Modelling nitrogen use efficiency by world poultry production systems in 2050 under contrasting production and dietary scenarios

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Abstract

Poultry production is highly efficient in terms of nitrogen retrieval among livestock species. Nevertheless, more than 60% of nitrogen feed to animals is lost, mostly as manure. The evolution of these production systems in future is uncertain and will be strongly affected by global economic and food systems development. A model describing poultry production systems, resources consumption and production efficiencies has been developed. A strong effect of socioeconomic pathways has been found. According to the results obtained, poultry production in future will be only sustainable under a paradigm of moderate meat and eggs demand and improving nutrient recycling.

Keywords: Feed, poultry production systems, N excretion, nitrogen use efficiency, Shared Socio-economic Pathways

1. Introduction

Poultry production is one of the most animal agriculture efficient systems leading to a high protein recovery rate (Mottet et al., 2017). This high efficiency, as well as the ability of poultry to recycle by-products and food waste into cheap and high-value protein sources for humans (Truong et al., 2019), has led to a continuos increase of poultry production worldwide (poultry population increased almost 4-fold in the last 50 years acording to FAO, 2019), that is expected to continue in future (Alexandratos and Bruinsma, 2012). Nevertheless, the average recovery rate for protein on these animales ranges between 10 and 30% (Motet et al., 2017). The residual nitrogen from the poultry production system is mostly found on manure, that can be a source of pollution.

More than 90% of poultry are chickens, providing more than 4.5 Gg of Nitrogen as feed in 2017 (FAO, 2019), mainly as chicken meat (c. 70%). Production systems are highly variable with different management, performances and which, in turn, affect local and global demand of resources as well as the N use efficiency. With the growing share in total population and animal products demand, poultry production will therefore play an important role in the global agro-food system during the next decades, as a food resource, feed consumer and manure producer.

The evolution of the global economic systems for food and energy supply during the next 30 years is uncertain and may follow diverse pathways with different levels of economic prosperity and environmental concerns. This modelling study explores the feed and land demand, the N excreted and the N use efficiency (NUE) (at the flock level) in 2050 by world poultry production systems under different scenarios for meat and eggs demand, production performance and feed ration.

2. Methods

3.1 Model description

The poultry sub-model in IMAGE consists of three main modules: 1) Intensive meat; 2) Intensive eggs and 3) Backyard or mixed production. For a given production, each module estimates the number of animals needed for 6 different cohorts, feed consumed and manure excreted considering animal diet and performances. Feed consumption for each cohort depends on feed characteristics and needs. According to these characteristics and animal performances, nitrogen and phosphorus balances are developed. Diets and animal performances vary within time and among different regions (26 world regions from IMAGE). A deep bibliographic review provided this information.

3.2 Scenarios description

Based on van Vuuren et al. (2014), a set of 5 scenarios called the Shared Socio-economic Pathways (SSPs) describing several possible future development trajectories were used. The SSP1 storyline describes an efficient world with economic prosperity, technological progress and societal environmental concern. SSP2 corresponds to the "business as usual" expected trajectory. SSP3 describes a fragmented world with regions differing widely in economic development. SSP4 depicts inequal evolution between regions, with a lowere development than SSP3. Finally, SSP5 is based on an extreme development based on fossil fuel consumption and globalization.

Diet composition for all regions and scenarios were developed for 2050 based on evolution premises of SSP (e.g. high by-products use for SSP1 and high soy inputs in SSP5).

3. Results

Fig. 1 shows the evolution of Evolution of feed consumption (Tg N) and excretion (Tg N) from 1970 to 2050 for all scenarios. Extreme differences can be observed for both parameters among scenarios. While in SSP1 (moderate meat and eggs demand and higher alternative feed sources used) N demand and excretion for 2050 remain almost stabilized (reference 2005), for SSP5 (high demand, high input) both feed and excretion increase 2-fold for 2050 (ref. 2005). Sustainability of poultry production in future might be based on a moderate meat and eggs demand, an improvement on productive efficiency and the development of feed sources based on nutrient recycling.

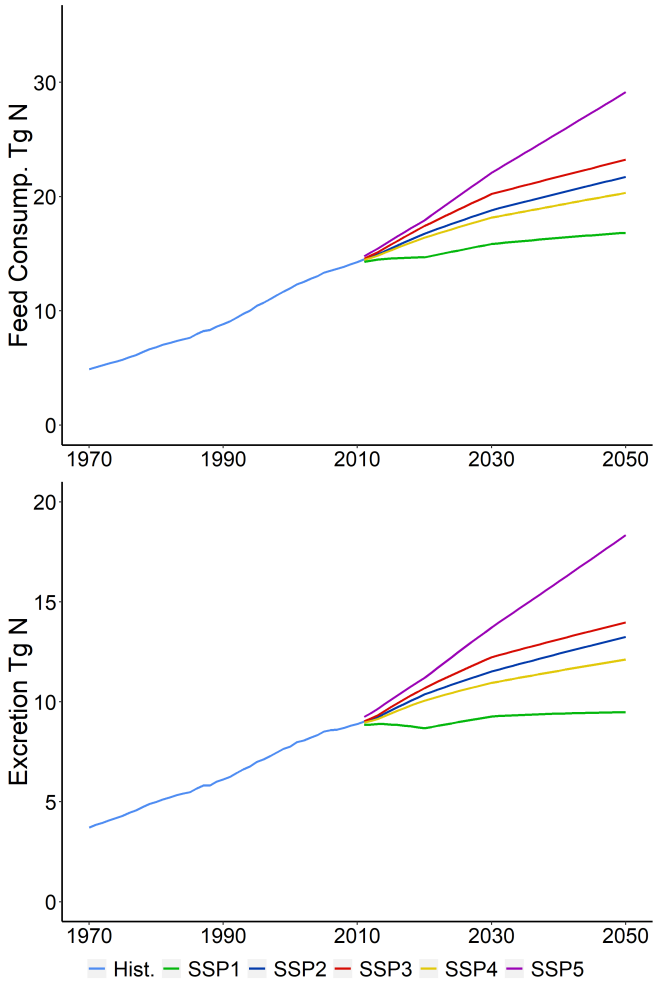

Fig. 1: Evolution of feed consumption (Tg N) and excretion (Tg N) from 1970 to 2050 for all 5 SSPs

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