Sustainable feed for chicken meat

How can we decrease the environmental impact of feed used in slow-growing broiler production systems?

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Commissioned by:

Pluimvee met Smaak

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Preface

This report is part of the Academic Consultancy Training, belonging to MSc studies at Wageningen University.

The principal behind this project is Wageningen Livestock research in Lelystad. This project is part of their project 'Pluimvee met Smaak' aiming to improve sustainability of broiler husbandry system.

Our team consists of five students:

- Yvonne Wientjes: Manager of the team, Master Animal Sciences student specialized in Animal Breeding and Genetics and Animal Nutrition, the Netherlands.
- Karin Brummel: Secretary of the team, Master Animal Sciences student specialized in Animal Breeding and Genetics, the Netherlands.
- Maike Pegge: Controller of the team, Master Animal Sciences student specialized in Animal Nutrition, the Netherlands.
- Roelof de Jong: Member of the team, Master Agricultural and Bioresource Engineering student specialized in Farm Technology, the Netherlands.
- Esther Ugalde: Member of the team, Master Agricultural and Bioresource Engineering student specialized in Farm Technology, Spain.

This team consist of students from different specializations which results in an optimal representation of the aspects of the project. The part about animal requirements and animal nutrition on the one hand (Animal Science students) and the system innovation part on the other hand (Agricultural and Bioresource Engineering students) are represented in this team. Besides that, all members follow an academic education, in which they gathered sufficient knowledge about scientific research.

First of all we would like to thank our commissioners Bram Bos and Arni Janssen for their critical view and help during our project. Next to this, our expert Theun Vellinga provided us a lot information about environmental impact and assisted us during the Life Cycle Assessment (LCA) calculations. Theo Viets learned us the basic theory behind LCA, because none of us has experience with this system. We are thankful that Paul Arens was willing to share data of Agrifirm on broiler feed composition, which was very useful for our LCA as well. Besides that, we want to thank Paul van Boekholt of Hubbard Breeders for sharing information of broiler growth rates. Also we want to thank Marinus van Krimpen for providing information on the use of grass for chicken feed. Last but not least, we would like to thank our coach Meike van Roekel for her help and support during this project.

We hope you will enjoy reading this report and hopefully it can be of use for further research!

Kind regards,
Yvonne, Karin, Maike, Roelof and Esther

Summary

Sustainability of food production for humans is becoming more and more important, which results in an increased attention on animal welfare and environmental impact. In broiler production systems, increasing the animal welfare has among others resulted in the use of slow-growing broilers. Using these longer living broilers however increases the environmental impact due to a lower feed efficiency compared to conventional broilers.
The goal of this project was to come up with recommendations to decrease the environmental impact of feed used in slow-growing broiler production systems. This project started with describing the most important criteria for assessing the environmental impact categories, which were used in the rest of the report. This was followed by making an in depth SWOT analyses of the feed production in three broiler production systems; conventional, slow-growing and organic systems. After the SWOT analyses, the functions and requirements of the broiler production system were analysed, with the help of a tree of objectives, to come up with a morphological chart with alternative recommendations for the separate functions. Thereafter, the feed used in the conventional and slow-growing production systems were analysed with an LCA. An LCA was also performed for some diets with an alternative composition to analyse the possibilities to decrease environmental impact by using different feed compositions.
The environmental impact criteria used in this report were: land use, energy use, acidification, eutrophication and global warming potential. The SWOT analyses showed that all the environmental impact criteria were higher for slow-growing broilers compared to conventional broilers. This is mainly due to the longer growing period and the higher activity level of slow-growing broilers, resulting in a higher total amount of feed needed. In organic production systems, the use of fertilizers and pesticides is not allowed, leading to a lower yield, and crops were produced more on a local scale. Besides that, the growing period is longer than for the slow-growing broilers. These factors resulted in a higher land use and energy use and a lower acidification, eutrophication and global warming potential in the organic system compared to the slow-growing system.
The most important recommendations from the morphological chart were to use other feed ingredients like seaweed and algae, human garbage, other waste products, worms or grass. Other recommendations were to let the broiler choose their own feed without processing it, to restrict the energy requirements of the broilers by reducing the activity level or stabilizing the temperature and to produce feed more locally in greenhouses instead of worldwide.
Results of the LCA showed that all environmental impact criteria were higher in the slow-growing systems compared to the conventional systems. By changing the feed composition by including other ingredients, reductions of some environmental impact criteria compared to the conventional systems were achieved. However, reduction of all environmental impact criteria at the same time was not achieved. A slow-growing diet with high potential for reducing the environmental impact compared to the conventional diet was the diet which included animal fat and fishmeal. This resulted in a decrease in land use, eutrophication and global warming potential compared to the conventional system. Furthermore, diets with a high percentage of wheat hulls, a lower amount of soy meal and no soy oil can reduce the environmental impact compared to the currently used slow-growing diet.
From this study, it can be concluded that using fishmeal and animal fat as feed ingredients in the diet of slow-growing broilers results in possibilities for decreasing the environmental impact of the feed used in a slow-growing broiler diet. Those ingredients are not yet allowed in the diets of those broilers, so a change in legislation is needed for this. For really drawing conclusions on the possibilities to decrease the environmental impact of the feed used by slow-growing broilers, more research is needed. For example, the possibilities for using other ingredients, like human garbage, other waste products, worms and grass needs to be further studied. Besides that, the possibilities for producing feed in greenhouses as well as competition with human food production in the Netherlands need more research.

