Food Chemistry 200 (2016) 24–31

Contents lists available at ScienceDirect

Food Chemistry

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

Comparison of flavour qualities of three sourced *Eriocheir sinensis*

Shuai Wang [a,1], Yu He [a,1], Yayue Wang [a,1], Ningping Tao [a], Xugan Wu [b], Xichang Wang [a,*], Weiqiang Qiu [a], Mingjun Ma [b]

[a] College of Food Science and Technology, Shanghai Ocean University, No. 999, Hucheng Huan Rd., Nanhui New City, Shanghai 201306, China
[b] Key Laboratory of Freshwater Aquatic Genetic Resources, Ministry of Agriculture, Shanghai Ocean University, No. 999, Hucheng Huan Rd., Nanhui New City, Shanghai 201306, China

A R T I C L E   I N F O

Article history:
Received 31 March 2015
Received in revised form 30 November 2015
Accepted 29 December 2015
Available online 30 December 2015

Keywords:
Chinese mitten crab
Flavour
Taste intensity
Odour compounds

A B S T R A C T

Flavour qualities of three edible parts of three types of Chinese mitten crab from different areas were examined. The flavour profiles detected by E-tongue and E-nose showed that differences existed in tastes and odours among wild-caught crabs (WC), Yangcheng crabs (YC) and Chongming crabs (CM). The total free amino acids contents of WC were all at the highest level in meat, gonads and hepatopancreas. Ovaries had the highest nucleotides content and equivalent umami concentration (*EUC*) than other tissues in both female and male. The *EUC* was the highest in all parts of WC, followed by YC and CM. The total content of nine key volatile compounds was the highest for WC in the gonads and hepatopancreas; in the muscle, they were the highest in female YC and male CM, but the lowest for WC.

1. Introduction

The Chinese mitten crab (*Eriocheir sinensis*) is one of the most important economic aquatic animals worldwide, especially in East Asia; its consumption has been the highest of all crabs in terms of economic value since 2005, according to the statistics of the FAO Fisheries and Aquaculture Department. The continued growth of Chinese mitten crab production reflects strong market demands, and indicates their popularity with the oriental customer. Many studies have examined their nutritional qualities, including fatty acids, amino acids and minerals, and the changes in these components during culture (Chen, Zhang, & Shrestha, 2007; Guo, Gu, Wang, Zhao, & Zheng, 2014; Ying, Yang, & Zhang, 2006). However, there have been few studies that focused on flavour characteristics.

Wild-caught crabs (WC), like mud crabs, swimming crabs and Chinese mitten crabs, consistently show better nutritional value than cultured crabs (Alava et al., 2007; Kari Woll & Marit Berge, 2007; Wu et al., 2007; Wu, Cheng, Zeng, Wang, & Yang, 2010). The wild-caught crab of the Yangtze population is the most expensive Chinese mitten crab on the market (He et al., 2014). Chinese mitten crabs farmed in Yangcheng Lake in China (YC) have an excellent taste, pleasant aroma and attractive colour (Chen & Zhang, 2007; Gu, Wang, Tao, & Wu, 2013). These crabs are priced only a little lower than wild-caught crabs. Crabs farmed in Chongming (CM, Shanghai) and other places (Songjiang, Taihu Lake, etc.) attract the lowest price compared with WC and YC crabs, although they also have good body size, nutritional values and aroma (Wu et al., 2007). WC crabs mainly live on natural food, such as aquatic plants and benthic animals, which typically leads to survival of the fittest. YC crabs primarily live on formulated feed, supplemented with natural food at different stages of breeding traditionally, whilst CM crabs are fed using different patterns during the whole process (Shao, Wang, He, Wu, & Cheng, 2013). Therefore, WC crabs from Yangtze and YC and CM pond-reared crabs are representative of the current Chinese mitten crab market.

Umami and sweetness are the characteristic tastes in the meat and hepatopancreas of Chinese mitten crabs, which are due mainly to free amino acids and 5′-nucleotides (Shao, Wang, He, Wu, & Cheng, 2014). However, the taste compounds of gonads have not been analysed completely, and there has been insufficient data to illustrate the extreme umami intensity in the female gonads.

In the research of volatile compounds, MMSE is a novel approach for volatile compound extraction, which is similar to solid-phase microextraction (SPME) but shows higher sensitivity of volatile compound analysis (Gu et al., 2013; Wu, Gu, Tao, Wang, & Ji, 2014). Electronic tongue (E-tongue) and electronic nose (E-nose) could characterise the slight differences in taste and odour of differently sourced foods without subjective factors and judgments, representing powerful tools to distinguish flavour profiles (Pennazza et al., 2013; Zaragozá et al., 2013). Electronic tongue and electronic nose were used to compare the flavours of the three edible parts. The flavour compounds were then analysed and evaluated to identify the differences between the three types

* Corresponding author.
E-mail address: xcwang@shou.edu.cn (X. Wang).
[1] These authors contributed equally to this work.

http://dx.doi.org/10.1016/j.foodchem.2015.12.093
0308-8146/

of crab. The aim of this study was to characterise the tastes and aromas of these crabs using the technologies mentioned above to find possible relationships between the flavour quality and the market price.

2. Materials and methods

2.1. Materials and sample preparation

Wild Yangtze River *E. sinensis* were caught in Zhenjiang, Suzhou province, China. Pond-reared crabs of Yangcheng Lake and Chongming were obtained from local farms. Twenty male and 20 female crabs were transported to the laboratory and all sampled within half a day. The average weights were 150 g (male) and 120 g (female). The gonads and hepatopancreas were removed and steamed for 15 min in a handle-less cup with a two-tier cover. The bodies of crabs were then steamed too and the abdomen meat was separated after rapid chilling. The samples were chopped lightly using a blender (JZ-I, Tianjin Sifang Equipment Ltd., China) in an ice-bath and stored separately at −80 °C.

