Food Chemistry 197 (2016) 161–167

Contents lists available at ScienceDirect

Food Chemistry

journal homepage: www.elsevier.com/locate/foodchem

Brewing and volatiles analysis of three tea beers indicate a potential interaction between tea components and lager yeast

Lei Rong [a,1], Li-Juan Peng [a,1], Chi-Tang Ho [b], Shou-He Yan [c], Marc Meurens [c], Zheng-Zhu Zhang [a], Da-Xiang Li [a], Xiao-Chun Wan [a], Guan-Hu Bao [a], Xue-Ling Gao [d,*], Tie-Jun Ling [a,*]

[a] State Key Laboratory of Tea Plant Biology and Utilization, Anhui Agricultural University, 130 West Changjiang Rd., Hefei, Anhui, China
[b] Department of Food Science, Rutgers University, New Brunswick, NJ, USA
[c] Institut des Sciences de la Vie, Université Catholique de Louvain, Croix du Sud 2/8, 1348 Louvain-la-Neuve, Belgium
[d] School of Tea & Food Science, Anhui Agricultural University, 130 West Changjiang Rd., Hefei, Anhui, China

ARTICLE INFO

Article history:
Received 26 May 2015
Received in revised form 3 October 2015
Accepted 19 October 2015
Available online 19 October 2015

Keywords:
Tea beers
Comparison model
Triangular test
HS-SPME GC–MS
PCA
Interaction
Tea components
Lager yeast

ABSTRACT

Green tea, oolong tea and black tea were separately introduced to brew three kinds of tea beers. A model was designed to investigate the tea beer flavour character. Comparison of the volatiles between the sample of tea beer plus water mixture (TBW) and the sample of combination of tea infusion and normal beer (CTB) was accomplished by triangular sensory test and HS-SPME GC–MS analysis. The PCA of GC–MS data not only showed a significant difference between volatile features of each TBW and CTB group, but also suggested some key compounds to distinguish TBW from CTB. The results of GC–MS showed that the relative concentrations of many typical tea volatiles were significantly changed after the brewing process. More interestingly, the behaviour of yeast fermentation was influenced by tea components. A potential interaction between tea components and lager yeast could be suggested.

1. Introduction

Beer is one of the most widely consumed alcoholic beverages in the West. Normal beer is made of barley malt, grains, water, yeast, hop (*Humulus lupulus* L.), and other raw materials. The volatile compounds of beer are extremely complex and are primarily derived from these raw materials by yeast fermentation (Riu-Aumatell, Miró, Serra-Cayuela, Buxaderas, & López-Tamames, 2014).

Volatile compounds are especially important to beer as they contribute to the quality of final product and have been extensively studied (Callemien, Dasnoy, & Collin, 2006; de Silva et al., 2012; Fritsch & Schieberle, 2005; Langos, Granvogl, & Schieberle, 2013; Saison, De Schutter, Delvaux, & Delvaux, 2009). The methods of extracting volatiles from beer include liquid–liquid extraction, stir bar sorptive extraction, headspace and headspace-solid phase microextraction (HS-SPME) (de Silva, Augusto, & Poppi, 2008; Rossi, Sileoni, Perretti, & Marconi, 2014). HS-SPME is a simple and solvent-free sample preparation method. It can avoid contamination of nonvolatile compounds from samples by extracting and concentrating volatile compounds in headspace (Lv et al., 2012). In recent years, SPME has been widely used for the analyses of volatiles of beer (de Silva et al., 2008; Rossi et al., 2014), ranging from identification of specific groups of compounds, such as monophenols (Pizarro, Pérez-del-Notario, & González-Sáiz, 2010), terpenes (Takoi et al., 2010; Van Opstaele, De Rouck, De Clippeleer, Aerts, & De Cooman, 2010) and carbonyl compounds (Saison et al., 2009; Vesely, Lusk, Basarova, Seabrooks, & Ryder, 2003) to comprehensive characterisation of total volatiles (Langos et al., 2013; Rossi et al., 2014).

As an essential plant material, hop provides bitter taste and noble hop aroma for beer and therefore plays a key role in modern beer brewing (Aberl & Coelhan, 2012). Over 1000 compounds have been characterised in hop essential oil (Roberts, Dufour, & Lewis, 2004). Terpene alcohols are an important factor in hoppy aroma (Kishimoto, Wanikawa, Kono, & Shibata, 2006; Peacock, Deinzer, Likens, Nickerson, & McGill, 1981; Takoi et al., 2010).

On the other hand, tea (*Camellia sinensis*) is a popular aromatic beverage, and particularly in China. According to different

* Corresponding authors.
E-mail addresses: sharling@ahau.edu.cn (X.-L. Gao), lingtj@ahau.edu.cn (T.-J. Ling).
[1] These authors contributed equally to the paper.

