well as reduce anxiety and depression [39]. The sedative effect of hop products in combination with valerian is the only effective medical application of hops recognized by the European Medical Agency [40]. Beta acids are further known to be active against gram-positive bacteria such as *Staphylococcus aureus* or *Listeria monocytogenes* [41]. However, the water solubility of beta acids is low, therefore no effects towards human health are expected. Further health beneficial metabolites in beer are phenolic compounds for their anti-oxidative capacity [42,43]. Many health benefits are attributed to phenolic compounds, including an improvement in wound-healing and alleviating of different skin diseases as well as skin ageing [44]. In most beers 70–100% of the polyphenols derive from barley and 30–0% derive from hops, respectively [11,45]. However, the prenylflavonoid XN, which is in the focus of pharmacological research for almost three decades, derives exclusively from hops [45]. Experiments with tissue culture or model organisms have shown that XN has anti-carcinogenic [34,46–48] and dementia mitigating properties [11,49,50] as well as obesity reducing properties [51]. Further flavonoids and flavonoid glycosides occurring in hops [52–54] and in beer [45], showed

antimicrobial effects such as antibacterial [57–59], antifungal [58], antimalarial [61,62] or antiviral effects [61–63]. Important to note that these are basic research results and as of now only few clinical trials have been conducted. Therefore, these health beneficial effects might not be achieved by beer consumption, also due to the low water solubility of these phenolic compounds, especially XN. The XN concentration in beer varies depending on the brewing method, from 0.2–12.7 mg<sup>l</sup><sup>-1</sup>. However, dry-hopping can significantly increase the XN concentration [43].

## 2.1 Health effects of dry-hopped alcohol-free beer

Technically dry-hopping is a cold-extraction of hop cones or pellets in water and alcohol [64], where typically extensive amounts and often different cultivars are used compared to beer styles without dry-hopping. Because dry-hopping is applied after the wort boiling the added hop metabolites do not get isomerized and aroma, i.e. the volatile terpenoids and other fractions do not volatilize [65], while the oxidative wort and beer stability can be increased [66]. Additionally, to a more intense aroma also higher levels of bioactive compounds can be achieved through dry-hopping as shown for XN [43], catechin, quercetin, and kaempferol [67]. Dry-hopping is particularly important to increase the XN concentration, because the XN from hops that have been added prior wort boiling gets converted into the less active isoxanthohumul [53]. Further, approaches to increase the XN concentration in beer are the usage of XN-enriched hop-extract (Patent DE10320250A1). The aim for any XN mediated health beneficial effect in a beverage is to achieve a concentration between 0.4 and 3.5 mg<sup>l</sup><sup>-1</sup>, as this is the minimum effective concentration in the studies on XN health effects mentioned earlier. Indeed, it has been claimed that a beer with 1.5 mg l<sup>-1</sup> XN is possible (Patent DE10320250A1). For AF(C)B, however, it will be a challenge to achieve such concentrations since the water solubility of XN limits the concentration to 1.3 mg<sup>l</sup><sup>-1</sup> at 23 °C in ethanol-free matrices [68]. From all raw materials of the brewing process, hops appeared to possess the highest concentration of Ca, Cu, Fe, Mg and Zn [66,69]. The high amounts of hops used in dry-hopping consequently increase the metal ion concentration in the final beer. This would have positive effects due to an increased foam stability [70] and the nutritional value of those ions; however, it may in turn affect the stability of the beverage through the Fenton or Haber-Weiss reaction [69]. In conclusion, dry-hopping can be used to substantially change and enrich the flavor but also the quality and health value of a beverage. This technique is mainly used for the production of craft beers [71] and is likely to increase several health beneficial properties deriving from hop [43]. Thus a dry-hopped alcohol-free craft beer (AFCB) has a good marked potential considering a growing number of health conscious consumers [6].

## 2.2 Marketing chances of alcohol-free craft beer

AFB beer is seen as a substitution for conventional beer, e.g. for people who like the taste of beer but need to operate vehicles, are pregnant or have a medical condition that does not allow the consumption of alcohol, use medication that might interact with the ethanol of conventional beer, belong to religious or social groups that agreed on alcohol-abstinence, or have concerns about the negative health aspects of alcohol-consumption. Consequently,

a key value proposition of AFCB is the absence or low amount of ethanol along with flavor-richness and a superior taste where AFBs often have sensory deficits, which can be a “lack of body”, low aromatic profiles, or off-flavors [72]. Some of these sensory deficits are caused by a loss of aromatic esters, different alcohols and aldehydes [73]. However, dry-hopping might be able to cover these deficits. Especially if beer styles are used that require an abundance of hops, as for example India Pale Ale, then the product would have distinct and strong aroma profiles and higher bitterness levels. Currently only few products are on the market that belong to the category of AFCB.

