Minor thesis

Broiler growth performance of a new dual purpose breed
&
Partial substitution of the organic feed with bread crumbs

A dual purpose experiment to assess the growth performance of broilers from a new dual purpose breed under organic farming & investigate on the ability of bread crumbs left-overs of bakeries to partially substitute the organic feed.

Author: Theophyle Havard Dit Duclos
N° 2014005317
Supervisor WUR: Egbert Lantiga
Farming System Ecology │30 ECTS

Wageningen, January 2017

Aknowledgements

When I arrived in Wageningen for the master Organic Agriculture, I could not imagine the adventure that was going to happen. I landed in Droevendaal doing my thesis rearing chickens. This experience opened the insights of organic poultry farming with an agroecological approach.

I would like to greatly thanks Egbert Lantiga for supervising and supporting me during this thesis. Thanks to Andries Siepel that helped me in my daily work, sharing his good advices and practical solutions. Thanks to Alexander Wezel and Cor Langeveld, that believed in my success achieving this ambitious thesis.

Great thanks the ever smiling Robin and Hendri from Le Perron bakery, that gave me all their crumbs and for their excellent pain au chocolat that I used to eat each time I was going there.

I would like to deeply thank my friends and housemates from Droef 43 Stijn, Nico, Mimi, Jan, Anouk, Adria, and all my friends Maria, Lisa, Pauline, Silvia, Federico, Théau, Xavier, Gauthier that were always welling to help me at the farm, building up the outdoor runs, weighing the chicks, changing the coop and sharing my daily life as a young farmer. We spent good times around those chickens and this opened our minds on backyard farming, fortunately, more chicks are now growing in Droevendaal.

Thanks to my parents, Marie-Anne and Patrick, that came to visit and even helped me with the broilers. They believed in me and without them, I would not be the man I am today. At last, I would like to thank Flore, my partner, for her daily care and support during the writing of this thesis.

Abstract

An integrated study has been conducted to assess the growth performances of a new dual purpose breed, the Vredelinger, in organic farming system in a mobile coop. At the 3rd generation, the broilers weighted in average 1.3kg after 144 days. The growth performances of the 8th generation broilers have been assessed in the first experiment.

In parallel, a second experiment has been conducted during 50 days on organic feed substitution at 30% with bread crumbs left overs of bakeries. The growth performances and feeding behavior of the broilers have been studied. 144 one day old chicks were reared under organic requirements. The young hens and broilers were sexed at 46 days, and were weighing 670 ± 10g. The hens were removed, 72 broilers were kept and divided in four groups of 18. Until 97 days the two control groups, B and D, received industrial organic feed only and the two other groups, A and C, received with an alternative diet composed with 30% bread crumbs left-overs of bakeries. At 97 days, the live weight of the control group B and D were respectively of 1939 ± 51g and 1979 ± 43g; while the alternative group A and C were respectively 1919 ± 56g and 1934 ± 31g. The ANOVA shows no significant difference in live weight between the four groups, P-value=0.835>0.05. The daily average gain was 25.9 g, while the effective FCR was in average 3.91 for the control groups and 3.83 for the alternative groups. The 8th generation of Vredelinger broilers have performances similar to heavy breed such as the Avian south but are far from the specialized Hubbard breed. The breeding program has been really efficient and the breed can now be considered as a dual purpose slow growing breed. Compared to other breed that have been raised in the same conditions in Droevendaal, the Vredelinger broiler were not really active and using the outdoor run, prefering to stay inside the coop. As grazing is an important feed source in organic farming, outdoor use and foraging behavior should be assessed.

Bread crumbs inclusion at 30% did not influence the performances of the broilers. Physio-chemical analysis and particle size distribution revealed the particles bigger than 2mm from the bread crumbs had more nitrogen content, thus more protein content, than the organic feed. This is due to the high content in roasted seeds that are oftent used by artisanal bakeries. Moreover, the broilers seemed to consume more bigger particles and rejected the finest particles from the feed. As bread crumbs are free, they represent an economy of 30% in feed costs, thus are a relevant opportunity to substitute industrial organic feed based on corn and soybean. However, collecting crumbs can be random and is consuming time and energy. Creating links between bakeries, farmers and consumers can help improving circular economy and social network while reducing feed and waste production at the community level.

Key words: dual-purpose breed, organic broiler, mobile coop, bread crumbs, growth performance, particle size distribution, feeding behavior.

Table of contents

1. Introduction (references)

In 2009, the Louis Bolk Institute started a new breeding program for a dual purpose chicken breed crossing modern hybrid layers and two heritage breeds, Hagheweider and Sussex. The breed is aimed at small scale organic poultry farming. The laying hens should lay approximately 250 eggs per year and the broilers could be reared to produce organic meat and diversify the incomes. In 2014, the 8th generation hatched and the breed will be called Vredelinger. Yet, no study has been performed to assess the growth performances of the broilers in organic farming. The growth rate and feed intake is needed to compare it with existing modern breeds.

Dual purpose breeds have longer growth period (Nauta et al., 2014) to reach a standard slaughter weight and lower feed efficiency than specialized breeds. As the organic feed is scarce and expensive, the lower efficiency may raise doubts about the potential of this new breed for small scale organic farming system.

This breed has been designed for agroecological purposes. However, the organic feed is a weak point for the production of slow growing broilers. To enhance the agroecological perspectives of this project, a long-term strategy has been developed to partially substitute the expensive processed organic feed with an abundant, cheap and local source: the bread crumbs left-overs of organic artisanal bakeries appeared to be an interesting alternative.

Artisanal bakeries usually discount or give away their unsold stock, but always throw the bread crumbs from the slicing machine. Bread crumbs are produced continuously in every bakery that are selling sliced bread. Their production is positively correlated with the sales of sliced breads. Crumbs are mainly made of the baked seeds that fall from the bread crust when sliced. The resource of bread crumbs seams abundant all year long, the more breads are sold, the more crumbs are produced. Substituting feed with left-overs from local bakeries can be a solution to increase the diversity of services offered by organic poultry production, lowering the needs of inputs, thus the production costs. Bread crumbs as chicken feed could lower the competition for arable land, reduce the transport and the processing of the feed. Moreover, recycling bread crumbs is recycling the nutrients that would instead be incinerated or buried.

1.1. Aim of the thesis

The first part of the essay is conducted to assess the growth performances of the broilers from the 9th generation of a new dual purpose breed from Louis Bolk Institute observing the specifications of organic broiler farming.

The second part of the essay is conducted to assess the possibility to substitute 30% of organic feed with bread crumbs left-overs of local bakeries, thus increasing the agroecological services of small scale organic chicken farming and lower production costs.

An accurate monitoring of the growth rate and feed intake will be conducted. The particle size distribution or granulometry of the organic feed and the bread crumbs will be assessed. Laboratory analysis will be conducted to assess the dry matter, N-content and ash content per feed and also regarding the particle size of each feed. This will give us a brief overview of the nutritional value of the different diets.

The apparent feed intake will be assessed based on the amount of feed given to the broilers during the time of the experiment. To improve the accuracy of the measure, the amount of feed rejected by the broilers will also be monitored and substituted to the apparent feed given to get the true or effective feed intake. As the feed given, the rejected feed will also be analyzed. The feed left is not commonly taken into account in the feed intake assessment. Those analyses will give an overview of the feeding behavior of the broilers regarding the particle size distribution and the composition of the particles rejected.

1.2. Scope

The first objective is to give Dr. Nauta an accurate assessment of the broiler growth performances of this new dual purpose breed. This will help them to appreciate the potential of this breed to compete with other breeds available nowadays, dual-purpose or specialized.

The second objective is to find out whether or not it is possible to partially substitute the organic feed with bread crumbs left-overs of local organic bakeries. Recycling waste from local bakeries into chicken feed, thus lowering the feed inputs is providing an interesting agroecological solution to be explored for both organic bakery and organic feed sectors. However, if it this alternative diet has a negative influence on the growth performances of those dual purpose broilers, or on the production costs, some conclusions and recommendations can be made about it.

