Animal Performance Trends in the United States and European Union Prior to and During Adoption of Genetically Modified Crops.

Introduction

Genetically modified (GM) animal feed crops were first sold commercially in the US in 1996 and the first crop was soybean that was resistant to the herbicide glyphosate. Since then, herbicide resistant corn and cotton and insect resistant corn, soybean and cotton have been commercialized and adoption has outpaced other agricultural innovations. Other crops that have been genetically modified that are used for animal feed include alfalfa, and canola. The livestock industry uses 40% of corn production (USDA, 2013d) and more than 80% of soy production (USDA, 2013b). Corn grain, corn silage, corn gluten feed, corn gluten meal, full-fat soybean and soybean meal are common ingredients in animal diets.

GM crops are evaluated by regulatory agencies by using a comparative assessment approach. This approach relies on identifying the differences between the GM crop and its non-GM counterpart and then evaluating the impact of these differences for effects on the environment and nutritional wholesomeness for humans and animals. Most regulatory agencies require a comprehensive compositional analysis of nutrients, anti-nutrients and secondary metabolites, as specified in OECD consensus documents (OECD, 2002, 2012), to determine the nutritional impact of transgene insertion and these studies have demonstrated a lack of nutritional impacts, especially when compared to natural variability. The first glyphosate resistant crops were evaluated in studies with rats, catfish, broilers and dairy cattle (Hammond et al., 1996). Since then, some countries, most notably the EU-27, required whole-food animal feeding studies, such as with rats for evaluating health effects and with broilers to evaluate nutritional effects. These studies are typically conducted with a rapidly-growing animal specie and maximum inclusion levels within the experimental diets (OECD docs). FASS (FASS, 2012) maintains a bibliography of animal feeding studies that have been published in peer-reviewed journals that currently consists of more than 400 studies. Animal feeding studies were reviewed by Flachowsky et al. (2005; 2007), Snell et al. (2012) and Ricroch et al. (2013) and each concluded that GM crops are nutritionally equivalent to their non-GM counterparts.

One study with rats (Seralini et al., 2012) and one with hogs (Carman et al., 2013) have reported adverse effects of feeding glyphosate resistant soybean meal. Both suggested that these crops were not adequately studied and suggested that there needs to be longer studies with more animals. Both of these studies have been criticized by many in the scientific community for their study designs, including EFSA (EFSA, 2012) and FSANZ ((FSANZ, 2012).

EFSA (EFSA, 2011; Kuiper et al., 2013) suggested last year that animal feeding studies are not needed to demonstrate nutritional equivalence if there is a lack of compositional changes, which suggests the need for a testable hypothesis. But recently, politicians in the EU passed legislation requiring a 90-d rat toxicity study. Even though composition studies have shown that transgene insertion and seed production has resulted in minimal effects on composition compared to other factors such as environment (Harrigan et al., 2010; Harrigan and Harrison, 2012; Herman and Price, 2013), others (Huber) have hypothesized that glyphosate depletes crops of minerals resulting in severe reproductive disorders. Considering that animal health is critical to optimizing reproductive and productive performance and the large numbers of animals that have been fed commercially with GM-derived feedstuffs, government databases could be used to determine if adoption of GM crops has impacted animal performance during the years since adoption of GM crops.

MATERIALS AND METHODS

Data were collected from publicly-available sources in July, 2013. Adoption of GM crops was obtained from (USDA, 2013a). In general, USDA data sets were from (USDA, 2013e). Data were collected for broiler production, milk production, hog production and beef production. Broiler data for the US are presented from two data sources, USDA and the National Chicken Council, Washington, DC. USDA data were from the Annual Poultry Slaughter reports and the variables were: 1) total numbers of chickens slaughtered,2) average live weight of chickens at slaughter and 3) percent of chickens condemned at slaughter by USDA. Dairy data were from Milk Production reports for USDA and included numbers of lactating cows and average milk per cow. Hog and cattle data were from Livestock Slaughter Annual Summary from USDA and variables were total commercial cattle, average dressed weight of steers, total commercial hogs, average dressed weight of barrows and gilts. Additional variables for broilers were from the National Chicken Council (NCC, 2013), and were: 1) days to market, 2) market live weight, 3) feed efficiency, and 4) percent mortality.

EU data were from FAOSTAT (FAOSTAT, 2013) and data were summarized for EU-27 countries.

RESULTS AND DISCUSSION

The first GM crops were planted in 1996 in the US and by 2000 HT soy and cotton were on nearly 50% of acreage. Adoption increased steadily afterwards and in 2013 HT soybeans were on 93% of acres and all five categories, HT soybeans, HT cotton, BT cotton, BT corn and HT corn, were on at least 75% of acres (USDA, 2013a). In a report for the year 2012, James et al. (2012) reported that the US grows GM crops on more acres than any other country. Moreover, they reported that globally there were 12 years of double digit growth rates and for the first year developing countries grew more (52%), than industrialized countries (48%).