People who do not consume ethanol due to religious beliefs are another growing consumer target group for AFBs. Particularly, some Muslim groups show a growing interest in AFB [74,75]. Therefore, it is not surprising that many breweries already started exploiting this growing potential. For these markets, producers have to ensure and to prove that their product conforms to religious rules. That is to say producers face the challenge to sell AFB that is completely free of ethanol and, especially important for Muslims, meets the halal-standard. However, there are no general rules that apply to all Muslim groups, thus high investments are needed to acquire the necessary certifications of AF(C)B. Here groups are to be considered who argue that the consumption of beer, even alcohol-free beer, should be permitted, as the word ‘beer’ could be associated with intoxicants. However, an ethanol concentration 0.05 vol% seems tolerable for most religious groups [72]. Moreover, considering several Fatwas and the fact that AFB is increasingly successful in some Islamic countries, it further seems that even an ethanol level of < 0.5 vol% is widely acceptable, thus there is a substantial market for AF(C)B [74–78].

### 2.3 Marketing chances for non-alcoholic functional drinks

Functional beverages, which concentrate on their health properties, range from fermented teas such as Kambucha [79], to special herb-based ice teas [80], juice-based beverages [81], or other beverages containing medical herbs [82] or exotic fruits [83]. In this article only a particular type of functional drinks will be covered - the relaxation drinks (RD). In contrast to stimulating energy drinks [84], RDs are characterized by a mild sedative effect based, for example, on the addition of hops [6]. However, it is important to note that the sedative effect of RD with melatonin, valerian, or tryptophan could not be clearly demonstrated as of now [84,85]. In contrast, the sedative effect of hops is even acknowledged by the European Medicines Agency [40]. The effect is based at least partly on an oxidation product of the hops’ bitter acids, namely the 2-methyl-3-buten-2-ol [38]. However, beside the sedative and stress relieving effect of RDs, they also might have health related properties such as a favorable vitamin or mineral composition or high levels of antioxidants. Therefore, a dry-hopped and low-calorie beverage could have similar health beneficial properties as described for AF(C)B, but here further research is necessary to proof this notion.

Studies in Germany, in the USA and China showed that the consumers in the 21st century are more critical and aware of the product properties than in previous decades [86]. These consumers have

high demands towards product quality and need to be convinced on several levels. Organic, fair-trade, healthy and functional are some of the keywords to be considered when addressing these consumer groups. This consumer group is not only demanding high quality products of the before mentioned criteria but also has a higher willingness to pay [87,88]. Here it is important to balance the price carefully as consumers view the price as a cost and as a quality criterion [88]. Especially for Germany, a recent market analysis has shown that consumer demand, particularly for innovative alcohol free beverages, is still rising. Generally, the German consumer is interested in regional products with low content of sugars and free of artificial additives. Furthermore, younger people are interested in exotic flavors [89], which could be introduced into a RD through techniques as dry-hopping. Hops contribute largely to the aroma of beer, in particular based on the odor-active terpenes and terpenoids. The monoterpenalcohol geraniol, for example, is associated with a citrus aroma [90,91], but there are several aroma characters possible that derive from hop ranging from herbal, floral or spicy to sylvan [91,92]. It is important to note, that some hop-derived compounds, mainly some monoterpene and monoterpene alcohols, require biotransformation by yeast in order to be odor-active, thus dry-hopping alone is unlikely to introduce similar aroma diversity into a RD as there is in beer [95,96]. In summary, the key value proposition of a RD is a high product quality, an interesting distinct taste, a mild sedative effect and further potential health-related properties. Regarding the latter, the regulation EC1924/2006 released by the European Food Safety Authority (EFSA) is important to consider. It controls the use of health claims for advertisement: Ingredients in a product, which are claimed to have certain health benefits, can only be declared as such, after a “scientific assessment of the highest possible standard” implemented by EFSA, has proven the named benefits. The costs and time investment for the health claim application including general safety and human studies, application fees and else [95] sum up to several million Euros (personal communication), which may be uneconomical for many niche products. Health claim registration barriers are, for example, that health claims can only be approved under the conditions that they are already listed in the community registry. Substances which have only recently been characterized for health properties as XN are unlikely to be authorized by the EU within the near future. Also claims for other polyphenols have been denied by EFSA, with the exception of polyphenols in olive oil [96,97]. Nevertheless, highlighting research results as part of a knowledge-based marketing strategy is a possibility to provide information for the “informed consumer” without contravening the health claim regulations. In the case of a RD the relaxation promoting properties can be highlighted.

