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Greenhouse gas emissions from pig and poultry production sectors in China from 1960 to 2010

WANG Li-zhi[1], **XUE Bai**[1], **Tianhai Yan**[1,2]

[1] *Animal Nutrition Institute, Sichuan Agricultural University, Ya'an 625014, P.R.China*
[2] *Agri-Food and Biosciences Institute, Co. Down BT26 6DR, United Kingdom*

Abstract

Pig and poultry production in China had experienced considerable changes from 1960 to 2010. The present study aimed to evaluate the effects of these changes on greenhouse gas emission inventories (expressed as CO_2 equivalent) from these two sectors. The inventories included methane emissions from enteric fermentation, methane and nitrous oxide production from manure management. The greenhouse gas emissions from these sources in 2010 in pig sector were 17, 62 and 21%, respectively, and that in poultry sector (including chicken, duck, goose and others) were 1, 18 and 81%, respectively. Total CO_2 equivalent increased from 1960 to 2010 in both pig (11 582 to 55 564 Gg yr^{-1}) and poultry (1 497 to 14 873 Gg yr^{-1}) sectors. Within poultry sector, emissions from chicken, duck, goose and others accounted for 74, 15, 11 and 0.01% in 2010, respectively. However, during the last 50 years, these emissions continuously reduced when related to production of 1 kg of pork (8.01 to 1.14 kg kg^{-1}), poultry meat (1.19 to 0.37 kg kg^{-1}) and egg (0.47 to 0.33 kg kg^{-1}), which is mainly associated with the continuous improvement in production efficiency in all management systems. These results provide benchmark information for Chinese authorities to develop appropriate policies and mitigation strategies to reduce greenhouse gas emissions from pig and poultry sectors.

Keywords: China, greenhouse gas inventory, pig, poultry

1. Introduction

Greenhouse gase (GHG) emissions from livestock industry are mainly from 3 sources: methane (CH_4) production from enteric fermentation (M_{ef}), CH_4 and nitrous oxide (N_2O) emissions from manure management (M_{mm} and N_{mm}, respectively). Of these sources, M_{ef} from ruminants is the major contributor which mainly comes from the microbial degradation of organic matter in the rumen, with a small proportion produced from microbial fermentation in the large intestine (Moss *et al.* 2000). The M_{ef} in livestock accounts for approximately 25% of the total CH_4 from anthropogenic sources (Olivier *et al.* 2005). For non-herbivorous animals (e.g., pig and poultry), the large intestine is the only microbial fermentation site of organic matter which produces CH_4 (IPCC 2006). Therefore, ruminant animals can produce much more enteric CH_4 than non-herbivorous animals at a similar body size. For example, M_{ef} from sheep and pig are proposed to be 5.0 and 1.0 kg yr^{-1} per individual, respectively, by IPCC (2006) in the Tier 1 methodology for use in developing countries. However, emission factors of CH_4 and N_2O from manure management are positively

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Correspondence Tianhai Yan, Tel: +44-28-92682884,
E-mail: tianhai.yan@afbini.gov.uk

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related to body size and feed intake of animals, irrespective of animal species (IPCC 2006). The M_{mm} for dairy cattle, sheep, pig and chicken were 8.95, 0.10, 1.53 and 0.015 kg yr^{-1} per individual, respectively, and the N_{mm} for the above species were successively 0.358, 0.209, 0.145 and 0.005 kg yr^{-1} per individual (Zhou *et al.* 2007).

Although GHG emissions from individual pig and poultry are much lower in comparison to cattle and sheep, their large population results in a considerable contribution to GHG accumulation across the world. For example, GHG emissions from manure of pig and poultry sectors account for 42% of total livestock manure emissions across the world (FAO 2016). This is particularly relevant in countries like China, where pork and poultry are the main meat sources in human diets. China has about half of the pig population raised in the world (Moeller and Crespo 2004) and produces 40% of total global poultry eggs (Feng and van der Sluis 2002). The meat and egg consumption in China is expected to continuously increase with its economy development (Yoshioka 2011). However, little information is available on GHG emissions from pig and poultry production in China during the last 50 years.