During 2008, less than 5% of animals within each of the major animal types were raised for organic markets (USDA, 2012) as opposed to conventional markets (Table 1). It is likely that most of the conventionally-raised animals in the US consume large portions of their diets as GM crops. If it is assumed that since 2000 most animals were fed some GM-derived feed ingredients, it can be estimated that in the US 100 billion animals have been fed GM feed(s) (Table 2).

Given these facts, and the fact that animal performance is dependent on animal husbandry systems that minimize health maladies, it would be reasonable to hypothesize that if feeding large amounts of GM crops had deleterious effects in health then animal performance characteristics would be affected negatively. Yearly performance data for broilers, dairy cows, beef cattle and pigs reported by USDA are in Figure 2 to **Figure 5**, and all show a steady increase in performance over the years, suggesting that GM feeds have not resulted in obvious changes in animal health. To understand impacts that GM feeds can have on performance, it helps to understand the exposure of each animal ag type to feeds. This is best understood by comparing broiler and dairy cow systems that represent two extremes of GM feed exposure.

More broilers are raised in the US every year than all other domestic species combined. In typical broiler operations within the US, chickens are fed diets for 42 days that are comprised of approximately 35% soybean meal and 65% corn grain [NRC]. This is a relatively short period compared to other animal ag systems, but constitutes a high percentage of corn and soybean meal exposure in a digestive system that lacks the pre-gastric fermentation that occurs in ruminants. Additionally, corn is fed with almost no processing, other than grinding, whereas soybean meal is more extensively processed. Soybean oil is extracted from full-fat beans resulting in further concentration of the protein fraction. For GM soybeans, essentially no DNA or the protein gene products, Cry protein for BT events and EPSPS enzyme for Roundup resistant events, would be in the oil fraction. The protein-enriched meal is then heat-treated to inactivate anti-nutrients, trypsin inhibitor and lectin. Although broilers potentially are exposed to large amounts of corn and soybean meal for only a 42 days, they increase their body size during this period 60-fold, making them very sensitive to diet perturbations (Cromwell et al., 2003; EFSA, 2008).

Additional data for broilers were obtained that are indicative of broiler health. Broiler carcasses are inspected by USDA at slaughter. Post-mortem condemnations are the result of visible lesions present on organs and carcasses, which include tumors. Post-mortem condemnations for all years were <2% and were 1% in 2013 (**Figure 6**). As reported by the National Chicken Council, mortality was essentially unchanged throughout the years presented and was at its lowest in 2012 (**Figure 7**). Moreover, feed to gain, which partially represents the efficiency of utilization of feed sources, was more efficient during this period (**Figure 8**).

In contrast to broilers, the typical dairy cow is fed for a much longer time and reproduces several times during their productive life. A typical cow grows for about 14 months and is bred to have its first calf at two years of age, which initiates their first lactation. The average US cow has three lactations with approximately one year between lactatioms. This results in a typical cow having a productive life of five years with three conceptions, three gestations and parturition of three calves (30% of US dairy cows have twins resulting in a average delivery of 3.9 calves per cow). Most cows are fed soy-based milk replacers from the first week of life and then are given access to grain and forage diets throughout their life. Even though dairy cows are fed large amounts of forages, one common forage is alfalfa hay fed as pasture, dried hay or ensiled. Roundup resistant alfalfa hay was introduced in 2004 but USDA does not track adoption of GE alfalfa. Another common forage that is fed in large amounts (50% of lactating cow diets on a dry matter basis) is corn silage. A typical dairy diet could contain 50% corn silage, 20% corn grain and 10% soybean meal. Also, many cows receive large portions of their rations as fuzzy cottonseed (no processing except for removal of the lint) or roasted full-fat soybeans (only processing is roasting). Therefore, although there are much fewer cows raised than broilers, they can be fed fairly large amounts of GM-derived feeds for forty times longer than broiles with the added metabolic demands of three concurrent pregnancies and lactations.

Similar animal productivity data are available for the EU27 from FAOSTAT. Cultivation of GE crops in these countries is less than the US. In 2012, five EU countries, (Spain, Portugal, Czechia, Romania and Slovakia) planted 130K hectares of Bt maize. The EU-27 is highly dependent on imports of oilseeds and oilseeds products (protein meals and vegetable oils) to meet demand for food, feed and industrial uses, including biofuel production. This is especially true for oilseeds with no or limited domestic production (USDA, 2013b). About 70 percent of soybean meal consumed in the EU is imported and 80 percent of this meal is produced from GE soybeans. The United States is the EU's second largest supplier of soybeans after Brazil and the third largest supplier of soybean meal after Brazil and Argentina. The second largest category of products imported into the EU of a biotech origin is corn products. Unlike soybean products, the EU production is sufficient to meet most of its own corn consumption, with imports accounting for only 10 percent of total supply (USDA, 2013c).

Data for animal productivity by years are presented for the EU27 Member States (**Figure 9** to **Figure 12**) during the same period of time as was presented for the US. Likewise, there are steady increases in productivity for animals during this period and there are an additional 70 billion animals between 2000 and 2011.