### 3 Conclusion

Alcohol-free beer has numerous health-benefits, which largely derive from the cereals. However, particular bioactive metabolites and distinct aroma characteristics can be added to AFB by dry-hopping. It seems that there is a growing market for such products since the health consciousness is rising in North America and Europe as well as some religious groups developed a growing interest in premium non-alcoholic beverages. Furthermore, dry-hopping could also be a method to increase the diversity of relaxation drinks. In the

context of the highly innovative and constantly growing functional drink market dry-hopped relaxation drinks could especially target for health conscious consumers.

## Acknowledgement

The authors thank the Research Center for Bioeconomy of the University of Hohenheim (Stuttgart, Germany) for the support and in particular Benjamin Biesdorf for his editorial work.

## 4 References

- Kearney, J.: Food consumption trends and drivers. Philosophical transactions of the Royal Society of London, Series B, Biological sciences **365** (2010), pp. 2793-807.
- FAO.: Food Balance Sheets. FAOSTAT database (2016), Available at: <http://faostat.fao.org/>. (Accessed: 31 Mar. 2016).
- IFOAM.: The World of Organic Agriculture. The World of Organic Agriculture (2015).
- 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.
- 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.
- Hagemann, M. H.; Bogner, K.; Marchioni, E. and Susanne, B.: Chances for dry-hopped non-alcoholic beverages? Part 1: Concept and market prospects, BrewingScience **69** (2016), no. 7-8, pp. 50-55.
- Brewers Association.: Statistics, craft beer defined. (2016), Available at: <https://www.brewersassociation.org/statistics/craft-brewer-defined/>. (Accessed: 30 Jul. 2016).
- Preedy, V.: Beer in health and disease prevention (London, UK, 2011).
- Zenithinternational.: Press release, Alertness and Relaxation Drinks Report. (2011), Available at: [http://www.zenithinternational.com/reports\\_data/139/Alertness and Relaxation Drinks Report 2011](http://www.zenithinternational.com/reports_data/139/Alertness and Relaxation Drinks Report 2011) (Accessed: 11 Aug. 2016).
- Lucot, M.: Relaxation drinks, Press release **33** (2016).
- Sohrabvandi, S.; Mortazavian, A. M. and Rezaei, K.: Health-related aspects of beer: A review, International Journal of Food Properties **15** (2012), no. 2, pp. 350-373.
- Schneider, C.; Thierauf, A.; Kempf, J. and Auwärter, V.: Ethanol concentration in breastmilk after the consumption of non-alcoholic beer, Breastfeeding Medicine **8** (2013), no. 3, pp. 291-293.
- Long, C. G. and Cohen, E. M.: Low alcohol beers and wines: attitudes of problem drinkers to their use and their effect on craving, Addiction **84** (1989), no. 7, pp. 777-783.
- Muckelbauer, R.; Gortmaker, S. L.; Libuda, L.; Kersting, M.; Clausen, K.; Adelberger, B. and Müller-Nordhorn, J.: Changes in water and sugar-containing beverage consumption and body weight outcomes in children, British Journal of Nutrition **115** (2016), no. 5, pp. 1-10, doi:10.1017/S0007114516001136.
- Ortega, F. B.; Lavie, C. J. and Blair, S. N.: Obesity and Cardiovascular Disease, Circulation Research **118** (2016), no. 11, pp. 1752-1770.
- Krennhuber, K.; Kahr, H. and Jäger, A.: Suitability of beer as an alternative to classical fitness drinks, Current Research in Nutrition and Food Science Journal **4** (2016), no. 4, pp. 26-31.
- Montanari, L.; Marconi, O. and Mayer, H.: Production of alcohol-free beer, in Beer in health and disease prevention (ed. Preedy, V. R.) (London, UK, 2009), pp. 61-78.