Pig and poultry production sectors in China have been under considerable changes during the last 30 years, as a consequence of the economic boom which sustained an average annual economic growth of almost 10% since 1980 (Wearden 2010). This has resulted in an increasing demand in consumption of animal meat to improve the diet structure of Chinese people. Such a strong demand has led to a fast expanding of livestock production sectors in China. From 1980 to 2009, the number of slaughtered pigs increased from 198.6 to 645.4 million individuals and egg production increased from 2.6 to 27.4 million ton (MOA 1980–2010). The second aspect of the change in pig and poultry production in China is the adaptation of modern feeding and management techniques which, in return, have significantly improved the productivity of pig and poultry farms (NBSC 2012). However, there is no such information available for the Chinese production systems. This information may allow Chinese authorities to develop appropriate mitigation strategies to reduce GHG emissions from pig and poultry sectors. Therefore, the objectives of the present study were to: (i) Quantify M_{ef}, M_{mm} and N_{mm} for pigs and poultry (chicken, duck, goose and others, e.g., turkey) in China from 1960 to 2010, and (ii) evaluate variation during this period in GHG emissions per unit product (pork, poultry meat and egg).

2. Materials and methods

2.1. Data collection

Pig and poultry data from 1960 to 2010 used in the present study were collated from national statistical records (MOA 1980–2010) and the Livestock Information Network in China (CAAA 2012). Additional information, such as life span of broilers and growing/finishing pigs, proportion of boars and poultry for breeding and manure management systems, was obtained from a range of sources including farm surveys, scientific publications, internal reports and advices from livestock production specialists. The farm survey and specialist advice were undertaken using questionnaires through a range of communication approaches, e.g., face-to-face, telephone and e-mails. Further information for the poultry sector was obtained from a range of internal publications, e.g., Regulations for Feeding and Management of Yellow-Feathered Chicken (MOA 2010), Technical Regulations of Feeding and Management of Hyline Brown Chicken (HQTMA 2010) and Technical Regulations of Layer Production (BMAQTS 2006). Similar information for the pig sector was also obtained from a range of internal publications, e.g., Technical Regulations for Feeding and Management of Pigs (SQTMA 2006), Technical Specifications for Breeding Pigs (BMAQTS 2008), and Technical Specifications of Feeding and Management for Beijing Black Pigs (BMAQTS 2007).

The pig data used in the present study included annual national pork production and total national numbers of slaughtered pigs, stocking growing pigs, sows and breeding boars. The poultry data were collated as total national numbers of all poultry and each species (chicken, duck, goose and others — mainly turkey). For each species, data required included annual national meat and egg production, and total national numbers of slaughtered poultry, stocking broilers and laying and breeding birds.

2.2. Calculation of greenhouse gas emissions

The present calculation was based on the principle of the methodology of IPCC (2006). The inventories for pigs were developed as a sum of GHG emissions from 3 groups: slaughtered pigs, stocking growing pigs and sows/boars. A similar approach was also used for each species of poultry (chicken, duck, goose and others — mainly turkey), which was categorized as 3 groups: slaughtered poultry, stocking broilers and hens/breeding birds. The populations for growing/finishing pigs and broilers (slaughtered and in stock) were adjusted as annual average number (AAN, eq. (1)) according to their life span, if they were less than one year in life (IPCC 2006).

$$\text{AAN}=\text{Total population}\times(\text{Days in life}/365) \quad (1)$$

Where, total population is total national number of growing/finishing pigs or broilers (slaughtered and in stock).

The inventories for each group of pigs and poultry were developed from 3 sources of GHG emissions, i.e., M_{ef}, M_{mm}, and N_{mm}, respectively. The M_{ef} and M_{mm} were calculated