2.2. Electronic tongue

The E-tongue system (Astree; Alpha MOS, Toulouse, France) comprises seven non-specific sensors (BB, CA, GA, HA, JB, JE, ZZ), and the chemical responses of the sensors are changed into electric signals by an electronic unit when the system is soaked in the flavour solution. In this experiment, the average of the signals from 100 s to 120 s were collected. To extract the flavour solution, the samples were homogenised with 80 mL ultrapure water, and then centrifuged at −4 °C to get the supernatant. The clear liquid was detected immediately by the E-Tongue after filtration.

2.3. Electronic nose

The E-nose system (Fox 4000; Alpha MOS) comprises three groups of sensors: group A: T30/1, P10/1, P10/2, P40/1, T70/2, PA/2; group B: P30/1, P40/2, P30/2, T40/2, T40/1, TA/2; and group CL: LY2/LG, LY2/G, LY2/AA, LY2/GH, LY2/gCTL, LY2/gCT. The scientific basis of the 18 sensors is similar to the E-tongue. For the automatic injection, the samples were put into a glass vial, and then incubated at 50 °C for 120 s; 2500 mL of headspace gas was injected within 1s, and the response values of the 18 sensors were recorded at 120 s.

2.4. Free amino acids analysis

The trichloroacetic acid (TCA) method was used to extract the free amino acids in the different edible parts of crabs, according to the description of Konosu (1982). The extracted solutions were analysed by an automatic amino acid analyser (L 8800; Hitachi Ltd, Japan).

2.5. 5′-Nucleotides analysis

Measurement of 5′-guanosine monophosphate (GMP), 5′-inosine monophosphate (IMP) and 5′-adenosine monophosphate (AMP) was based on the method of determination of ATP-related compounds. Nucleotides were extracted by perchloric acid, and neutralised by potassium hydroxide (KOH). After filtration through 0.22-μm filters, the solution was collected and analysed on an HPLC device (2695e; Waters Ltd., Milford, MA). The detection parameters were as follows: chromatographic column, Intersil ODS-3 (250 mm × 4.6 mm); column temperature, 30 °C; eluents, 0.025 M KH_2PO_4/K_2HPO_4 (2:1) and methanol; flow rate, 1 mL/min; elution mode, gradient elution.

2.6. Equivalent umami concentration (EUC) analysis

The equivalent umami concentration was developed to calculate the MSG-like umami intensity (Yamaguchi, Yoshikawa, Ikeda, & Ninomiya, 1971):

$$Y = \sum a_i b_i + 1218\left(\sum a_i b_i\right)\left(\sum a_j b_j\right)$$

where Y equals g MSG/100 g sample; a_i, umami amino acid concentration (g/100 g); b_i conversion coefficient of umami amino acids (Glu, 1; Asp, 0.077); a_j, 5′-nucleotide concentration (g/100 g); b_j, conversion coefficient of 5′-nucleotides (IMP, 1; GMP, 2.3; AMP, 0.18); 1218, synergistic constant.

2.7. Volatile compounds analysis

The volatile compounds of the crabs were detected by headspace monolithic material sorptive extraction-gas chromatography-mass (HS-MMSE-GC–MS). Samples in a glass vial were heated at 90 °C for 50 min, and the volatile compounds were absorbed by a monotrap (RCC 18; GL Science Ltd., Tokyo, Japan) in the headspace of the vial. The compounds concentrated in the monotrap were desorbed in a thermal desorption unit (TDU, Gerstel GmbH & Co. KG, Mülheim an der Ruhr, Germany), and injected into a GC–MS (6890A-5975C; Agilent, Santa Clara, CA) via a cooled injection system (CIS, Gerstel). The GC and MS parameters were: column, DB-5MS (60 m × 0.32 mm; Agilent); carrier gas, helium (99.999%); flow rate, 1.2 mL/min; detector interface temperature, 250 °C; ion source temperature, 230 °C; ionisation energy, 70 eV. The oven temperature was programmed from 40 °C to 100 °C at 5 °C/min, then to 180 °C at 3 °C/min, finally to 240 °C at 5 °C/min and held for 5 min.

Volatile compounds were identified by a NIST search (NIST 08) and by their retention index (RI), and quantified using the internal standard 2,4,6-trimethylpyridine (TMP).

$$\text{Conc (ng/g)} = \frac{\text{Peak area ratio (compound/TMP)} \times 1\ \mu\text{g(TMP)}}{5\ \text{g (samples)}}$$

2.8. Statistical analysis

The principal component analysis (PCA) of E-tongue and E-nose was analysed by the software of the Alpha MOS workstation (version 14.0). The samples were tested four times for E-tongue system and three times for E-nose system. The analyses of free amino acid and nucleotides were repeated at least three times, and the results were expressed as mean ± standard deviation (*SD*) ($n = 3$). The significant differences analysis was calculated using one-way analysis of variance (ANOVA) by SPSS 22.0, and reported at a p-value <0.05.

3. Results and discussion

3.1. Analysis of the whole flavour and aroma detected by E-tongue and E-nose

E-tongue and E-nose showed excellent ability to discriminate food taste and aroma, such as classification of different degree, identification of different origin and description of different processing, especially for meat products, drinks and wine (Qiu, Wang, & Gao, 2014; Zheng, Liang, Wu, Zhou, & Liao, 2014). Previous research showed that the different edible parts of the Chinese mitten crab could be separated obviously and easily by their PCA results (Gu et al., 2013). Therefore, in this paper, the E-tongue