- Castro-Sepulveda, M.; Johannsen, N.; Astudillo, S.; Jorquera, C.; Álvarez, C.; Zbinden-Foncea, H. and Ramírez-Campillo, R.: Effects of beer, non-alcoholic beer and water consumption before exercise on fluid and electrolyte homeostasis in athletes, Nutrients **8** (2016), no. 6, pp. 345.
- Gleeson, M.: Immunological aspects of sport nutrition, Immunology and Cell Biology **94** (2016), no. 2, pp. 117-123.
- Scherr, J.; Nieman, D. C.; Schuster, T.; Braun, S.; Wolfarth, B. and Halle, M.: Non-alcoholic beer reduces inflammation and the incidence of upper respiratory tract infections after a marathon, Medicine and Science in Sports and Exercise **43** (2011), no. 1, pp. 18.
- Statista.: Getränke-Konsum von Sportlergetränken, isotonischen Getränken in Deutschland 2016. (2016), Available at: <https://de.statista.com/statistik/daten/studie/265028/umfrage/konsum-von-sportlergetraenken-isotonischen-getraenken-in-deutschland/> (Accessed: 23 Sep. 2016).
- Tarancon, J. and Lachenmeier, D.: Determination of osmolality in beer to validate claims of isotonicity, Beverages **1** (2015), pp. 45-54.
- Bamforth, C. W.: Nutritional aspects of beer? A review, Nutrition Research **22** (2002), no. 2, pp. 227-237.
- Sripanyakorn, S.; Jugdaohsingh, R.; Elliott, H.; Walker, C.; Mehta, P.; Shoukru, S.; Thompson, R. P. H. and Powell, J. J.: The silicon content of beer and its bioavailability in healthy volunteers, British Journal of Nutrition **91** (2004), no. 3, pp. 403.
- Sripanyakorn, S., Jugdaohsingh, R., Dissayabutr, W., Anderson, S. H. C., Thompson, R. P. H. and Powell, J. J.: The comparative absorption of silicon from different foods and food supplements, British Journal of Nutrition **102** (2009), no. 6, pp. 825.
- Jugdaohsingh, R.: Silicon and bone health, The journal of nutrition, health and aging **11** (2007), no. 2, pp. 99-110.
- Slavin, J. L.: Position of the american dietetic association: health implications of dietary fiber, Journal of the American Dietetic Association **108** (2008), no. 10, pp. 1716-1731.
- Goñi, I., Díaz-Rubio, M. E., Pérez-Jiménez, J. and Saura-Calixto, F.: Towards an updated methodology for measurement of dietary fiber, including associated polyphenols, in food and beverages, Food Research International **42** (2009), no. 7, pp. 840-846.
- Krumholz, H. M.: The new cholesterol and blood pressure guidelines, JAMA **311** (2014), no. 14, pp. 1403.
- Romeo, J.; Wörnberg, J.; Nova, E.; Díaz, L. E.; Gómez-Martínez, S. and Marcos, A.: Moderate alcohol consumption and the immune system: A review, British Journal of Nutrition **98** (2007), no. 51, pp. S111-S115.
- Mayer, Jr. O.; Šimon, J. and Rosolová, H.: A population study of the influence of beer consumption on folate and homocysteine concentrations, European Journal of Clinical Nutrition **55** (2001), no. 7, pp. 605-609.
- Masuda, M.; Ide, M.; Utsumi, H.; Niiro, T.; Shimamura, Y. and Murata, M.: Production potency of folate, vitamin B12, and thiamine by lactic acid bacteria isolated from japanese pickles, Bioscience, Biotechnology, and Biochemistry **76** (2012), no. 11, pp. 2061-2067.
- Capozzi, V.; Russo, P.; Dueñas, M. T.; López, P. and Spano, G.: Lactic acid bacteria producing B-group vitamins: a great potential for functional cereals products, Applied Microbiology and Biotechnology **96** (2012), no. 6, pp. 1383-1394.
- Suzuki, K.; Iijima, K.; Sakamoto, K.; Sami, M. and Yamashita, H.: A review of hop resistance in beer spoilage lactic acid bacteria, Journal of the Institute of Brewing **112** (2006), no. 2, pp. 173-191.