1.3. Main research questions:

- What are the growth performances of broilers of the new dual purpose breed Vredelinger reared under organic conditions?

- Do broilers fed with 30% bread crumbs inclusion in their feed show similar performances than broilers fed with 0% inclusion?

- What are the feeding values of bread crumbs compared to industrial organic feed?

Sub-questions:

- Is the broiler population homogeneous?
- How long does it take for the broilers to reach a target live weight of 2,4kg?
- What is their feeding behavior regarding the particle size?
- What is the abundance of bread-crumbs?
- What is the composition of bread-crumbs compared to organic feed?
- Does the 30% inclusion of bread crumbs diet have an influence on the feeding behavior regarding the particle size?
- What would be the economic return of this alternative diet?
- Can bakeries be an agroecological opportunity for local chicken production?

1.4. Expected outcome

Regarding the low performances of the broilers at the 3rd generation, it is expected that Vredelinger broilers will have lower growth performances than specialized organic breed that have been selected to be slaughtered at 12 weeks such as the Hubbard.
It is expected that the 30% inclusion of bread crumbs can substitute the feed without lowering the growth performances as is it show in the literature that corn and soybean can be partially or fully substituted with others seeds or bread crumbs.

Thesis outline

Chapter 2 is a literature review on dual purpose and specialized breeds, organic and conventional production systems, industrial feed composition, and alternative feed sources to justify my choices. Chapter 3 will detail the Material & Methods arising from the literature review to assess the growth performances of this dual purpose breed and assess the effects of bread crumbs as a partial substitute. Chapter 4 will present some surprising results on the growth performances, diet composition and feeding behavior, and the discussion linked with. Then conclusions will be made on the feasibility to use the Vredelinger breed for organic meat production and on the feasibility to use bread-crumbs as a feed substitute.

2. State-of-the-art of poultry production: organic vs conventional

2.1. Breeding: fast vs slow-growing

Modern conventional broilers have been selected over the past decades to reduce costs and maximize production through faster growth and more efficient nutrient use. They perform best on low-fiber grains and highly digestible protein sources. A fast growing breed has an average daily gain over 45 g, thus, the slow-growing breed are gaining less than 45 g per day (Waldroup, 2004). A lower protein but higher fat content has been measured in the thigh meat of slow-growing broilers. Fast-growing broiler breast meat showed higher moisture content and less ash retention than slow-growing (Küçükyilmaz et al., 2012).

Breed specialization has been developed more efficient either layers with an average egg production of 250 eggs/year and broilers for meat production reaching the target body weight of 2,4kg in 42 days with an average FCR of 1.7 (Ross, 2014). Layer breed are not suitable for meat production; the males are systematically slaughtered day old. Killing half of the day old chicks is not ethically not acceptable in modern societies.

A study comparing broiler growth from an old “slow-growing Canadian breed from 1955” and the modern fast-growing “Cobb 500-2012” demonstrated the Cobb are outweighing 4 times the size of the old breed. Although broiler breeder body weight targets evolved to be more efficient, having larger muscle mass, some problems appeared in the balance. Despite the larger mass, the heart and lungs are smaller in percentage of body weight (Collins et al., 2014). For those breeds the parents need to be severely restricted on feed to reach sexual maturity without health issues, but with welfare issues (Renema, 2007). Those breed are designed for industrial conventional poultry production and do not adapt well to organic production. They do not adapt well to the outdoor environment and the long rearing period of 81 days minimum. Slow-growing broiler are more suitable for organic production (Castellini et al., 2002).

Some breeds are called dual purpose, the hens provide a good production of eggs and the broilers are growing heavy enough to be slaughtered for meat production. They can be pure breed that are relatively heavy such as the French black Marans. However, the Dr. Nauta at Louis Bolk Institute started a breeding program crossing modern specialized layer hybrids and pure heavy broiler in order to create a new dual purpose breed for organic farmers. The production of organic eggs and meat insures more income for the farmer and allows him to make his own breeding program on farm. Dr. Nauta estimated at 13€/kg the price of organic broiler carcass which is an interesting income in addition to eggs. The Vredelinger hens are already performing well with 250 eggs/year. The objective for the broilers is to get closer to the performances of specialized slow-growing for organic production to be valuable on a market. At the 3rd generation, the Vredelinger broilers weighted 1,3kg at 144 days (Nauta, 2014). This is not performant compared to the heavy avian south breed fed in organic system. The avian south broiler body weight at 84 days reached 1623.10 g with a feed intake of 5965 g and a FCR was 3,68 (Simiz et al., 2011). If the Vredelinger broilers can compete with those performances, they can be considered as heavy and the dual-purpose breed can be commercialized for organic eggs and meat production.

2.2. Nutrition: corn and soybean

The livestock sector contributes substantially to global warming, water and air pollution and biodiversity loss. One third of arable land is currently used for feed production thus increasing the pressure on arable land (Schader et al., 2015). To increase the sustainability of livestock production, the efficiency must be improved, the demand reduced and the reduction of food-competing feed optimizing grassland and food waste (Schader et al., 2015).

Like all other animals, chicken needs a sufficient amount of energy, protein, minerals, vitamins and water to perform well. Both wild and domesticated fowl select their feedstuffs and compose a diet that matches their physiological requirements (Syafwan et al., 2012).

The needs in energy and protein depends on the nutrient needs for maintenance and for production. Chickens are very sensitive to nutrient shortage or imbalance because they grow relatively quickly (Simiz et al., 2011). This is why they are so interesting for scientific experiments on diet formulations. It is proven that an increase in protein level in the diet improved weight gain and feed conversion ratio (Vieira et al., 2004). However, an excessive overall protein level in the diet causes stresses and increases the nitrogen and ammonia emissions in the environment (Fanatico, 2008).

It is stated that organic housed poultry have higher energy requirement due to locomotion, as they have more freedom of movement, and thermal regulation, as they are exposed to higher environmental variations. The protein requirements seem to be similar (Van Knegsel & Van Krimpen, 2008). In the organic regulation the birds have access at least 8 hours per day to 2,5m^2/bird of outdoor run if reared in a mobile coop, and 4m^2/bird (ECOCERT, 2012).

According to the EU regulation (EC) no.834/2007 and (EC) no.899/2008, only 20% of the feed has to be self-produced or from the region. To be certified organic, 95% of the feed has to come from organic farming, but it can come from overseas (ECOCERT, 2012).

Typically, both for conventional and organic poultry production, corn is used for energy and soybean for protein. Most of the production comes from the United State and South America. In organic, the soybean cannot be defatted with chemical solvent or complemented with synthetic amino acids. Thus, the soybean is roasted, extruded or expelled to be more digestible and destroy the anti-nutritional factors but makes it more expensive (Fanatico, 2008).

Importing feed from overseas is risky: it is sensitive to price variations and has several impacts on the global nutrient balance (Schader et al., 2015). There is a nutrient accumulation with the droppings of the birds, that will end up in soil, water and air pollution mainly with nitrogen emissions. Moreover, this feed has a high carbon foot print as it travelled a lot. This is not the organic feed we are aiming for in a modern society. Therefore, an alternative feed source has to be explored to fit with the philosophy of organic farming.

2.3. Alternative feed: boycott corn and soybean

As feed costs represent up to 70% of total costs, and the increasing demand for cereals led to a constant rising price. A cheaper and more coherent source of feed appears to be the goldmine to make organic farming more competitive (Catala-Gregori et al., 2009). Corn and soybean are mainly produced in America and imported, thus they have a very high carbon foot print. Moreover, both feed productions are competing with food production on arable land. For this reason, corn and soybean should be boycotted and non-competing resources should be used, such as grass and food waste.

Bread crumbs are mainly composed of roasted seeds that were on artisanal whole bread when it got sliced. The main seeds encountered are from pumpkin, sunflower, sesame and flax, mixed with so called bread crumbs. Indeed, those seeds are rich in protein and oil, which can substitute partially or completely the use of corn or soybean in the feed.