CONCLUSION

Although the data presented in this paper cannot be subdivided between animals fed GM and non-GM feeds, it is reasonable to conclude that the majority of the 180 billion animals raised between 2000 and 2011 were fed GM feeds and this represents a sizable population to examine. During this time there is no indication of widespread health maladies and, in fact, productivity was apparently improved for all animal agriculture types during this period.

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Table 1. Broiler and livestock production in U.S. during 2011 reported for organic and conventional production.

	Organic[1]	Total[2]	Organic as a Percent of Total
Broiler	9,015,984	9,075,112,000	0.1%
Beef cows	63,680	34,364,000	0.2%
Dairy cows	249,766	9,315,000	2.7%
Hogs	10,111	116,451,000	<0.1%

[1] (USDA, 2012)

[2] (USDA, 2013e)

Table 2. Cummulative number of animals from 2000 to 2011 (X 1 million)

Animal[1]	U.S.	EU-27	Total
Broiler	105,426	70,611	176,037
Hogs	105	3,005	3,111
Beef cattle	410	359	770
Dairy Cows	35	101	136
	105,976	74,076	180,052

1 Numbers for broilers, hogs (barrows and gilts) and beef cattle (steers) are for slaughtered animals during calendar year. Dairy animals are number of dairy cows in a calendar year divided by three to account for three lactations per animal.

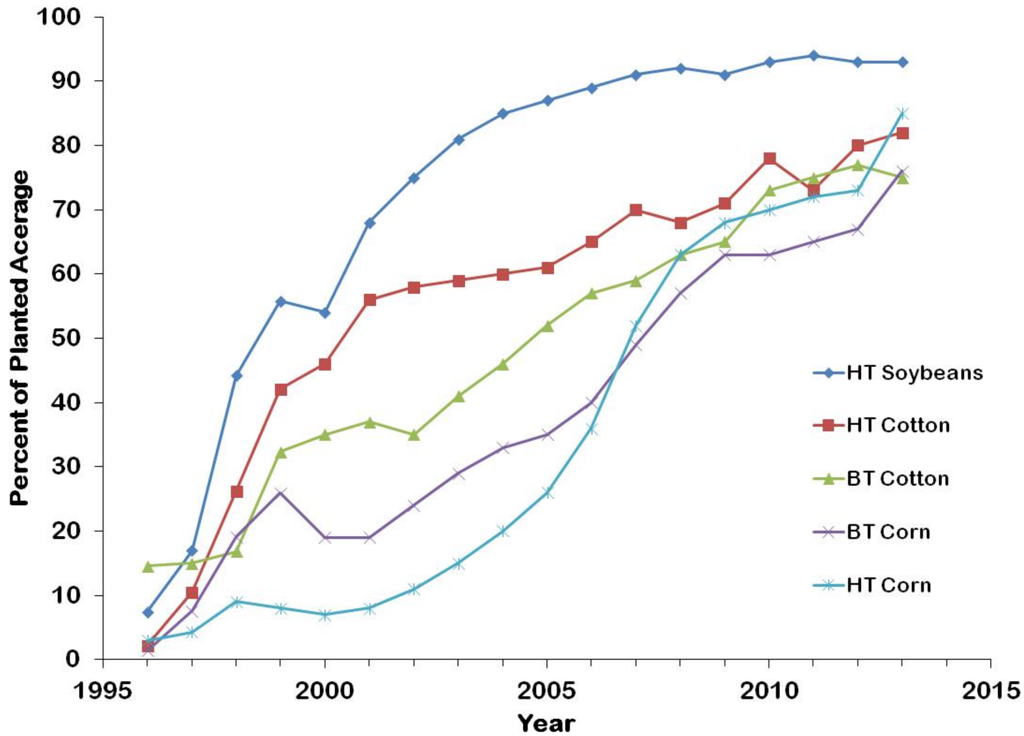

Figure 1. Adoption (% of planted acres) of major GM row crops in the U.S. (USDA, 2013a).