35. Brewers Association: Beer Style Guidelines, (Boulder, CO, USA, 2015), pp. 1-55.
36. Lowe, D. P. and Arendt, E. K.: The use and effects of lactic acid bacteria in malting and brewing with their relationships to antifungal activity, mycotoxins and gushing: a review, *Journal of the Institute of Brewing* **110** (2004), no. 3, pp. 163-180.
37. Gerhauser, C.; Alt, A.; Heiss, E.; Gamal-Eldeen, A.; Klimo, K.; Knauft, J.; Neumann, I.; Scherf, H.-R.; Frank, N.; Bartsch, H. and Becker, H.: Cancer chemopreventive activity of Xanthohumol, a natural product derived from hop, *Molecular cancer therapeutics* **1** (2002), no. 11, pp. 959-69.
38. Morimoto-Kobayashi, Y.; Ohara, K.; Takahashi, C.; Kitao, S.; Wang, G.; Taniguchi, Y.; Katayama, M. and Nagai, K.: Matured hop bittering components induce thermogenesis in brown adipose tissue via sympathetic nerve activity, *PLOS ONE* **10** (2015), no. 6, pp. e0131042.
39. Saugspier, M.; Dorn, C.; Thasler, W. E.; Gehrig, M.; Heilmann, J. and Hellerbrand, C.: Hop bitter acids exhibit anti-fibrogenic effects on hepatic stellate cells in vitro, *Experimental and Molecular Pathology* **92** (2012), no. 2, pp. 222-228.
40. Biendl, M.; Engelhard, A.; Forster, A.; Gahr, A.; Lutz, A.; Mitter, A.; Schmidt, R. and Schönberger, C.: Hops. Their cultivation, composition and usage, (Nuremberg, Germany, 2014).
41. Franco, L.; Sánchez, C.; Bravo, R.; Rodríguez, A.; Barriga, C. and Juárez, J.: The sedative effects of hops (*Humulus lupulus*), a component of beer, on the activity/rest rhythm, *Acta Physiologica Hungarica* **99** (2012), no. 2, pp. 133-139.
42. Franco, L.; Galán, C.; Bravo, R.; Bejarano, I.; Peñas-Lledo, E.; Rodríguez, A. B.; Barriga, C. and Cubero, J.: Effect of non-alcohol beer on anxiety: Relationship of 5-HIAA, *Neurochemical Journal* **9** (2015), no. 2, pp. 149-152.
43. EMA.: Assessment report of *Humulus lupulus* L.. European Medical Agency (Brussels, Belgium, 2014).
44. Kramer, B.; Thielmann, J.; Hickisch, A.; Muranyi, P.; Wunderlich, J. and Hauser, C.: Antimicrobial activity of hop extracts against foodborne pathogens for meat applications, *Journal of applied microbiology* **118** (2015), no. 3, pp. 648-57.
45. Leitao, C.; Marchioni, E.; Bergaentzlé, M.; Zhao, M.; Didierjean, L.; Taidi, B. and Ennahar, S.: Effects of processing steps on the phenolic content and antioxidant activity of beer, *Journal of Agricultural and Food Chemistry* **59** (2011), no. 4, pp. 1249-1255.
46. 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.
47. Chen, W.; Becker, T.; Qian, F. and Ring, J.: Beer and beer compounds: physiological effects on skin health, *Journal of the European Academy of Dermatology and Venereology* **28** (2014), no. 2, pp. 142-150.
48. Arranz, S.; Chiva-Blanch, G.; Valderas-Martínez, P.; Medina-Remón, A.; Lamuela-Raventós, R. M. and Estruch, R.: Wine, beer, alcohol and polyphenols on cardiovascular disease and cancer, *Nutrients* **4** (2012), no. 12, pp. 759-781.
49. Colgate, E. C.; Miranda, C. L.; Stevens, J. F.; Bray, T. M. and Ho, E.: Xanthohumol, a prenylflavonoid derived from hops induces apoptosis and inhibits NF-kappaB activation in prostate epithelial cells, *Cancer Letters* **246** (2007), no. 1-2, pp. 201-209.