Dried bakery products included at 7% in the diet of broilers did not impaire their performance (Catala-Gregori et al., 2009). Bread is mostly composed with wheat, which has no anti-nutritional factor associated with. It is highly energetic and can partially or completely replace corn in diet formulation (Ayanrinde et al., 2014). Another study showed that corn can be replaced with biscuit waste in diet formulation. The final liveweight of the control birds were 1.87kg with a FCR of 3,18 and the biscuit fed birds weighted 1.64kg with a FCR of 4.09. Even if the FCR are clearly higher, the mean live weight was not significantly different between the groups (Ugbesia Igene et al., 2013).

Different studies have been conducted to find alternative sources of protein. For instance, many other seeds have been tested. With an inclusion of 10% of pumpkin seed meal in the whole diet, the performance and sensorial quality of broiler meat did not change (Martinez et al., 2010). Another study showed that the inclusion of 10% of pumpkin seed meal, partially replacing soybean meal and vegetable oil, improved the performances and edible portion yield (Aguilar et al., 2011).

Sunflower meal is a good source of protein with similar availabilities than those of soybean meal, especially in methionine and cysteine. However, it is lacking lysine, which is the main limiting amino-acid (Senkoylu & Dale, 1999). Furthermore, it contains anti-nutritional factors such as the O-quinons that decrease the availability of lysine and methionine. O-quinons, like most of the anti-nutritional factors can be destroyed by thermal treatment (Piva, 2010).

A study showed that replacing soybean meal with sunflower meal did not affected the body weight gain, but decreased the food efficiency and then was recommended to replace up to two-thirds of the soybean meal (Rama Rao et al., 2006).

Organic feed usually contains less protein than conventional feed, because synthetic amino-acids are not allowed. Therefore, it can affect negatively the performances. The methionine shortage can be compensated with sesame seed expellers (Rodenburg et al., 2008). However, sesame seeds contain anti-nutritional factors such as tannins and oxalates. When roasted, the anti-nutritional factors are significantly reduced. An inclusion up to 15% of roasted sesame seed meal did not affect the performance of the broilers (Olaiya & Makinde, 2015). Another study showed that an inclusion of 12% of roasted sesame hulls increased feed intake and final body weight without affecting the feed conversion ratio (Mahmoud et al., 2015).

Flaxseed are rich in alpha linoleic acid (omega-3 fatty acid). If only a small amount is fed to broilers, the content in the meat can rise from 90 mg/100 g up to 400 mg/100 g. This is increasing the nutritional value of chicken meat by 4 (Farrell, 2009). However, flaxseed contains anti-nutritional factors such as linatine. If included with more than 10% in the diet, it reduced significantly the body weight gain of broiler, even if the omega-3 content is increased (Mridula et al., 2015).

Insects such as the black soldier fly larvae are a high value source of protein and fat which contents are respectively 44% crude protein and 32% fat. Moreover, they are relatively rich in lysine, thus can outcompete the soybean meal (Makkar et al., 2014).

As bread crumbs contain all the ingredients cited previously and have been roasted, they seem to be the perfect food-waste for chicken feed substitution, however it may lack lysine. This diet based on bread crumbs can be completed with insects, such as the black soldier fly larvae, that are high in lysine, protein and energy (Makkar et al., 2014). Regarding the literature, it is highly probable that bread crumbs can partially replace corn and soybean in the feed. This would have different advantages: turning a waste into a circular commodity; find a local feed source that has a lower carbon food print, lower the dependency toward corn and soybean production; lower competition on arable land.

Food from farm to fork and back to farm again has to become a leitmotiv for every agroecological production.

3. Material & Methods

3.1. Procedure Ethics

All of the procedures involving birds in this experiment were approved by the Animal Experimental Committee of Wageningen University (Wageningen, the Netherlands).

3.2. Experimental design

The fertile eggs of the Vredelinger dual purpose breed were brooded during 21 days in Warmonderhof facilities. When they hatched, 153 one day old chicks have been collected and brought to Wageningen Unifarm indoor brooding room. At 1 week old they were all vaccinated against the New Castle Disease by Dr. Nauta. During the first 4 weeks, the chicks were reared indoor and fed *ad libitum*. During this first period, 9 chicks died. Then from 4 to 7 weeks they were reared in the mobile coop with a heater in addition and no access to the outdoor runs. The individual live weight of the chicks was recorded in average every 3 days all along the study.

Since the chicks arrived, they were ringed regarding their family filiation. The rings needed to be changed as the chicks grew to avoid discomfort or leg injuries. At 7 weeks it was possible to sexed the 144 chicks. The young hens were sexed regarding a smaller size of the crest compared to males. The sex ratio was 50/50 exactly. The 72 young broilers remaining were randomly mixed in four groups of 18 broilers each, two groups receiving the control diet and two groups receiving the alternative diet. It is following 2x2 parallel group design (source). They were dyed on their feathers neck to differentiate the four groups in case they fly to the neighbor or escape.

The first two groups will be the control group to assess the growth performances of the breed. The other two groups will be the alternative group to test the 30% bread crumbs inclusion diet. All the groups are fed ad libitum, are opened at the same time, weighted the same day.

The feed left in the gutter was remove once a week, weighted and some sample kept. This is aimed at assessing the apparent and the true or effective feed intake.

A granulometric analysis has been conducted to assess the particle size distribution of the organic feed, the bread crumbs, and the mix at 30% inclusion. The same granulometric analysis has been conducted on the feed left in the gutter to assess the particle size that are the most rejected.

A laboratory analysis has been conducted to measure the dry matter content, the N-content and the ash-content of the organic feed, the bread crumbs and the mix and also regarding the particle size distribution to find differences in nutritional value.

Period of the year & place

The first 91 one day old chicks, males and females mixed, arrived on February 2nd 2015, day 0, at Droevendaal Experimental Unifarm, Wageningen. On February 4th, another 62 chicks have been brought to the farm. For the first 4 weeks they were reared indoor in a brooding area made for the occasion in small heated room of the barn. On March 2nd they all were moved to the mobile coop in two groups of 72, with a heater in addition and no access to the outdoor runs. On March 20th, the females were separated and the broilers randomly divided in four groups of 18. They were fed all with the same diet during 4 days to lower the stress from the manipulation. On March 24th, at day 49, the parallel experiment starts: two groups with the control diet and two groups with an alternative diet with bread crumbs. They were all of them fed *ad libitum* until the end of the experiment on May 10th at day 96. The next day, on May 11th, they were all weighted on an empty stomach and most of them were brought to a slaughter house in Luntenen, the best broilers have been kept to become breeding roosters for the Vredelinger breeding program of Dr. Nauta.

3.3. Animals

Vredelinger dual purpose breeding program started in 2009 with Dr. Nauta in Warmonderhof, the Netherlands. The spawners batch has been formed from a number of layer hybrid strains and two heritage breeds, Hagheweider and Sussex. The family breeding method has been used to create 5 different families. The females are selected to lay 250 eggs per year in average. The males are supposed to be slow growing broilers but no data on their growth performances are existing yet. In February 2015, the 9th generation hatched and the experiment to assess the growth performances of the broilers could start (fig. 1).

