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Effect of organic and conventional rearing system on the mineral content of pork

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ABSTRACT

Dietary composition and rearing regime largely determine the trace elemental composition of pigs, and consequently their concentration in animal products. The present study evaluates thirteen macro- and trace element concentrations in pork from organic and conventional farms. Conventional pigs were given a commercial feed with added minerals; organic pigs were given a feed based on organic feedstuffs. The content of macroelements (Na, K, Mg and Ca) and some trace elements (Ni, Fe, Zn and Sr) in organic and conventional meat samples showed no significant differences ($P > 0.05$). Several trace element concentrations in organic pork were significantly higher ($P < 0.05$) compared to conventional pork: Cr (808 and 500 μg/kg in organic and conventional pork, respectively), Mn (695 and 473 μg/kg) and Cu (1.80 and 1.49 mg/kg). The results showed considerable differences in mineral content between samples from pigs reared in organic and conventional systems. Our results also indicate that authentication of organic pork can be realized by applying multivariate chemometric methods such as discriminant analysis to this multi-element data.

1. Introduction

As far as consumption of pork by humans is concerned, pork is increasingly recognized as an important source of nutrients, including fatty acids, protein and minerals. There is considerable interest in the multi-element composition of pork from the perspectives of human health (Reig, Aristoy, & Toldra, 2013) and piglet growth and development (Jukna, Valaitiene, Meskinyte-Kausiliene, & Jankauskas, 2013; Lopez-Alonso et al., 2007). Currently, pig production mainly relied on the intensive indoor system. Organic food is progressively increasing in popularity. With the development of economy, organic pork products have received increasing attention in developed countries (Grebitus, Yue, Bruhn, & Jensen, 2011; Prunier & Lebret, 2009) and developing countries such as China (Han & Ding, 2011; Liu, Wang, & Han, 2009). Organic pig rearing system is primarily based on the standards that absolutely avoid genetically modified organisms (GMO), animal by-products and chemical fertilizer (Smith-Spangler et al., 2012). The system should also offer enough space indoor with a lower intensity and free access to outdoor (Karwowska & Dolatowski, 2013). Therefore, the organic animal products are considered to be healthier and safer food compared to those from the traditional intensive rearing system because the organic pork is an environmentally friendly product (Millet et al., 2004).

There are many factors that affect the purchase of organic pork. Many consumers believe that organic pork has a higher nutritional value compared to the pork from the conventional rearing system (Koistinen et al., 2013; Smith-Spangler et al., 2012). So consumers are willing to pay higher price for pork originating from an organic system (Liu et al., 2009). It is extremely important for consumers to be informed about the effects of the organic rearing system on the nutritional value, but the number of studies is still limited. Recently, some of the studies were focused on the comparison of growth performance, fatty acid composition and meat quality traits between the pork from organic and conventional rearing systems (Hansen, Claudi-Magnussen, Jensen, & Andersen, 2006; Hogberg, Pickova, Andersson, & Lundstrom, 2003; Kim et al., 2009). Despite the considerable interest in the nutritional composition of organic pork from many publications, data on the levels of macro- and micro-minerals in pork from organic systems are very limited.

Many consumers believe that pork originating from organic farms has higher nutritive value and can be beneficial for human health. The purpose of the present study was to analyze the concentrations of macro- and trace element in the organic and conventional pork and the potential for classifying the organic and conventional pork by the element data.

2. Material and method

2.1. Animals, housing and diets

The pigs studied were a 50 animal subsample selected from a total of 200 crossbreeds [Duroc × (F1 Landrace × Yorkshire)]. Pigs in the

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present study were randomly chosen for organic and conventional groups, and male and female accounted for half of the proportion in each group. All pigs were reared in an identical way from birth to weaning (one month). After one week of weaning, 50 pigs were divided into two groups and fed with two different diets: one conventional and one organic diet (Table 1). The organic feeding system was according to the National Standard on Chinese Organic Product (GB/T 19630.1-2011). None of the organic feeds contained growth promoter and antibiotics. Under the current experiment, each pig for conventional rearing system had an indoor area of 1.5 m^2, while each pig for the organic rearing system had an indoor area of 1.5 m^2 and an outdoor area of 3 m^2. The outdoor environment was full of soil and grass besides several stones. The organic farm did not plant any crops for at least 8 years to guarantee no chemical fertilizer and pesticide. Self-feeders and nipples were provided in each pen. Both organic and conventional reared pigs were fed for seven months, and diets and water were given ad libitum. Pigs rearing under the organic production system spent 4 to 6 h in the outside per day. Pigs (approximately 114 kg live weight; the daily gain weight of the conventional and organic pigs were 436.8 g/kg and 435.7 g/day) were slaughtered at a commercial slaughter company. Pigs were transported to the abattoir the day before slaughter and slaughtered after an electrical stunning. Musculus longissimus dorsi was taken from each left side and immediately moved to frozen at −20 °C until analyzed.