50. Viola, K.; Kopf, S.; Rarova, L.; Jarukamjorn, K.; Kretschy, N.; Teichmann, M.; Vonach, C.; Atanasov, A. G.; Giessrigl, B.; Huttary, N.; Raab, I.; Krieger, S.; Strnad, M.; de Martin, R.; Saiko, P.; Szekeres, T.; Knausmüller, S.; Dirsch, V. M.; Jäger, W.; Grusch, M.; Dolznig, H.; Mikulits, W. and Krupitza, G.: Xanthohumol attenuates tumour cell-mediated breaching of the lymphendothelial barrier and prevents intravasation and metastasis, *Archives of toxicology* **87** (2013), pp. 1301-12.
51. Liu, M.; Hansen, P. E.; Wang, G.; Qiu, L.; Dong, J.; Yin, H.; Qian, Z.; Yang, M. and Miao, J.: Pharmacological profile of xanthohumol, a prenylated flavonoid from hops (*Humulus lupulus*), *Molecules* **20** (2015), no. 1, pp. 754-779.
52. Sasaoka, N.; Sakamoto, M.; Kanemori, S.; Kan, M.; Tsukano, C.; Takemoto, Y. and Kakizuka, A.: Long-Term Oral Administration of Hop Flower Extracts Mitigates Alzheimer Phenotypes in Mice, *PLoS ONE* **9** (2014), no. 1, pp. e87185.
53. Zamzow, D. R.; Elias, V.; Legette, L. L.; Choi, J.; Stevens, J. F. and Magnusson, K. R.: Xanthohumol improved cognitive flexibility in young mice, *Behavioural brain research* **275** (2014), pp. 1-10.
54. Legette, L. L.; Moreno Luna, A. Y.; Reed, R. L.; Miranda, C. L.; Bobe, G.; Proteau, R. R. and Stevens, J. F.: Xanthohumol lowers body weight and fasting plasma glucose in obese male Zucker fa/fa rats, *Phytochemistry* **91** (2013), pp. 236-241.
55. Sägesser, M. and Deinzer, M.: HPLC-ion spray-tandem mass spectrometry of flavonol glycosides in hops, *Journal of the American Society of Brewing Chemists* **54**, no. 3, pp. 129-134.
56. Stevens, J. F. and Page, J. E.: Xanthohumol and related prenylflavonoids from hops and beer: to your good health! *Phytochemistry* **65** (2004), no. 10, pp. 1317-1330.
57. 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.
58. Hirai, I.; Okuno, M.; Katsuma, R.; Arita, N.; Tachibana, M. and Yamamoto, Y.: Characterisation of anti-*Staphylococcus aureus* activity of quercetin, *International Journal of Food Science and Technology* **45** (2010), no. 6, pp. 1250-1254.
59. Huang, Y.-H., Huang, C.-C., Chen, C.-C., Yang, K.-J. and Huang, C.-Y.: Inhibition of *Staphylococcus aureus* PriA helicase by flavonol kaempferol, *The Protein Journal* **34** (2015), no. 3, pp. 169-172.
60. Stompor, M. and Żarowska, B.: Antimicrobial activity of xanthohumol and its selected structural analogues, *Molecules* **21** (2016), no. 5, pp. 608.
61. Snoussi, M.; Trabelsi, N.; Dehmeni, A.; Benzekri, R.; Bouslama, L.; Hajlaoui, B.; Al-sieni, A. and Papetti, A.: Phytochemical analysis, antimicrobial and antioxidant activities of *Allium roseum* var. *odoratissimum* (Desf.) Coss extracts, *Industrial Crops and Products* **89** (2016), pp. 533-542.
62. Herath, W.; Ferreira, D.; Khan, S. I. and Khan, I. A.: Identification and biological activity of microbial metabolites of xanthohumol, *Chemical and Pharmaceutical Bulletin* **51** (2003), no. 5, pp. 1237-1240.
63. Wong, S. K.; Jann, M. L. S.; Sudi, S.; Hassan, W. R. B. M.; Chin, L. P.; Embi, N. and Sidek, H. M.: Anti-malarial and anti-inflammatory effects of *Gynura procumbens* are mediated by kaempferol via inhibition of glycogen synthase kinase-3 $\beta$  (GSK3 $\beta$ ), *Sains Malaysiana* **44** (2015), no. 10, pp. 1489-1500.
64. Behbahani, M.; Sayedipour, S.; Pourazar, A. and Shanehsazzadeh, M.: In vitro anti-HIV-1 activities of kaempferol and kaempferol-7-O-glucoside isolated from *Securigera securidaca*, *Research in pharmaceutical sciences* **9** (2014), no. 6, pp. 463-9.
65. Sajitha Lulu, S.; Thabitha, A.; Vino, S.; Mohana Priya, A. and Rout, M.: Naringenin and quercetin – potential anti-HCV agents for NS2 protease