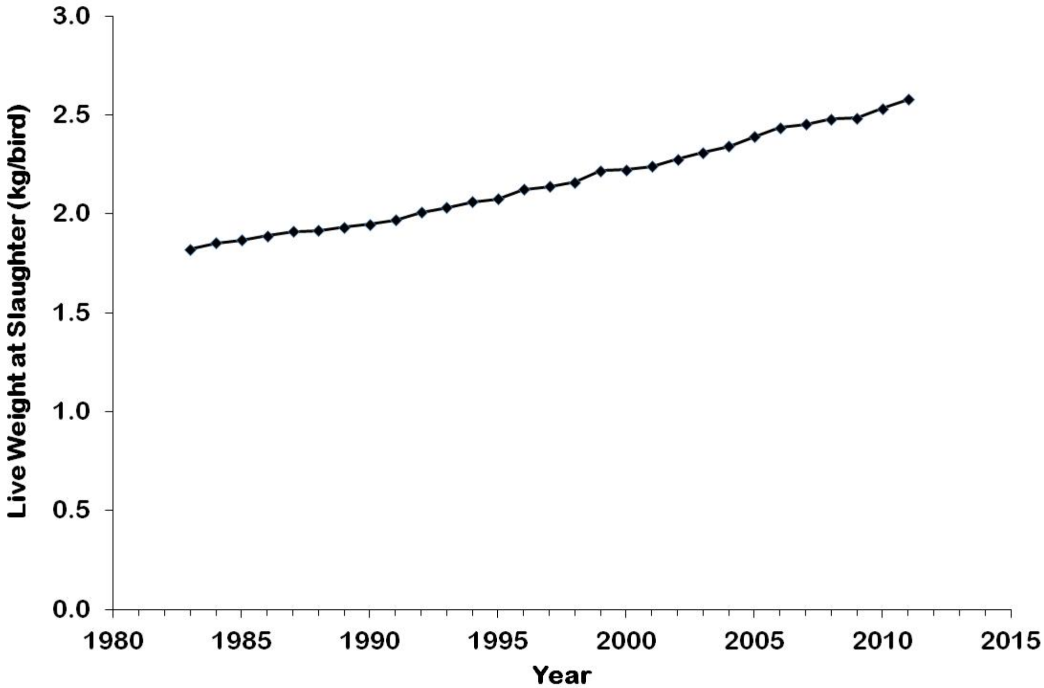

Figure 2. Average weight of chickens slaughtered in the U.S. by year as reported by USDA (2013e).

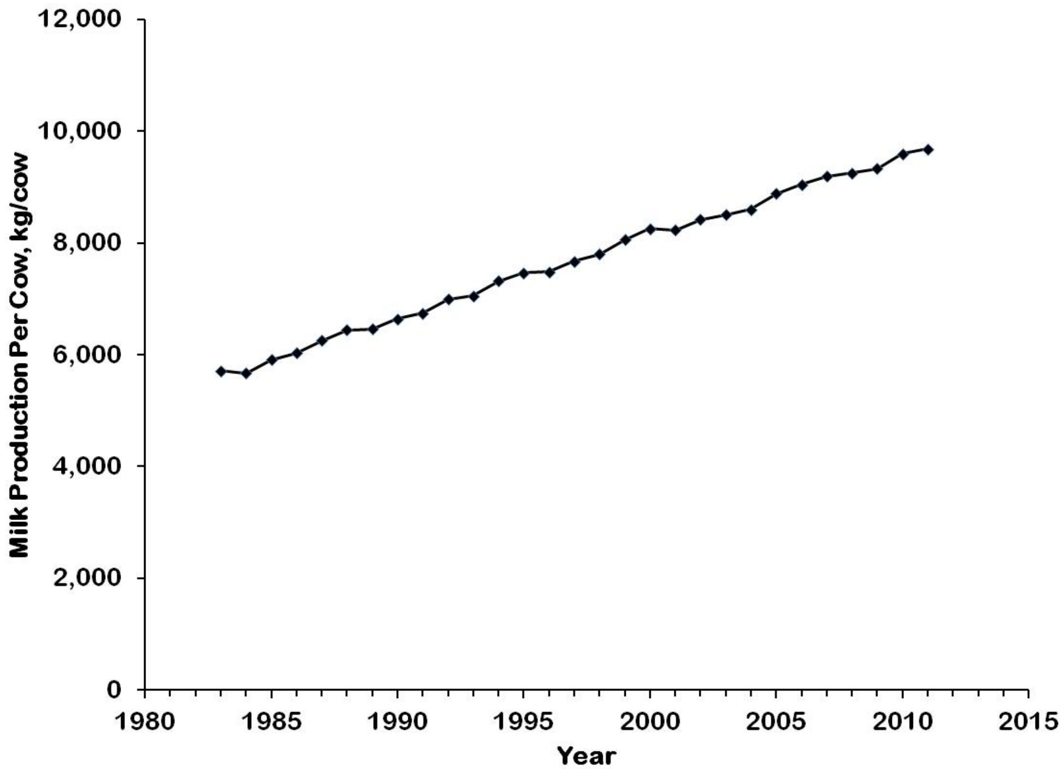

Figure 3. Average milk yield per cow in the U.S. by year as reported by USDA (2013e).