2.2. Multi-element analysis

About a 50 g sample from musculus longissimus dorsi was pretreated in a freeze-dryer for 1 day. Then the dried meat was defatted by ether in a Soxhlet extractor for 6 h to obtain the protein. After extraction, fat free dry mass was ground in a pulverizer and stored at −20 °C (Heaton, Kelly, Hoogewerff, & Woolfe, 2008). The organic and conventional feeds were ground and screened by a 100 mesh sieve. The analysis of multi-element data from defatted dry mass and feed was according to the method by Zhao et al. and Sun et al. (Sun, Guo, Wei, & Fan, 2011; Zhao et al., 2013). The dry mass was analyzed after microwave digestion using a MARS (CEM Company) microwave digestion system. Briefly, 0.2 g of sample, 10 mL of 65% HNO_3 (TraceMetal Grade, Fisher Scientific) and 1 mL of hydrogen peroxide solution (31%) (30%, Optima Pure, Fisher Scientific) were added into a PTFE digestion tube and digested for 40 min by increasing the power to 1600 W and the temperature to 210 °C in a stepwise fashion. The digested solution was diluted to 50 mL with ultra pure water (MΩ > 18.2 M, Milli-Q Element, Millipore) and stored in a plastic flask before analysis.

Thirteen elements were measured using Inductively Coupled Plasma Mass Spectrometry (ICP-MS, X Series 2, Thermo Fisher, America). The standard matter of chicken (GBW10018) was supplied by the Institute of Geophysical and Geochemical Exploration of China and was used for calculating recovery and accuracy. After digestion process and ICP-MS analysis, the recovery and the relative standard deviation (RSD) of each element in the standard matter of chicken (GBW10018) were higher than 90% and lower than 10% (measured in triplicate), respectively, indicating that the whole analysis method was validated for elemental analysis. Analysis of each sample was performed in triplicate and quantified using external standard analysis. All the results were expressed as the average of the triplicate measurements. The internal standards, including Ge, Y, Rh and Pt, were used to ensure the stability of the instrument. The samples were re-measured whenever the RSD of internal standards was >5% (Sun et al., 2011; Zhao et al., 2013).

Table 1
The composition of organic and conventional diets.

Ingredient	Organic diets	Conventional diets
Corn (%)	75 (organic)	70
Soybean meal (%)	25 (organic)	20
Concentrated feed (%)	0	10
NaCl (%)	0.3	0.3

2.3. Statistical analysis

The statistical analysis of the data was performed using the SPSS 22.0 package for Windows. A T-test was conducted to determine the significant difference between the organic and conventional production, whereas a $P < 0.05$ value was regarded as significant. Prior to multivariate analysis, elemental data was normalized. Partial least square-discriminant analysis (PLS-DA) was performed by SIMCA-P 11.5. It was to evaluate whether pork from different rearing systems could be distinguished by the parameters. Principal components were extracted to classify the two groups. The most significant variables were selected by stepwise analysis of all these data sets, and then a back substitution test was used to evaluate the prediction capability of the mode for each parameter.

3. Results

Diet element concentrations are presented in Table 2. The results showed a considerable difference between element contents in organic and conventional systems. Most of the element concentrations were affected by the diet composition. Mg, Ca, Cr, Mn, Fe, Cu, Zn, Se, Rb and Sr values were significantly lower in organic feed compared to those in conventional feed ($P < 0.05$). As far as Na, K and Ni are concerned, these did not differ between the feeds from organic and conventional systems ($P > 0.05$).

As shown in Table 3, the rearing system significantly influenced the element contents of pork. Several trace element concentrations in organic pork were significantly higher compared to conventional pork ($P < 0.05$): Cr (808 and 500 μg/kg in organic and conventional pork, respectively), Mn (695 and 473 μg/kg) and Cu (1.80 and 1.49 mg/kg). The contents of Se and Rb were almost 50% lower in organic pork than those in the conventional pork. As far as values for Na, Mg, K, Ca, Fe, Ni, Zn, and Sr are concerned, these did not differ between the pork from different rearing systems ($P > 0.05$).

In order to discriminate the two groups and screen the characteristic element, PLS-DA was carried out based on thirteen element composition of pork samples. As shown in Fig. 1, the scatter 3D plot which included three components indicated that the two groups could be clearly classified by the element data. Variable importance values were shown in Fig. 2. Five elements (Rb, Se, Cr, Cu and Mn) were calculated to possess higher importance values; meanwhile, these five elements were significantly different between organic and conventional pork.

Table 2
Element concentration in feed in organic farm and conventional farm.

	Organic feed		Conventional feed		
Minerals	Mean	std	Mean	std	P value
Na (mg/kg)	1023	36.9	1421	144	0.481
Mg (mg/kg)	1509^a	50.2	2574^b	163	0.000
K (mg/kg)	7813	338	8290	363	0.064
Ca (mg/kg)	573^a	27.6	7357^b	382	0.000
Cr (mg/kg)	1.43^a	0.08	2.59^b	0.18	0.000
Mn (mg/kg)	11.9^a	0.74	83.2^b	6.97	0.000
Fe (mg/kg)	153^a	20.0	376^b	21.0	0.000
Ni (mg/kg)	1.96	0.15	1.89	0.43	0.734
Cu (mg/kg)	4.25^a	0.08	159^b	10.8	0.000
Zn (mg/kg)	23.2^a	0.65	144^b	13.8	0.000
Se (μg/kg)	53.5^a	8.95	398^b	180	0.013
Rb (mg/kg)	6.43^a	0.42	12.0^b	0.58	0.000
Sr (mg/kg)	3.03^a	0.14	8.51^b	0.62	0.000

[a,b] Numbers with different superscripts are significantly different in the same row.