- targets, *Natural Product Research* **30** (2016), no. 4, pp. 464-468.
66. Yang, L.; Lin, J.; Zhou, B.; Liu, Y. and Zhu, B.: Activity of compounds from *Taxillus sutchuenensis* as inhibitors of HCV NS3 serine protease, *Natural Product Research* **31** (2017), no. 4, pp. 487-491.
  67. Schönberger, C. and Kosteletzky, T.: 125th Anniversary Review: The Role of Hops in Brewing, *Journal of the Institute of Brewing* **117** (2011), no. 3, pp. 259-267.
  68. De Keukeleire, D.: Fundamentals of beer and hop chemistry, *Química Nova* **23** (2000), no. 1, pp. 108-112.
  69. Kunz, T.; Frenzel, J.; Wietstock, P. C. and Methner, F.-J.: Possibilities to improve the antioxidative capacity of beer by optimized hopping regimes, *Journal of the Institute of Brewing* **120** (2014), no. 4, pp. 415-425.
  70. Forster, A. and Gahr, A.: On the fate of certain hop substances during dry hopping, *BrewingScience* **66** (2013), no. 7-8, pp. 93-103.
  71. Stevens, J. F.; Taylor, A. W.; Clawson, J. E. and Deinzer, M. L.: Fate of Xanthohumol and related prenylflavonoids from hops to beer, *Journal of Agricultural and Food Chemistry* **47** (1999), no. 6, pp. 2421-2428.
  72. Wietstock, P. C.; Kunz, T.; Waterkamp, H. and Methner, F.-J.: Uptake and release of Ca, Cu, Fe, Mg, and Zn during beer production, *J. Am. Soc. Brew. Chem* **73** (2015), no. 2, pp. 179-184.
  73. Bishop, L. R.; Whitear, A. L. and Inman, W. R.: A scientific basis for beer foam formation and cling, *Journal of the Institute of Brewing* **80** (1974), no. 1, pp. 68-80.
  74. Cocuzza, S. and Mitter, W.: Revival of a Process. Dry hopping – basics and techniques, *Brewing and Beverage Industry International* **3** (2013), pp. 29-30.
  75. Brányik, T.; Silva, D. P.; Baszczyński, 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.
  76. Blanco, C. A., Andrés-Iglesias, C. and Montero, O.: Low-alcohol beers: Flavor compounds, defects, and improvement strategies, *Critical Reviews in Food Science and Nutrition* **56** (2016), no. 8, pp. 1379-1388.
  77. The Economist.: Brewers in the Middle East – Sin-free ale. (2013), Available at: <http://www.economist.com/news/business/21582531-non-alcoholic-beer-taking-among-muslim-consumers-sin-free-ale> (Accessed: 31 Mar. 2016).
  78. Mintel.: Lightweight lager? Europeans embrace the non-alcoholic beer boom. (2014), Available at: <http://www.mintel.com/press-centre/food-and-drink/lightweight-lager-europeans-embrace-the-non-alcoholic-beer-boom> (Accessed: 31 Mar. 2016).
  79. Islamweb.: Fatwa No: 299059 - Ruling on beer with 0.5% alcohol. Islamweb (2015), Available at: <http://www.islamweb.net/emainpage/index.php?page=showfatwa&Option=Fatwald&Id=299059>. (Accessed: 31 Mar. 2016).
  80. Islamweb.: Fatwa No: 87498 - Drinking non-alcoholic beer. Islamweb (2004), Available at: <http://www.islamweb.net/emainpage/index.php?page=showfatwa&Option=Fatwald&Id=87498>.
  81. Halal Industrie Development Corporation.: Non-Alcoholic Beer. (2003), Available at: <http://www.hdcglobal.com/publisher/pid/219ab653-c702-49b4-8598-ebb11c060596/container//contentId/dbe4efb9-494b-41ce-bdd2-6ed087975d25>.
  82. Dufresne, C. and Farnworth, E.: Tea, Kombucha, and health: A review, *Food Research International* **33** (2000), no. 6, pp. 409-421.
  83. Oliveira, A. P.; Matos, R. P.; Silva, S. T.; Andrade, P. B.; Ferreres, F.; Gillzquierdo, A.; Meireles, S.; Brandão, T. M. and Valentão, P.: A new iced tea base herbal beverage with *Spargularia rubra* extract: Metabolic profile stability and in vitro enzyme inhibition, *Journal of Agricultural and Food Chemistry* **61** (2013), no. 36, pp. 8650-8656.
