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Aging of craft durum wheat beer fermented with sourdough yeasts

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Ethylcaproate (PubMed CID: 102916)
Isopentanol (PubMed CID: 31260)
Ethylcaprylate (PubMed CID: 7799)
2-Ethyl-1-hexanol (PubMed CID: 7720)
Ethyl caprate (PubMed CID: 8048)
2-Phenylethanol (PubMed CID: 6054)
Ethyl myristate (PubMed CID: 31283)

ABSTRACT

The shelf life of three different craft durum wheat beers, brewed in a Sardinian micro-brewery, fermented with autochthonous yeasts isolated from sourdough and commercial yeasts, were studied over a period of 6 months at two different temperatures: shelf temperature (28 °C) and normal cold storage temperature (8 °C). The results showed that the three beers had similar physico-chemical, volatile and sensory characteristics. This suggests the possible use of autochthonous yeasts in the brewing process to create a stronger link with the local region.

During aging, a decrease in the content of esters and higher alcohols, and an increase in carbonyl compounds occurred at the higher temperature. No significant differences were found in physico-chemical parameters during storage except for the color, which increased at 28 °C. Six months of aging did not significantly modify sensory perception of the beers.

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1. Introduction

Beer aging is one of the most important factors influencing the characteristics of beers and it is usually considered a quality problem. During storage, aging compounds are formed in bottled beers, causing the development of aging flavors and changes in taste unpleasant for consumers. The consumer recognizes a brand of beer, associating it with a flavor characteristic of that beer. It is therefore essential for brewers to maintain the characteristic flavor of their product and to produce a beer of constant quality over time (Stephenson & Bamforth, 2002; Vanderhaegen, Neven, Verachtert, & Derdelinckx, 2006). However, the formation of aged flavors cannot be controlled, and it is difficult for brewers to ensure repeatability and stability of beer flavor over time.

Many factors modify flavor stability in the final product due to the complexity of malt production and beer composition (Bamforth, 2004). During aging, different changes in the chemical composition of beer occur. The principal aging substances formed are carbonyl compounds, in particularly aldehydes (Dong et al., 2013; Soares da Costa et al., 2004). These compounds can be produced by different reactions such as oxidation of higher alcohols, degradation of bitter acids, Strecker degradation of amino acids, oxidation of unsaturated fatty acids, and aldol condensations (Bamforth, 1999, 2004; Vanderhaegen et al., 2006; Wackerbauer & Hardt, 1997). Regarding sensory attributes, the presence of aging compounds generally leads to the development of sweet tastes and flavor of cardboard (Dalgliesh, 1977; Narziss, 1986). During storage, a decline in beer bitterness was also confirmed and could become a marker for estimations of oxidative damage (Karabin et al., 2014).

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"Craft beer" refers to a beer that is not pasteurized, un-filtered, and re-fermented in the bottle (Bokulich & Bamforth, 2013; Canonico, Comitini, & Ciani, 2014; Mascia, Fadda, Dostálek, Olšovská, & Del Caro, 2014). The great importance of these beers lies in their original sensory features and distinctive elements of taste and flavor that differentiate them from industrial beers. Craft beers are produced by micro-breweries and, usually are destined for the local market. Recently, the rise in globalization has led to the need for broadening of the market and the export of craft beers beyond their local territories. For this reason micro-breweries need to increase craft beer shelf life to lengthen storage and transport times.

From the chemical point of view, the phenomenon of beer aging has therefore been studied for many years (Bamforth, 1999; Hashimoto & Kuroiwa, 1975; Kaneda, Kobayashi, Takashio, Tamaki, & Shinotsuka, 1999) but most studies on beer shelf life have focused only on industrial lager beers, since these are the most prevalent beers on the market (Vanderhaegen et al., 2006). To our knowledge, no studies reported in the literature have focused on shelf life of craft beers, and, in particular, no information about craft durum wheat beers is present.

The aim of this paper was therefore to study the evolution of physico-chemical characteristics, sensory profiles and volatile compounds of three different craft durum wheat beers during aging, stored for a period of six months using two different temperatures: shelf temperature (28 °C) and normal cold storage temperature (8 °C). The three beers brewed in a micro-brewery located in the south-east of Sardinia, Italy, were fermented with three different yeasts, one commercial and two autochthonous that were isolated from a craft Sardinian sourdough. To our knowledge this is the first study on aging of craft durum wheat beers in order to investigate the possibility of expanding the market for craft beers outside of the region.