Figure 1. Photo of broilers from the 9th generation of Vredelinger breeding program at Unifarm, Wageningen

3.4. Housing and outdoor area

Brooding area was a small heated room of 12m2 in one of the barns. It was arranged with 5 plastic palox of 1.2x0,8m so about 1m2, with each an infrared heating light bulb, a bell drinker and a bell feeder. For the first week, the 5 families were in a different palox, then all the chicks were ringed regarding their family and remixed randomly in 5 groups of 30 chicks per palox. The heat bulbs above the litter were adjusted every day and the room temperature every week following the recommendations of Primefacts (appendix 1.). The wood chips litter was renewed once a week. The mobile coop used measure 6.85x5.48m = 37.5m^2 and has 4 elevated platforms for a total of 12.5m^2. There is 50m^2 overall surface area, divided in four compartments of 12.5m^2 surface area (fig. 2). The density is 1.92 broilers/m^2 on the ground, and 1.44 broilers/m^2 counting the platforms. It is far under the maximum 16 birds/m2 allowed by the EC regulation no. 834/07 and no. 889/08 for mobile housing. All compartments have a pop hole with a door of 1.2x0,45m and a spanning plank to link the level of the coop and the ground of the outdoor runs. Some wood chips litter was added every week or two to keep it dry and clean. At night the pop holes are closed to prevent fox predatory. They are coop vents alongside for fresh air and light inside the coop. The outdoor run is 100m^2 per group of 18 broilers. It is 5.25m^2/bird instead of the minimum

2,5m^2/bird required for birds reared in mobile housing according to EC regulation no. 834/07 and no. 889/08. The broilers had at least 8 hours per day of access to the outdoor run during the end

of March, and up to 12 hours per day in April and May. In the middle of each run there is a shading table and a water trough. In the run of the group A there is a tree standing. Group B and C runs are close to a hedgerow (fig. 2).

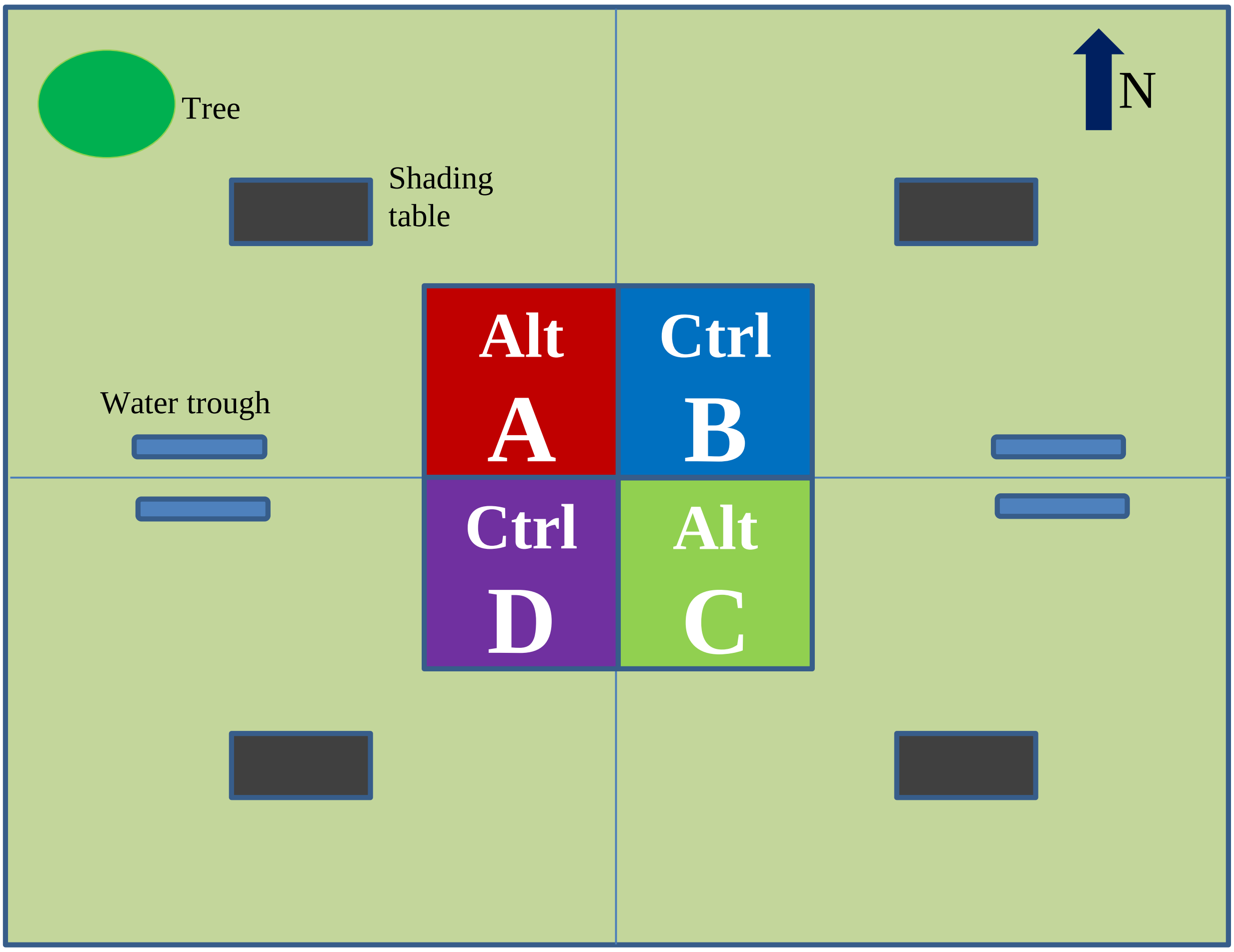

Figure 2. Scheme of the experimental site with the four groups of broilers

3.5. Nutrition

Until day 46, the chicks are fed *ad libitum* with an organic starter concentrate flour from Van Gorp dutch feed company: 632*ECO*OPFOKKRUIMEL START. It is advised from week 0 to week 3 for a good start of the chicks. Dr. Nauta decided to use only this one until 7 weeks to lower shipment costs. They received water *ad libitum* and the water consumption has not been measured. Every 2-3 days, new feed is added in the bell feeder so it stays always fresh for the chicks. The water and feed bells are hanged few centimeters above the litter so the chicks can't walk into it, litter doesn't go in and the feed stays clean. From 4 weeks on, all the chicks have been moved to the mobile coop, the water and feed is given in bells every 1-2 days. From 7 weeks on, the feed is given every morning for each group in a metal gutter of 2m long, laying on the ground inside the coop. The water was given through an automatic system of 20 drippers and a reserve of 100L per group. Each line of drippers is suspended 20cm above the ground.

From day 46 and for the whole diet experiment, the only organic feed used is the 473*ECO*OPFOKKUIKENMEEL from Van Gorp. This organic concentrate feed is mainly composed of crumbled grains and flour based on wheat, corn, soybean, peas. The nutritional composition is translated in appendix 2. This feed is designed for organic chicken growth, males and females, from 6 to 17 weeks. It is not specialized for broiler growth. The control groups are feed ad libitum with 100% of organic feed from day 46 until day 96.

Bread crumbs left-overs of organic bakeries: the alternative feed chosen as a local organic substitute feed source had to be organic to follow the specification of organic poultry production. However, it needed to be more agroecologically relevant than the industrial organic feed. Thus, it should not compete with human food crop such as corn or soybean. A local food by-product is an interesting solution to test. The bread crumbs were chosen regarding their availability, expected nutritional quality (seed diversity) and affordability. In early March, a partnership has been made with Le Perron organic bakery in Wageningen, they used to throw their crumbs when they clean every day, but now they will keep it and give it for free for the whole experiment. They were the main supplier of crumbs, even though some crumbs have also been collected at Lazuur, when needed. Lazuur is an organic grocery store that avoid waste generation. Their bread crumbs were not often available because other customers were already collecting it for their ornamental birds, farmyard or even as fish bait. Both bakeries are selling artisanal bread made with wholemeal wheat or spelt flour, which are full of seeds on the crusts. Thus, when sliced, the roasted seeds fall and are usually cleaned regularly. Le Perron and Lazuur are producing in average 1,5kg of bread crumbs every day, all year long. Bread crumbs are an abundant source of local food by-products. They contain crumbs, but mostly roasted seeds as pumpkin, sunflower. The distance between the farm and the bakery is about 5km. The crumbs were collected by bike three times a week at the opening of the bakery, the carbon foot print was close to zero. From day 49, the crumbs were mixed with the organic feed at 30% inclusion without any kind of processing. Some samples of 250 g and 20 g were made respectively for granulometric and physio-chemical analysis.