  84. Guler, A. and Tokusoglu, O.: Quality evaluation, total phenolic content, organic acid profiles and antioxidant activity of soft drinks with koruk (sour grape) concentrate, *Natural Science and Discovery* **2** (2016), no. 2, pp. 41-47.
  85. Coldea, T. E. and Mudira, E.: Valorization of aromatic plants in beverage industry: A review, *Hop and Medicinal Plants* **23** (2015), no. 1-2, pp. 25-33.
  86. Gruenwald, J.: Novel botanical ingredients for beverages, *Clinics in Dermatology* **27** (2009), no. 2, pp. 210-216.
  87. Richards, G. and Smith, A. P.: A review of energy drinks and mental health, with a focus on stress, anxiety, and depression, *Journal of Caffeine Research* **6** (2016), no. 2, pp. 49-63.
  88. Stacy, S.: Relaxation drinks and their use in adolescents, *Journal of Child and Adolescent Psychopharmacology* **21** (2011), no. 6, pp. 605-610.
  89. Weber Shandwick.: New realities – new normal, Germany (2010).
  90. Batte, M. T.; Hooker, N. H.; Haab, T. C. and Beaverson, J.: Putting their money where their mouths are: Consumer willingness to pay for multi-ingredient, processed organic food products, *Food Policy* **32** (2007), no. 2, pp. 145-159.
  91. Marian, L., Chrysochou, P., Krystallis, A. and Thøgersen, J.: The role of price as a product attribute in the organic food context: An exploration based on actual purchase data, *Food Quality and Preference* **37** (2014), pp. 52-60.
  92. Pabel, B.: Man trinkt natürlich! DLF Lebensmittel **10** (2015), pp. 42-43.
  93. Kishimoto, T.; Wanikawa, A.; Kono, K. and Shibata, K.: Comparison of the odor-active compounds in unhopped beer and beers hopped with different hop varieties, *Journal of Agricultural and Food Chemistry* **54** (2006), no. 23, pp. 8855-8861.
  94. Inui, T.; Tsuchiya, F.; Ishimaru, M.; Oka, K. and Komura, H.: Different beers with different hops. Relevant compounds for their aroma characteristics, *Journal of Agricultural and Food Chemistry* **61** (2013), no. 20, pp. 4758-4764.
  95. Van Opstaele, F.; De Causmaecker, B.; Aerts, G. and De Cooman, L.: Characterization of novel varietal floral hop aromas by headspace solid phase microextraction and gas chromatography–mass spectrometry/olfactometry, *Journal of Agricultural and Food Chemistry* **60** (2012), no. 50, pp. 12270-12281.
  96. Takoi, K. and Koie, K.: Biotransformation of hop-derived monoterpene alcohols by lager yeast and their contribution to the flavor of hopped beer, *J. Agric. Food Chem* **58** (2010), no. 8, pp. 5050-5058.
  97. King, A. J. and Dickinson, J. R.: Biotransformation of hop aroma terpenoids by ale and lager yeasts, *FEMS Yeast Research* **3** (2003), pp. 53-62.
  98. Jakobs, S.: Die Health Claims Verordnung und die Konsequenzen für die Lebensmittelindustrie: eine Unternehmensbefragung. (2012).
  99. European Food Safety Authority: Scientific Opinion on the substantiation of health claims related to polyphenols in olive and protection of LDL particles from oxidative damage (ID 1333, 1638, 1639, 1696, 2865), maintenance of normal blood HDL cholesterol concentrations (ID 1639), maintenance, *EFSA Journal* **9** (2011), pp. 2033.
  100. European Food Safety Authority.: Scientific Opinion on the substantiation of a health claim related to polyphenols in olive and maintenance of normal blood HDL cholesterol concentrations (ID 1639, further assessment) pursuant to Article 13(1) of Regulation (EC) No 1924/2006, *EFSA Journal* **10** (2012), pp. 2848.