http://dx.doi.org/10.1016/j.foodchem.2015.10.088
0308-8146/

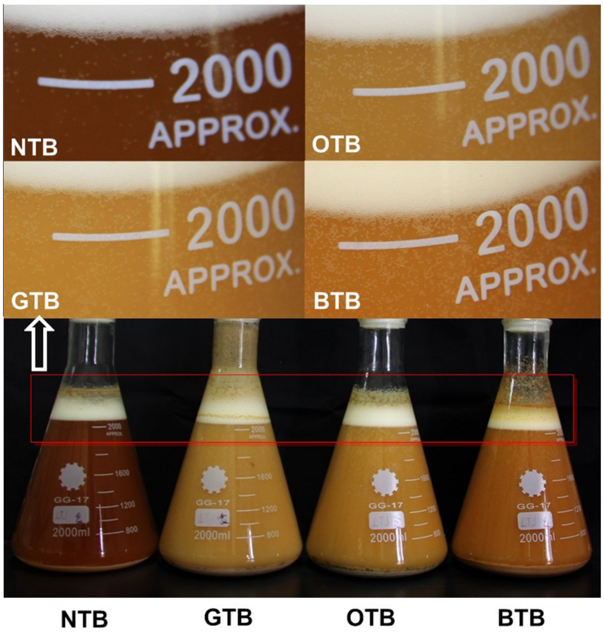

Fig. 1. The brewing of NTB and the three TBs (2.5 d).

manufacturing processes, Chinese commercial teas are classified into 6 categories, namely green tea, oolong tea, black tea, white tea, yellow tea and dark tea. Among them, the most popular teas are green tea (non-fermented), oolong tea (semi-fermented) and black tea (full-fermented). The volatile compounds, which are critical for flavour of tea, were reported to be significantly different among the three teas (Wang et al., 2008). In addition to the unique flavour, teas provide health benefits. The health functions are attributed to nonvolatile compounds in tea, such as polyphenols, caffeine and amino acids which possess antioxidant, antimicrobial, anti-carcinogenic, and hypolipidemic effects. In addition, these constituents contribute to some taste characteristics; e.g. hop contributes to bitterness of beer.

As tea is harmonious with hop in features of both taste and aroma, an integration beverage of tea and beer should be welcomed for its enhanced flavour and bio-functions.

In the present work, typical green, oolong, and black teas were separately introduced into wort to brew three kinds of tea beers (TBs, Fig. 1). A preliminary sensory evaluation showed a very special good flavour of TBs, which led to a supposition that the volatiles of tea in TB were influenced by brewing, i.e., the volatiles of TB were not the simple combination of volatiles in corresponding tea infusion and normal beer. Therefore, a simple but effective comparison model was designed to evaluate the supposition. The comparison was accomplished by triangular sensory evaluation test and HS-SPME gas chromatography–mass spectrometry (GC–MS) analysis methods.

2. Materials and methods

2.1. Raw materials and samples

Saaz hop was obtained from the Czech Republic. Three typical Chinese commercial tea samples (all made from leaves of *C. sinensis* var. *sinensis*) were chosen carefully from the market in China as follows: green tea (Huangshan Mao Feng), black tea (Keemun Black Tea), and oolong tea (Tie Guan Yin). The teas were stored at −20 °C prior to beer brewing.

2.2. Brewing process

TBs were produced by a modified lager-type beer brewing method, with addition of selected teas mentioned above (Supplementary material). The wort was prepared, using commercially available two-rowed malts [mashed by manual grinder (Corona, China) for just striping bran from barleycorn] according to the following mashing programme: 60 min at 52 °C, 60 min at 62 °C, and a further 30 min at 68 °C. The mash was then heated to 76 °C and filtered to yield wort, which was kept boiling for 90 min. Hops were added at the beginning of boiling (two thirds of total dosages) and at 10 min before the end of boiling (one third of total dosages). The teas were added together with the last dosage of hops, for independent test brewing of green tea beer (GTB), oolong tea beer (OTB), and black tea beer (BTB), respectively (Table 1). After cooling, the fermentation was started by adding 15.0×10^6 cells/ml of the lager yeast to each type of wort (12 °P). The primary fermentation was carried out at 10 °C for 5 days. Maturation was held at 12 °C for 3 days and then at 0 °C for 4 weeks. On the other hand, the brewing of non-tea beer (NTB, normal beer without tea) was carried out by a method similar to that mentioned above (Table 1).

2.3. Preparation of tea infusion (TI)

The three tea samples (green, oolong, and black teas, each 5 g) were added to 1000 ml of boiling water, respectively, and boiled for 10 min. After cooling on ice water, the supernatants were obtained as the green tea infusion (GTI), oolong tea infusion (OTI), or black tea infusion (BTI).

2.4. Design of the comparison model

A mixture of NTB and TI (1:1, v/v) was named as CTB (combination of TI and NTB). For comparison, an equivalent volume mixture of TB and water (TBW, 1:1, v/v) was prepared.

As the volatiles in TB were supposed to be not a simple combination of volatiles in corresponding TI and NTB, there should be significant differences between the volatiles of TBW and CTB, with regard to quality or quantity features. Therefore, in the designed model, each CTB versus TBW group was arranged to be compared by properties of both triangular sensory evaluation test and GC–MS analysis (Fig. 2).

Table 1
Conditions of brewing.

	Hop dosage 1[a] (g/l)	Hop dosage 2[b] (g/l)	Tea dosage [b] (g/l)
NTB	1	0.5	0
GTB	1	0.5	5
OTB	1	0.5	5
BTB	1	0.5	5

[a] Added at the beginning of wort boiling.
[b] Added at 10 min before the end of wort boiling.

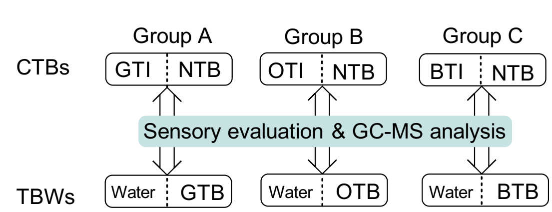

Fig. 2. The comparison model for sensory evaluation and GC–MS analysis.