2. Material and methods

2.1. Durum wheat beers and aging conditions

Three craft durum wheat beers were brewed in duplicate, in a Sardinian micro-brewery, with three different yeasts, one commercial and two autochthonous. The commercial yeast was the Safbrew S33 strain (Fermentis, Lesaffre Italia S.P.A., Italy), frequently used by brewers to produce top-fermented wheat beer, whereas the autochthonous yeasts *Saccharomyces cerevisiae* S42 and S38 were isolated from a craft Sardinian sourdough by the Microbiology section of the Department of Agraria (University of Sassari), and selected for their capacity to ferment maltose (Marongiu et al., 2014). The three beers were produced with 60% of malted barley, 20% of commercial malted wheat, and 20% of "Cappelli" wheat, an old variety of unmalted durum wheat that grows in Sardinia, following the technological protocol reported by Mascia et al. (2014). Beers aging conditions were as follows: after two months from their production, half of the beers were kept at a temperature of 8 °C (L = Low) in a refrigerated chamber, representing normal cold storage for beer, and the other half was brought at a temperature of 28 °C (H = High), in a dark room at controlled temperature, representing shelf temperature. The beers were analyzed firstly after two months, which is the storage period chosen by this micro-brewery before marketing (time 0 = t0) and then, every 40 days from t0, over a total period of 6 months (time 1 = t1 and time 2 = t2) at two temperatures.

2.2. Chemicals

The following chemicals, with purity >99%, were supplied by Sigma–Aldrich (USA): ethyl acetate, ethylbutyrate, 1-propanol, isobutanol, iso-amyl acetate, ethylcaproate, isopentanol, ethylcaprylate, acetic acid, 2-ethyl-1-hexanol, linalool, ethyl caprate, 2-phenylethanol, ethyl myristate, caprylic acid, ethyl palmitate, capric acid, heptanoic acid, ethyl ester, 3-octanol, 2-methylpropanal, 3-methylbutanal, penta-2,3-dione, furfural, heptanal, benzaldehyde, (E)-2-nonenal, diacetyl, 3-fluorobenzaldehyde, and O-(2,3,4,5,6-pentafluorobenzyl) hydroxylamine hydrochloride (PFBOA).

2.3. Physico-chemical analysis

Beers were analyzed through the Alcolyzer (Anton Paar GmbH, Austria) for apparent extract, original extract, and alcohol content. Standard beer analyses and determination of color, bitterness and pH were carried out according to EBC methods 9.6, 9.8, 9.35 (EBC, 2010).

2.4. GC–MS of alcohols and esters

Volatile compounds were quantified by headspace-solid phase micro extraction (HS-SPME) coupled with gas chromatography (GC – Agilent 6890N) and mass spectrometry detector (MSD – Agilent 5975B Inert) according to the method of Pinho, Ferreira, and Santos (2006). Extraction and concentration of the volatile compounds was carried out using HS-SPME with a 75 μm carboxen/polydimethylsiloxane (CAR–PDMS) fiber (Supelco, Bellefonte, PA, USA), and 30 m × 0.25 mm × 0.25 μm HP-INNOWax polyethylene glycol column (Agilent Technologies, Santa Clara, CA, USA). SPME fiber and extraction conditions were chosen according to the method published by Pinho et al. (2006), which was slightly optimized to obtain a complete profile of volatile compounds for our beer samples. Prior to SPME extraction, 250 mL of beer cooled to 4 °C were agitated in a shaker for 5 min to reduce the CO_2 content, then 10 mL of beer sample were weighted in a 15 mL glass vial, and NaCl (2 g) was added in order to increase the volatility of compounds in the HS. Solid phase microextraction was performed at 50 °C for 30 min. The desorption was achieved in splitless mode for 10 min, and the temperature of inlet was set at 260 °C. Helium 6.0 was the carrier gas, at a flow rate of 1.1 mL/min. The following oven temperature program was used: 10 min at 30 °C, followed by an increase of 2 °C/min to 52 °C and held for 2 min, an increase again of 2 °C/min to 65 °C, and of 5 °C/min to 250 °C and held for 3 min.

All analyses were carried out in duplicate. Peak areas were normalized using heptanoic acid ethyl ester as an internal standard for esters and acids, and 3-octanol as an internal standard for alcohols. The concentrations of volatiles were determined using external calibration. The identification of compounds was carried out by comparing their MS spectra and their retention times with those of the National Institute of Standards and Technology Mass spectral library (NIST), USA.

2.5. Carbonyl compounds

Carbonyl compounds were identified and quantified in duplicate by HS-SPME coupled with gas chromatography mass spectrometry (GC–MS) according to the method of Moreira et al., based on SPME with on-fiber derivatization (Moreira, Meireles, Brandão, & de Pinho, 2013). The extraction and concentration of carbonyl compounds was carried out using HS-SPME with 50/30 μm divinylbenzene/carboxen/polydimethylsiloxane (DVB–CAR–PDMS) fiber (Supelco, Bellefonte, PA, USA). 200 μL of PFBOA solution and 10 mL of deionized water were placed in a 20 mL glass vial. The DVB–CAR–PDMS fiber was then placed in the headspace of the PFBOA solution for 20 min a 50 °C to allow for derivatization. The fiber loaded with PFBOA was then exposed to the headspace of 10 mL of beer and 100 μL of 3-fluorobenzaldehyde

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