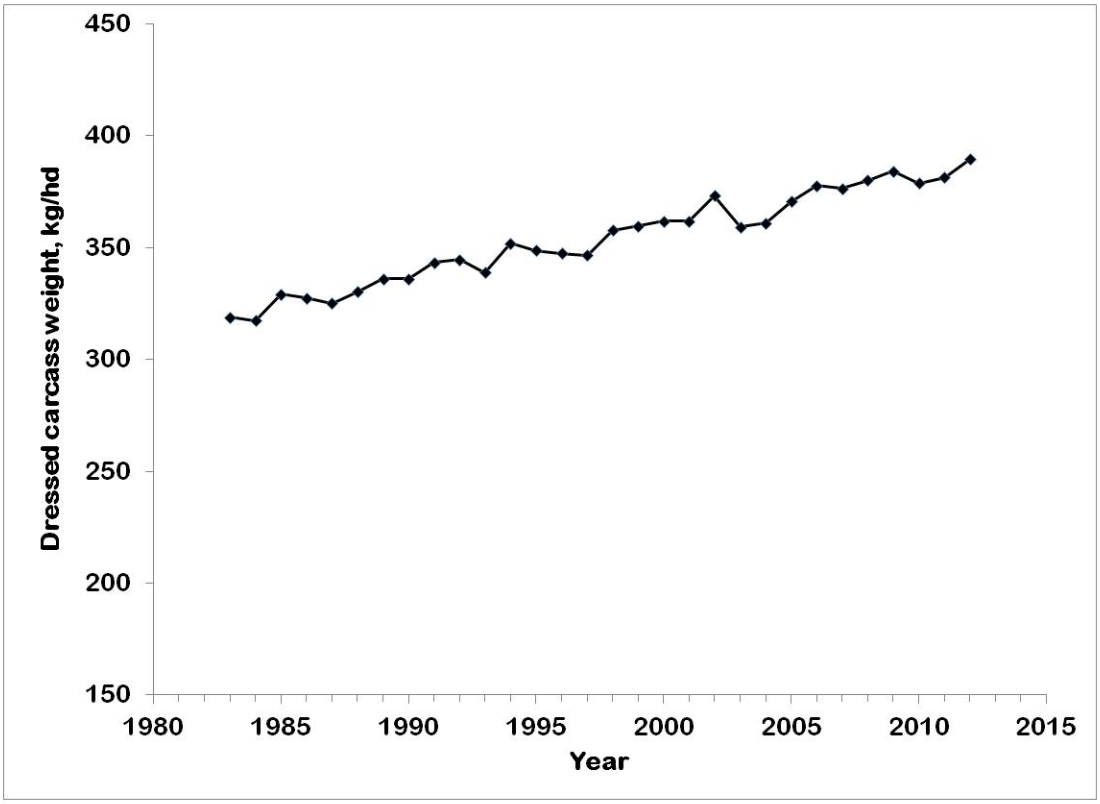

Figure 4. Average dressed weight of steers slaughtered in the U.S. by year as reported by USDA (2013e).

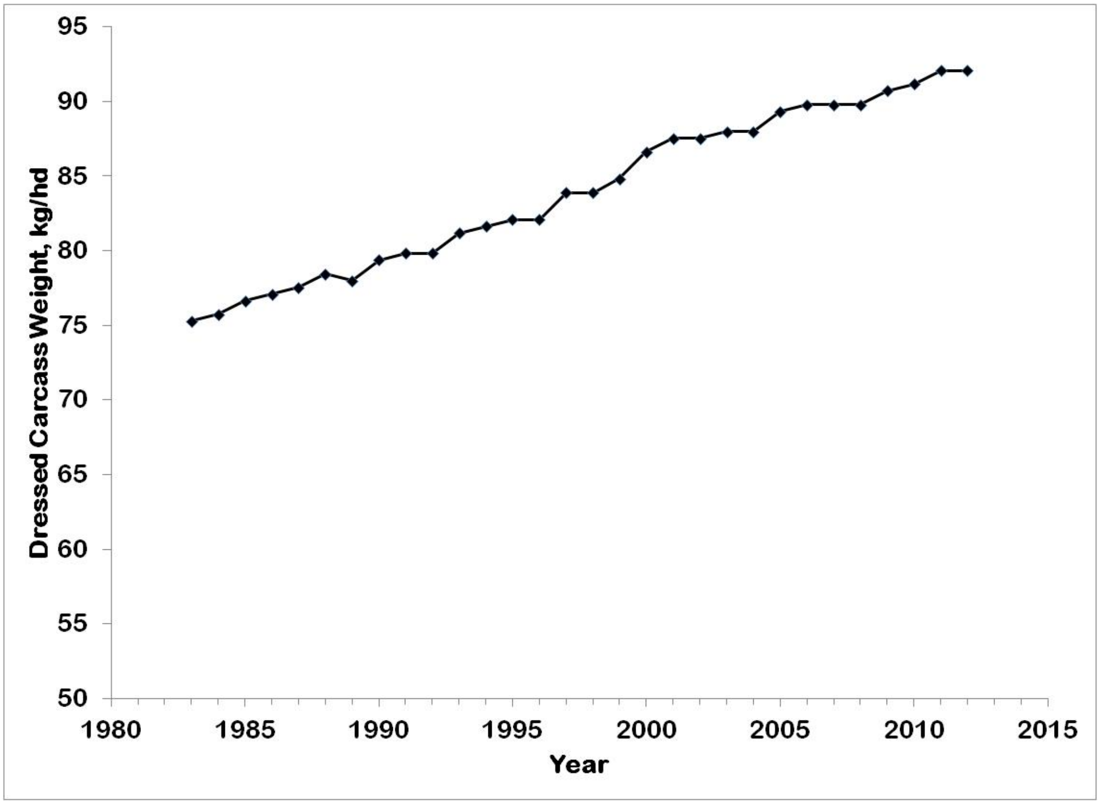

Figure 5. Average dressed weight of gilts and barrows slaughtered in the U.S. by year as reported by USDA (2013e).