The amount of feed given for each group was about 2kg/ day and the refill was visually assessed if needed. The feed given was recorded every day. The four groups are fed the same amount of feed and at the same time in the early morning every day. From day 46 to 49, all the broilers were fed with 100% of the organic feed. From day 49 on, the two control groups kept receiving the organic feed at 100% and the two alternative groups received the 30% bread crumbs inclusion diet. From day 58 and once a week, the feed left in the gutter was removed. The gutter is cleaned from the droppings and litter residues before being filled again with fresh feed for each group. The feed left is systematically weighted to calculate the effective or real feed intake. The feed left has also been analyzed through a granulometric and physio-chemical analysis.

3.6. Particle size distribution or granulometry

At the Drovendaal farm laboratory, a sample of 250g of each feed (given and left) has been sieved through 4 different screens to separate the matter in 5 different particle sizes: >4.0 mm, >2.8 mm, >2.0 mm, >1.0 mm and <1.0 mm. The matter screened was weighted regarding their size and the size distribution ratio could be assessed. The feed size the most rejected have compared among the experimental groups.

3.7. Physio-chemical analysis

A sample per particle size of each the feed (given and left) per group has been sent to the laboratory of the Farming System Ecology group at Wageningen University. The dry matter content, N-content and ash-content has been assessed. It is aimed at assessing and comparing the nutritional value of the crumbs compared to the organic fodder, also regarding the particle size.

3.8. Data collection and statistical analysis

The experiment was conducted in two parts. The first 7 weeks, with a batch of 144 male and female chick mixed. The bodyweight of every chick has been measured 12 times in the first 45 days. The feed intake, the growth rate and the feed conversion ratio have been assessed for the chicks. On day 45, the females were sexed, then removed, and the broilers split in four groups. On day 49, the organic experiment with the two different diets started: control and alternative diet with 30% bread crumbs inclusion. The eighteen broilers of each of the four groups have been weighted 20 times from day 46 to day 96. The feed given was recorded every day. The feed rejected was collected 8 times from day 58 to day 96. Table of the feed consumption of each group in appendix 4.

The one-way analysis of variance test - One-way ANOVA - was conducted to assess a potential significant difference in live weight between the four groups. The statistical analysis has been conducted on R software on Windows 8. The graphs and tables on growth performance, particle size distribution, physio-chemical analysis and temperature were made using French Excel 2010 on Windows 8 and on Excel 2016 on Macintosh (separation by "," instead of ".").

Research hypothesis:

- H_0: null hypothesis, there is no significant difference in mean bodyweight between the control groups and the alternative diet groups.
- H_A: alternative hypothesis, there is a significant difference in mean bodyweight between the control groups and the alternative diet groups.

The significance of the difference was considered is the type I error; P-value would be less than 5%: P-value<0.05. It means that the probability to reject the null hypothesis (H_0) when it is actually true is 5% (source).

Integrating bread crumbs left-overs of bakeries in broiler production - economics

A short economic analysis has been conducted to assess the price of the feed consumed and the feed rejected, also to compare the price of broilers fed only with industrial organic feed or with the alternative diet with 30% inclusion of bread crumbs. The bread crumbs are free so the alternative diet groups receive 30% free feed. The price per broiler is calculated based on the organic feed price = 0.56€/kg.

4. Results and discussion

4.1. Growth rate until 7 weeks

At the beginning of the growth rate experiment, the one day old chicks were weighing 42g on average. The males and females were mixed and reared indoor for the first 28 days in optimal conditions and fed *ad libitum* organic feed. After 46 days, the 144 chicks reached an average live weight of 670 g with a standard deviation (SD) of 82 g and a standard error of the mean (SE) of 10 g. The daily average gain is 14.6 g from day 1 to 46. On day 46, the females were sexed and only the broilers have been kept for the performance assessment. The broilers have been split in four groups of 18: two control and two alternatives. Two groups of 18 broilers (control B and control D) were fed only with the control organic feed until day 96. The mean live weight of the 36 broilers fed control diet, both groups together, have been taken into account to draw the growth rate graph below (fig 3.). Liveweight records are found in appendix 3.

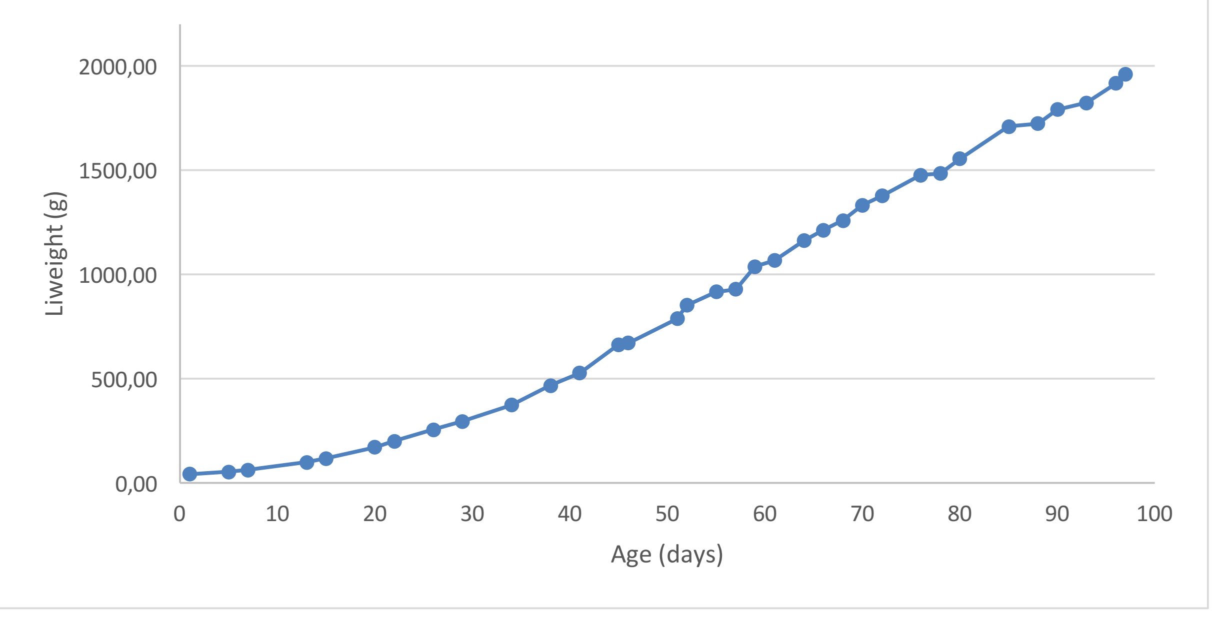

Figure 3. Growth rate of Vredelinger broilers fed industrial organic feed from day 1 to 97

At 85 days, the control broilers were weighing an average of 1709 ± 44 g. The daily average gain from day 46 to day 85 is about 29 g/day, far from the fast growing-breed with a minimum daily average gain of 45 g/day. That breed can be considered as a slow-growing breed (Waldroup, 2004). As slow growing breeds perform better in organic system, this breed may show its best performances in organic farming system, which is the case now

(Castellini et al., 2002). There is a huge improvement in growth rate from the 3rd generation of broilers that reached 1.3kg in 144 days, which is a daily average gain of 9 g/day (Nauta et al., 2014).

It is still far from the growth rate of the specialized breed Hubbard-JA 957, regarding the thesis experiment of Ted Hilderink which occured at Droevendaal farm, in the same mobile coop. At 85 days, the broilers fed in organic system weighted 2940 g with an average daily gain of 42 g/day (Hilderink, 2010). Compared to the heavy avian south breed fed in organic system, at 84 days the broiler reached 1623 g (Simiz et al., 2011). The Vredelinger breed has a better growth rate and then can be considered as heavy breed. However, the rearing conditions and the diet composition may have been different compared to the conditions of this experiment.

The experiment kept running until day 97, to get more data. The control broilers had an average live weight of 1959 ± 47g. The variability between the broilers is increasing compared to day 85. That problem of heterogeneity needs to be worked at the breeding process.