6. Conclusions

This study showed that the most important categories for assessing the environmental impact of the feed used in broiler production systems are: Land use, Energy use, Acidification, Eutrophication and Global warming potential.

6.1 SWOT

Different conclusions can be drawn by comparing the conventional, slow-growing and organic broiler production systems in SWOT analyses. The slow-growing broiler production system might result in a better animal welfare compared to the conventional broiler production system, but has negative effects on environmental impact. Part of this is caused by the longer growing period which results in a higher total amount of feed needed to reach slaughter weight. Furthermore, the housing system with more space and irregular temperatures increase feed used for activity and maintenance. The production and processing of feed has a major influence on environmental impact and more feed means a higher environmental impact. Next to a higher feed intake, outdoor access of slow-growing broilers causes an increase in emissions from manure. Different feed compositions and different production and processing methods as well as changes in the housing system might be needed to reduce the environmental impact.

6.2 Morphological chart

Different recommendations are shown in the morphological to reduce the environmental impact of the slow-growing broiler production system. Examples of those recommendations are:

- Grow crops in (floating) greenhouses
- Grow crops in outdoor run
- Use conservation agriculture
- Feed chickens with feeding station
- Use waste products
- Use alternative energy sources

6.3 LCA

Results of the LCA about feed production in the conventional and slow-growing production system showed that environmental impact of the conventional system was indeed higher as in the slow-growing system. The feed composition of the slow-growing broiler diet was changed to study the results of this on the environmental impact. It seemed that the use of animal fat and fishmeal, which is currently not allowed in the slow-growing production system, had a high potential for reducing the environmental impact. However, more research is needed to study if this is feasible. For example the amino acid composition needs to be studied. However, coming up with a diet which resulted in lower levels for all environmental impact categories than the conventional production system was not achieved in this project. This means that more research is needed.

7. Recommendations

During this report, recommendations are mentioned for reducing the environmental impact of the feed used in the slow-growing broiler production system. Most of them can be found in the morphological chart and the most important ones are discussed in the report as well. Two important recommendations of the morphological chart were the use of grass and ingredients from animal origin in the chicken diet. The use of grass was studied in more detail which can be found in the next paragraph. The use of protein and fat from animal origin was studied in the LCA. Further recommendations for this can also be found in this chapter.

Besides the recommendations for the broiler production system, there is also looked at the possibilities to reduce the environmental impact of the feed used by laying hens. Those implications are discussed in the last part of this chapter.

In general, it can be said that the recommendations mentioned in this report give an overview of possible alternatives to decrease environmental impact within the slow-growing feed system. However, more research is needed to the define the overall environmental impact of these recommendations.

Grass as feed component
Grass might be a good feed ingredient to reduce the environmental impact of the feed used in the broiler production system. The reasons for this are the possibility for local production and the robustness of grass, which means that maintenance costs are low.

The nutritional value of grass for broilers is not known. However, the nutritional value of grass for broilers is assumed to be comparable to the nutritional value of lucerne, of which information is available for chickens (personal comment of Marinus van Krimpen). Metabolizable energy of lucerne is relatively low (2.95 MJ/kg for roosters and laying hens), representing approximately 25% of the total energy content of the feed. The amount of crude protein is 152 g/kg and the fat content is 23 g/kg. The crude protein content represents 65% of the protein of the complete feed, but the amount of digestible proteins is only 79 g/kg. Digestible fat is available at an amount of 9 g/kg. These numbers are determined for roosters and laying hens, but not for broilers (Bassler, 2005).

Assuming the same amount of digestible proteins and fat for broilers and the same protein requirements, 34% of the total protein requirements can be digested from one kg grass. To take up the required amount of protein from grass, approximately 3 kg grass is needed per broiler per day. To take up the right amount of energy, approximately 4 kg of grass is needed, assuming that for broilers also 1 kg of grass represents 25% of the total energy content. This exceeds the maximum feed intake of broilers. Therefore, only grass is not sufficient to fulfil the broiler's requirements, due to the lack of volume to take up enough feed. This means that grass might fulfil some nutrient requirements, but to reach a sufficient amount of nutrients in the diet, grass has to be supplied together with other feed components.