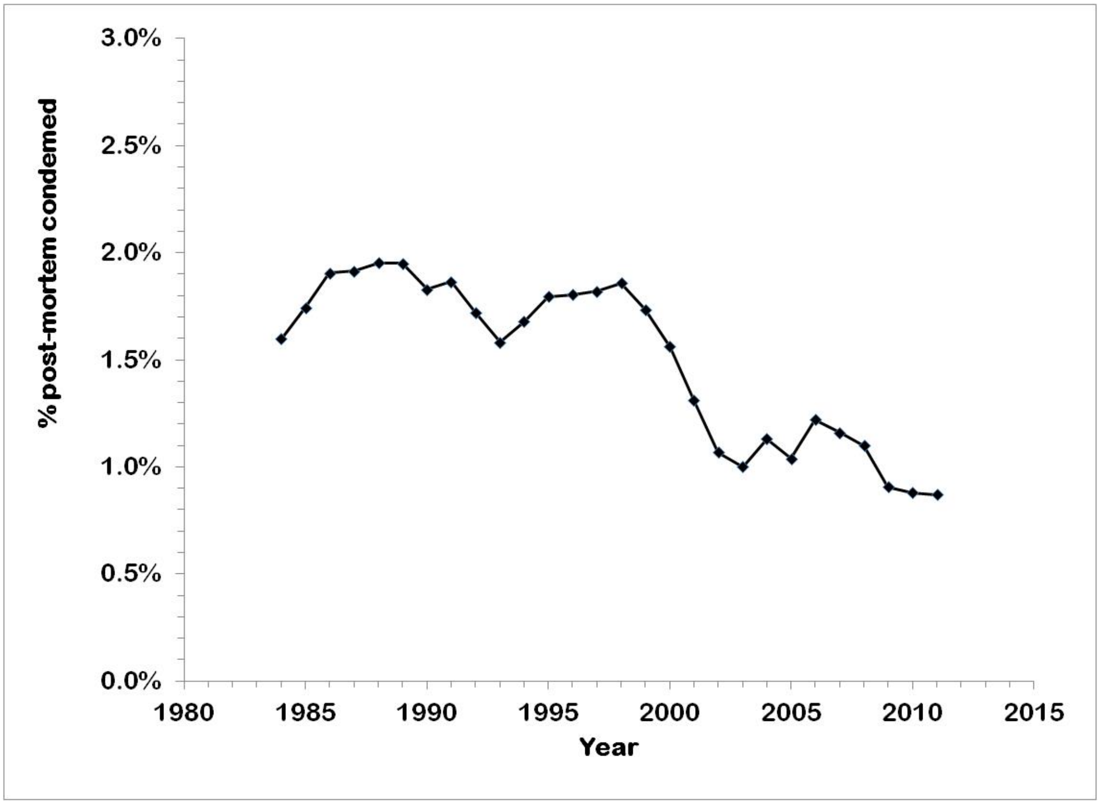

Figure 6. Percent of chickens condemned at post-mortem inspection by years year as reported by USDA (2013e).