From day 46 to day 97, about 14 weeks, the daily average gain is about 26.5 g/day. As we would like to estimate the time to reach a target slaughter weight of 2.4kg, we extrapolated from this number. To get 440 more grams, the broilers need to be raised for at least 16 more days, which is about 17 weeks in total. It is interesting because it is also the amount of time needed by the hens to lay their first egg. The dual-purpose breed would then offer an opportunity to raise broilers and hens. When the hens start to lay, the broilers can be slaughtered and sold up to 13€/kg carcass (Nauta et al., 2014). That might offer an income that covers the production costs of both broilers and hens.

4.2. Statistical analysis – R results

The results of the diet experimentation with bread crumbs are presented below. The following figures show the repartition of the mean live weight of the four groups of broilers at day 46, at the beginning of the diet experiment; at day 85, to be comparable to organic broilers; and at day 97, to see if differences would occur later.

Reminder: Group B and D = control

Group A and C = alternative

Mean weight day 46

The Bartlett test shows homoscedasticity of variances. It is a primary condition to make parametric tests. The P-value is 0.7704>0.05 so the variances are equal (fig. 4). However, slight differences can be seen among the groups : SD_A=95 g, SD_B= 81 g ,SD_C= 74 g and SD_D= 86 g (fig. 5).

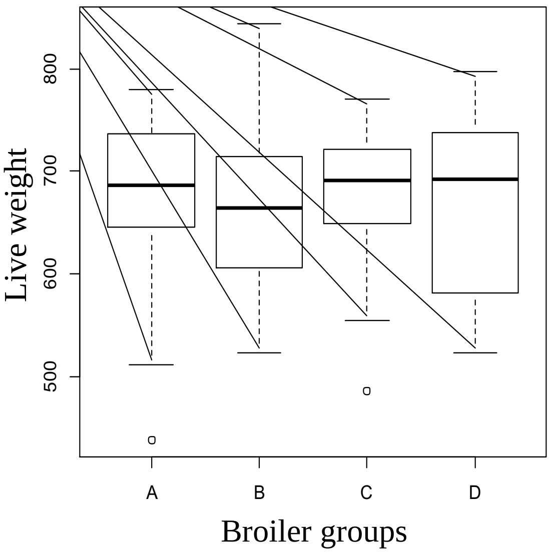

Figure 4. Mean live weight (g) of each group at day 46

Homoscedasticity of variances

Bartlett's K-squared = 1.1278

Df = 3

P-value = **0.7704**

The P-value of the ANOVA is 0.9997>0.05 so the null hypothesis H_0 is accepted. There is no significant difference in live weight between the four groups (Table 1.). The diet experiment starts with four identical groups in terms of variances, with a mean live weight of 670 g.

Analysis of Variance Table 1.

Response: liveweight

Day 46	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Group	3	80	26.8	0.0038	**0.9997**
Residuals	68	483728	7113.7		

Mean weight day 85

On day 85, after 36 days of experiment, the variances in live weight were still equal among the four groups, P-value = 0.06>0.05. However, higher variances can be seen in group A and B than in group C and D : respectively SD_A=196 g and SD_B= 200 g compared to SD_C= 106 g and SD_D= 177 g (fig. 5).

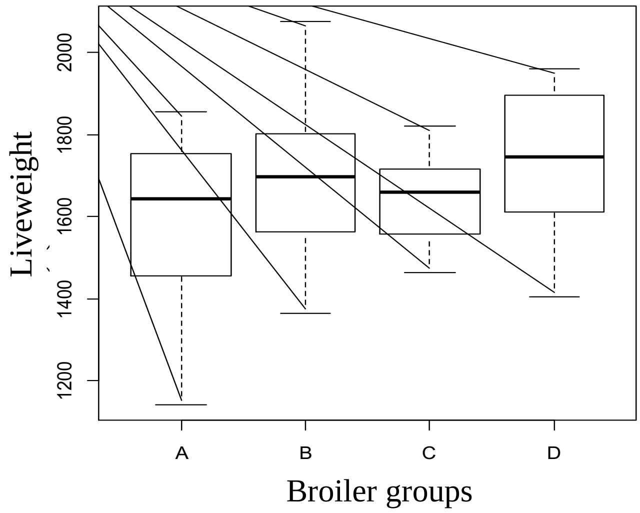

Figure 5. Mean liveweight (g) of each group at day 85

Homoscedasticity of variances
Bartlett's K-squared = 7.2628
Df = 3
P-value = **0.06398**

At day 85, the mean live weight of the control groups B and D are slightly higher than the alternative groups A and C. The mean live weight of the control group B and D are respectively 1693 g and 1726 g, SD_B= 200 g and SD_D= 177 g, SE_B= 47 g and SE_D= 42 g. While the mean live of the alternative group A and C were respectively 1604 g and 1632 g, SD_A=196 g and SD_C= 106 g, SE_A= 46 g and SE_C= 25 g. Regarding the ANOVA, P-value = 0.152>0.05, H_0 is accepted, there is no significant difference in mean live weight between the four groups (Table 2.).

Analysis of Variance Table 2.
Response: liveweight

Day 85	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Group	3	165185	55062	1.8205	**0.1517**
Residuals	68	2056674	30245		

Even if the difference in live weight is not significant (P-value = 0.152>0.05), it can be expected that differences in growth actually occur but are not significant after 36 days of alternative diet. Thus, the experiment have been conducted until 50 days of alternative diet to assess any differences.

Mean weight day 97

At day 97, after 50 days of experiment, the variances are still equal among the four groups, P-value=0.10>0.05. However, higher differences variances in group A and B than in C and D : respectively SD_A=238 g and SD_B= 218 g compared to SD_C= 132 g and SD_D= 182 g (fig. 6).

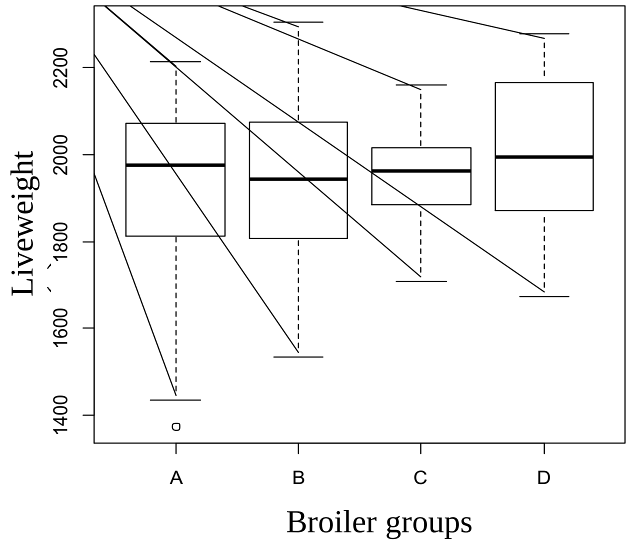

Figure 6. Mean liveweight (g) of each group at day 97

This may be cause by the position of the groups in the mobile coop. Group A and B are on the north face of the coop, while C and D are facing south. The difference in temperature between both face may influence the homogeneity within the groups as broilers have higher needs for thermal regulation (Simiz et al., 2011).

Homoscedasticity of variances
Bartlett's K-squared = 6.0829
Df = 3
P-value = **0.1076**

At day 97, the mean live weight of the control groups B and D are still slightly higher than the alternative groups A and C the mean live weight of the control groups are respectively 1939 g and 1979 g, SD_B= 218 g and SD_D= 182 g, SE_B= 51 g and SE_D= 43 g. While the mean live of the alternative group A and C were respectively 1919 g and 1934 g, SD_A=196 g and SD_C= 106 g, SE_A= 46 g and SE_C= 25 g. Regarding the ANOVA, P-value = 0.835>0.05, H_0 is accepted, there is no significant difference in mean live weight between the four groups (Table 2.). It is confirmed at day 85 and at day 97 that 30% of bread crumbs in chicken feed has no effect on the growth rate.