Furthermore, grass can be provided both in a unprocessed and processed way. During processing, for example drying, the nutritional value might go down. On the other hand, unprocessed grass contains more water and thus the broiler needs more capacity to take up a sufficient amount of grass. Table 7.1.1 shows the differences in chemical composition of unprocessed grass and grass silage fed to steers (French *et al.*, 2000). According to the table, protein content in g/kg DM in grass silage is lower than in unprocessed grass. Therefore, feeding unprocessed grassed might be more desired for broilers than grass silage. However, other processing methods need to be considered.

***Table 7.1.1**- Nutrient composition of grass and grass silage (French et al., 2000)*

Composition	Grass	Grass silage
Crude protein, g/kg DM	224	149
Ash, g/kg DM	123	91
Dry matter, g/kg	181	224
Oil, g/kg DM	29	28

The study of French *et al.* (2000) also showed beneficial effects of feeding grass to steers regarding human health, due to improvement of intramuscular fat. This means that next to the fact that including grass in the diet might decrease environmental impact, it might as well have positive effects on the broilers' meat.

Another option for including grass in the boiler diet is to let chicken feed themselves from grass grown at stable surroundings. This technique has for example been used by small farms in the USA and is called "pastured poultry". It consists of raising the chicken on top of living grasses, which is accomplished by keeping the birds in shelters or huts that are moved to a new spot of fresh pasture once a pasture is exploited. This enables the broilers to eat all the living grasses, plants, insects, etcetera, that they can find. Just like explained above, chicken can not only be fed on grass and for that aim, there are some feeders and watering system on each shelter. Despite the use of this method for some years, there is not enough available information about the energy and protein content of the grass for chickens.

Nevertheless, an experiment was made at Wageningen University to estimate the amount of herbage intake by chicken from different fields. This experiment showed that chicken grazing does not contribute enough to energy and protein requirements. Additional concentrate has to be provided to get the desire final body weight. However, this can be an interesting start point to future research about chicken feed.

Use of ingredients from animal origin

In diets for slow-growing broiler, only ingredients from vegetable origin were allowed. This means that fishmeal and animal fat, ingredients which were used in the diet for conventional broilers, are not allowed. In this study, the use of those ingredients in diets for slow-growing broilers was studied. It seemed that those ingredients had the potential to reduce the environmental impact. However, the amino acid compositions of those diets where not studied in detail due to time limitations. That is why further research is needed for this recommendation.

Feed requirements of laying hens

The diet of laying hens is composed in a different way than the diet for broilers. The reasons for this are that live weight, daily egg output, growth, environmental temperature and physical activity influence the energy requirements of layers (Filev and Sokarovski, 1990). That is why energy intake is important from the start of the laying phase onwards, because it controls the number of eggs produced (Miles and Jacob, 2000). Besides that, body weight is an important factor for egg production in laying hens, because small chickens lay smaller eggs (Miles and Jacob, 2000). That is why during the first weeks of age, young hens are fed a high protein diet (20%). This protein level continuously decreases until 12-15 % at egg production (Meunier and Latour). During the laying phase, certain amounts of lysine, methionine, calcium and phosphorus are needed to support maximum egg production (Filev and Sokarovski, 1990; Meunier and Latour).

***Table 7.3.1** - Metabolizable energy of composed diets for broilers and laying hens*

	Conv	SG-1	SG-2	SG-3	SG-4	SG-5	SG-6	SG-7	SG-8	SG-9	SG-10
Metabolizable energy broilers	11.64	11.50	11.64	11.50	10.33	11.18	12.74	10.16	10.18	10.34	10.12
Metabolizable energy laying hens	12.65	11.69	12.65	11.69	10.30	11.48	14.99	10.05	9.60	10.37	9.31

Table 7.3.1 shows that metabolizable energy content of the composed diets differs between broilers and laying hens. A study of Pishnamazi *et al*. (2005) showed that the genetic origin can be a cause of this difference. Filev and Sokarovski (1990) reported that the energy requirements for laying hens are around 12.5 MJ/kg. This is higher than the energy requirements for broilers, which were calculated during this study to be around 10 MJ/kg. Table 7.3.1 also showed that not a lot of the composed alternative slow-growing diets are in line with this energy requirement. Also the amount of digestible amino acids, vitamins and minerals in the diet are different between the broilers and laying hens. This means that more research is needed to draw conclusions on the differences and possibilities to change feed of laying hens.