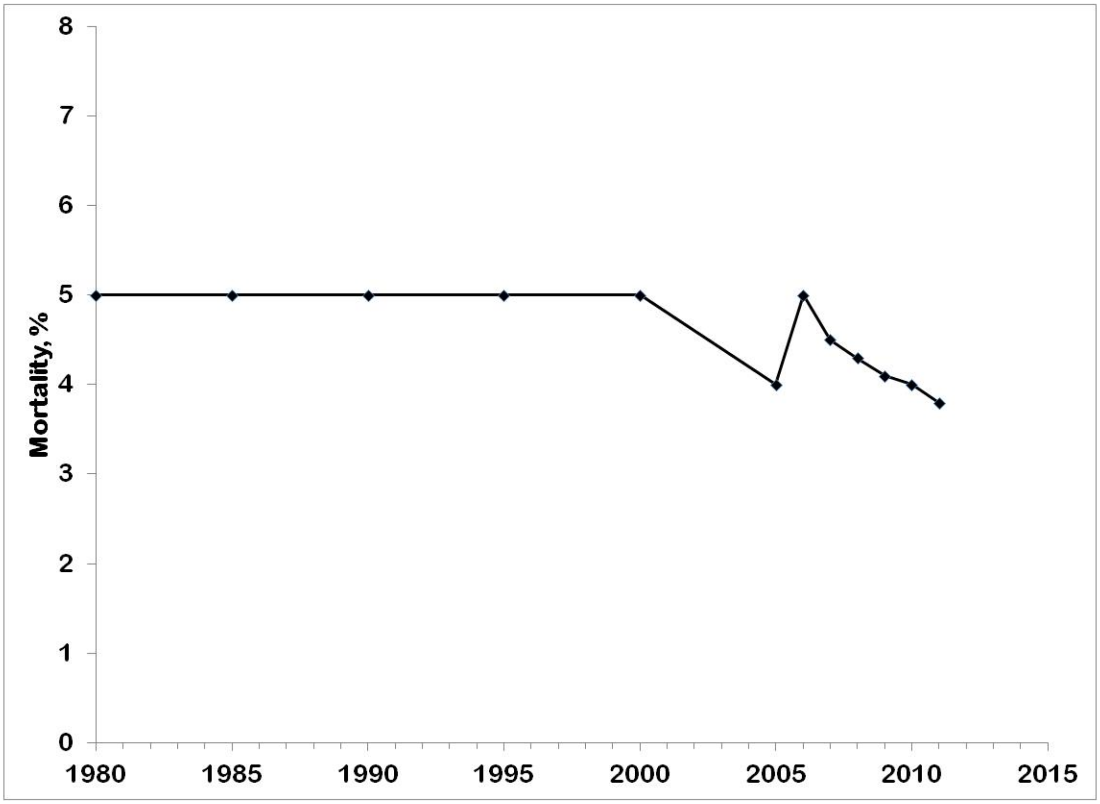

Figure 7. Percent mortality of broilers in the U.S. as reported by National Chicken Council (2013).

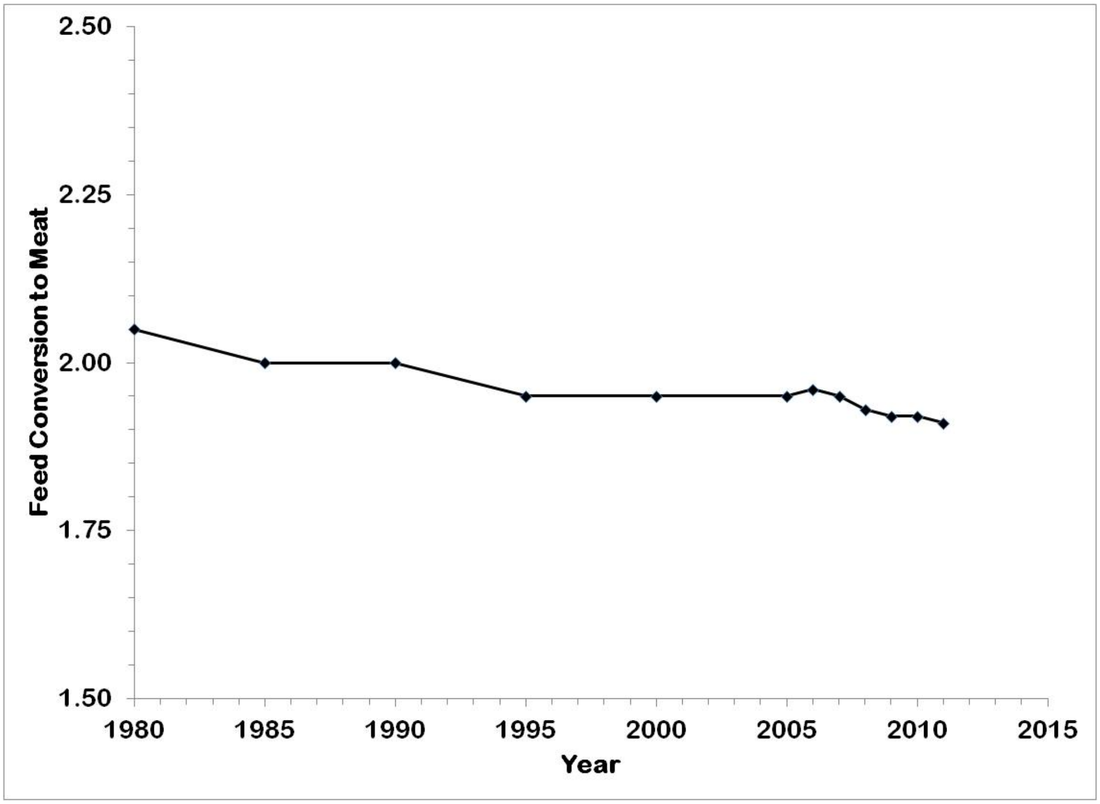

Figure 8. Kilograms of feed required for one kilogram of live weight gain in the U.S. as reported by National Chicken Council (2013).