Analysis of Variance Table 3.
Response: liveweight

Day 97	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Group	3	35012	11671	0.301	**0.8245**
Residuals	68	2636341	38770		

4.3. Growth rate from 7 to 14 weeks

As can be seen on the graph of the growth of each group from day 46 to day 97 (Fig. 7), the growth rates of each group are showing similar tendency all along the experiment.

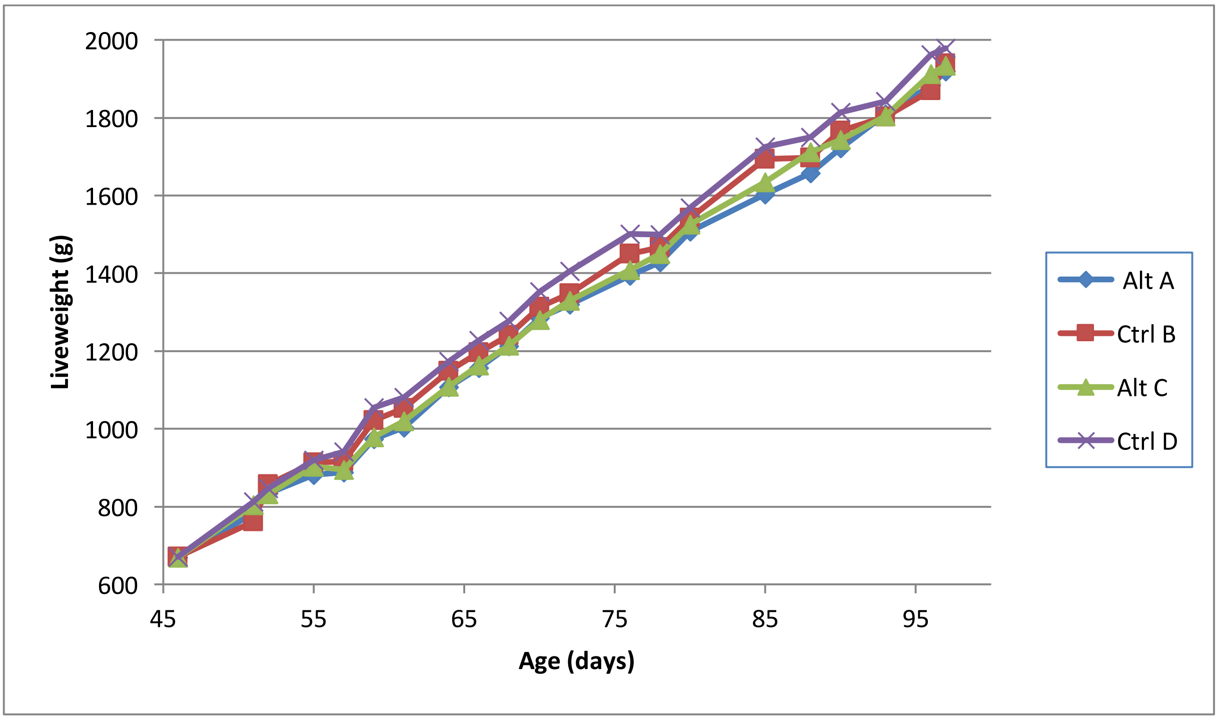

Figure 7. Growth rate of group A,B,C and D from day 46 to day 97

The alternative diet have been given from day 49. The next week a storm hitted the Netherlands for three days and the outdoor runs were completely flooded. The broilers were staying inside in cold and wet conditions until the weather changed and the outdoor runs could drain. This may explain the lower growth rate of all the broilers from day 52 to day 57. After that, for the 40 next days, the growth rate is regular for all the groups. From day 57 to day 97, the alternative group A and C show exactly similar daily average gain than the control group B and D = 25.9 g/day.

However, the alternative groups have slightly lower final live weight. This tendency started after the first week. It was observed that the broilers fed alternative diet were selecting the organic diet and rejecting partially the bug seeds of the crumbs such as pumpkin and sunflower seeds. After day 52, they were consuming all the crumbs but were not able to fill the gap.

4.4. Feed intake

The feed intake has been measured for all the 144 chicks, males and females together, until day 46. At that day each chick, consumed 1785 g of organic feed (fig. 8). The Feed Conversion Ratio from day 1 to 46 is 2.84. As females and males grow differently (Nauta et al., 2014), this graph cannot be considered as a reference graph for the feed intake of the broilers only. They may have consumed more feed. Records in appendixe 4.

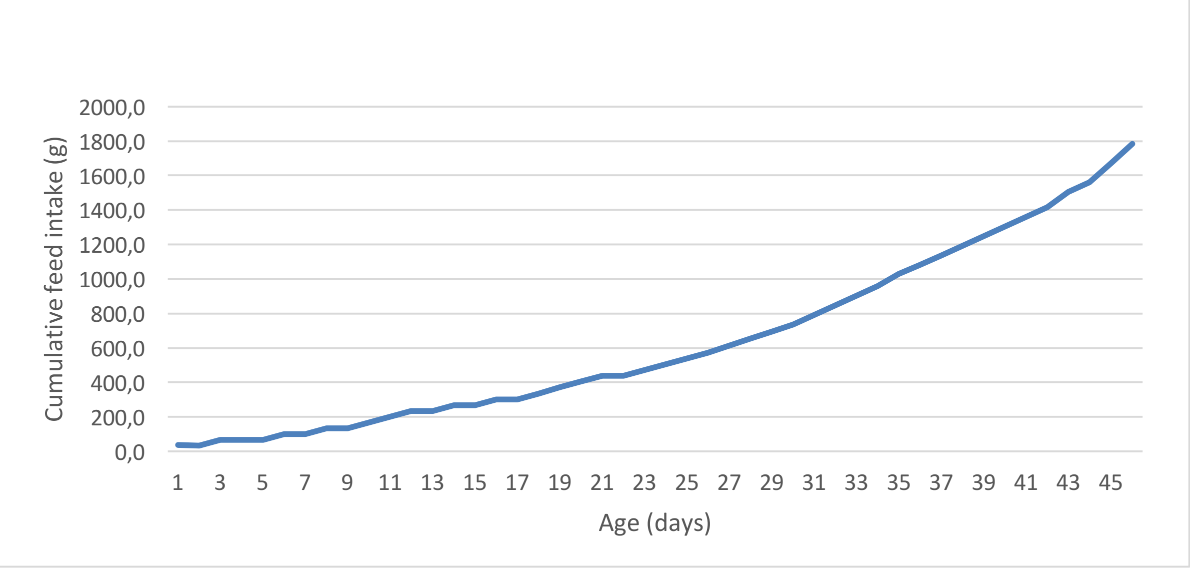

Figure 8. Cumulative feed intake per chick from day 1 to day 46

From day 49 the feed changed, and from day 59 the feed rejected by the broilers has been collected and measured for each group. This allows to show the rejection rate of feed compared to the apparent feed given. It gives the real or effective feed intake (fig. 9). As can be seen on the graph below, the feed rejection, represented by the difference between the line of the apparent feed intake and the effective feed intake that differs for each group. The apparent feed intake represents the amount of feed given to the broilers. As they were fed ad