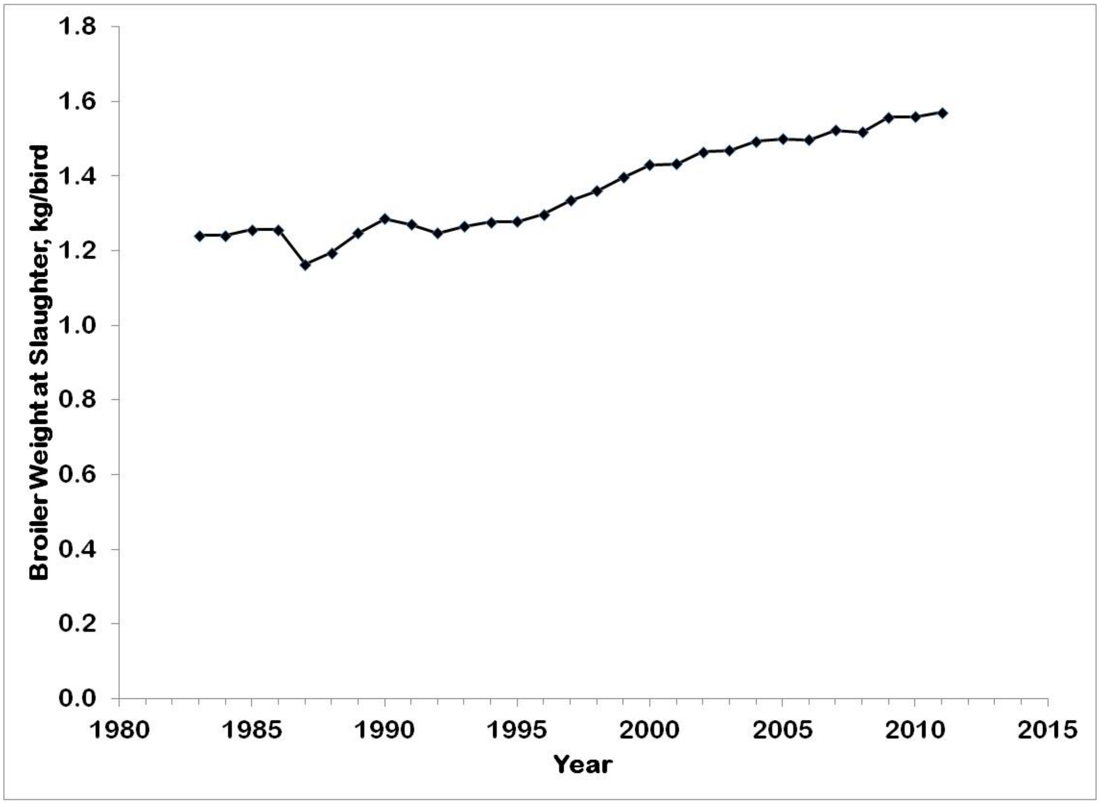

Figure 9. Average broiler weight at slaughter in the EU-27 as reported by FAOSTAT (2013).

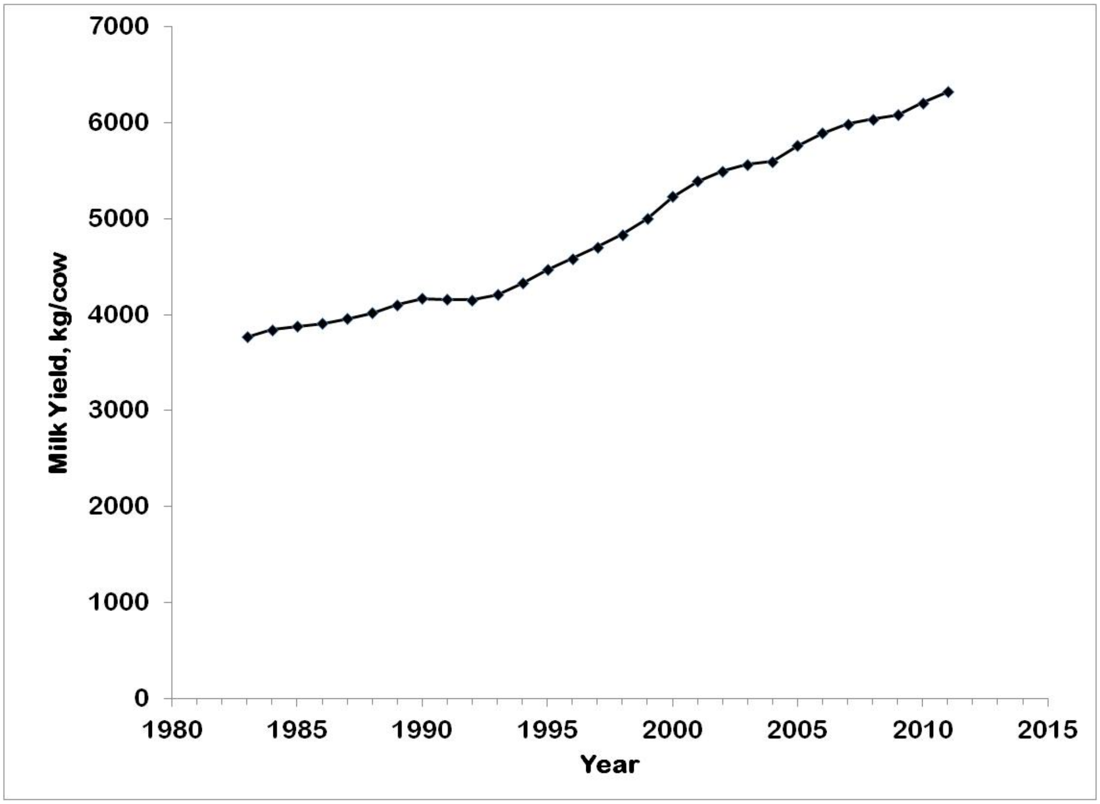

Figure 10. Average milk production per cow in the EU-27 as reported by FAOSTAT (2013).