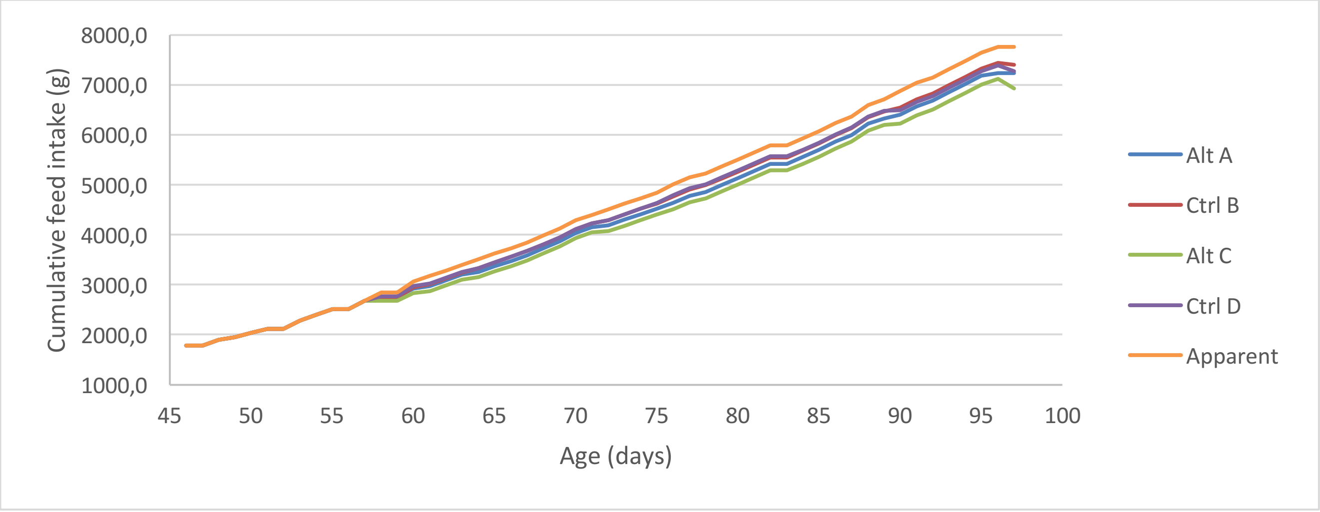

Figure 9. Cumulative apparent and effective feed intake per broiler from day 46 to 97

libitum, there was always a little bit of feed remaining in the gutter. This rejected feed has been weighted every week and deducted from the apparent feed to get the effective feed intake.

On day 85 the apparent cumulated feed intake is 6062 g, which is an average daily intake of 114 g/day for the period 46 to 85 days. The effective feed intake for the control groups B and D are respectively 5821 g and 5840 g and the alternative groups A and C respectively 5691 g and 5559 g. The alternative group have rejected slightly more feed than the control groups on day 85, in average 205 g of difference in feed intake between control and alternative groups

On day 96 the apparent feed intake is 7757 g, which is an average of 116g/day. The effective feed intake for the control groups B and D are respectively 7434 g and 7385 g and the alternative groups A and C respectively 7231 g and 7112 g. The alternative group have rejected slightly more feed than the control groups on day 96, in average 238 g of difference in feed intake between control and alternative groups, which has really evolved compared to day 85.

The breads crumbs have substituted 30% of the industrial organic feed, therefore the alternative fed broilers have a lower cumulative feed intake (fig. 10). As can be seen of the figure below, the difference, thus the economy in feed, increases towards time. On day 85, the control group B and D effectively consumed 5821 g and 5840 g of industrial organic feed respectively. While the alternative group A and C effectively consumed 4569 g and 4477 g of industrial organic feed respectively.

On day 97, the control group B and D effectively consumed 7434 g and 7385 g of industrial organic feed respectively. While the alternative group A and C effectively consumed 5647 g and 5563 g of industrial organic feed respectively. It is lower than the feed intake of the control group B and D at day 85. Records in appendix 5.

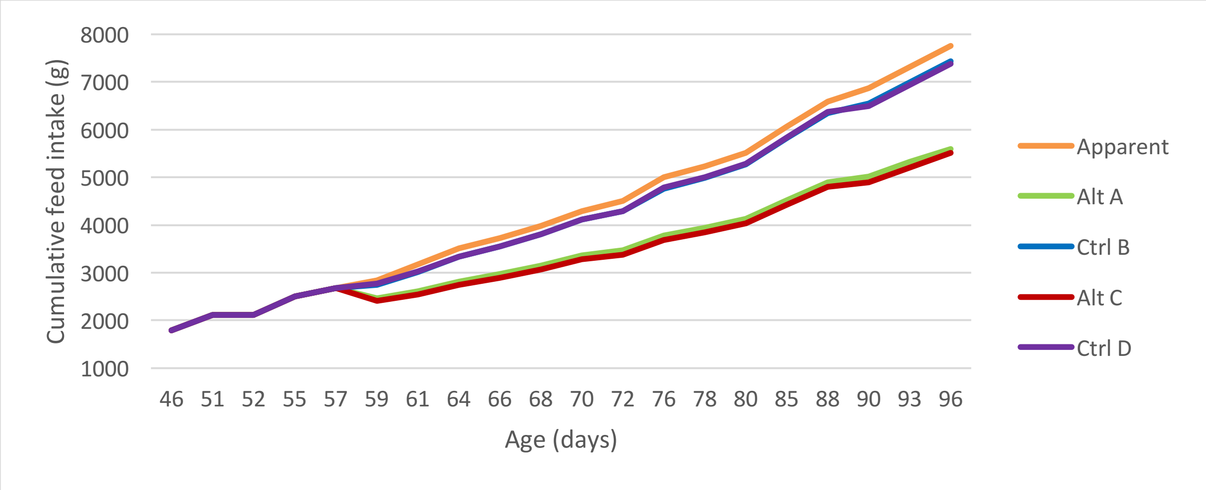

Figure 10. Cumulated effective industrial organic feed intake per broiler from day 46 to day 96

4.5. Feed conversion ratio (FCR)

The average FCR from day 1 to 46 is 2,84 while the chicks were mixed all together.

From day 46 to day 96, the evolution of the FCR is similar among the four groups (fig. 11).

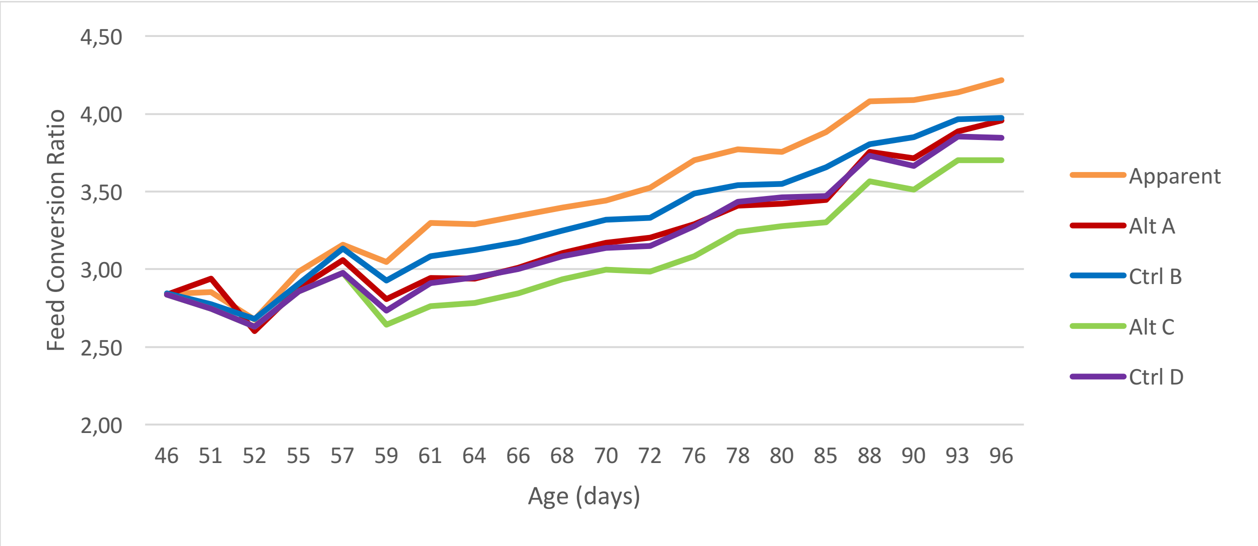

Figure 11. Evolution of the apparent and effective FCR per group from day 46 to day 96

For the period day 46 to day 85, the apparent FCR is 3.88. The effective FCR of the control group B and D are respectively 3.66 and 3.47 while the effective FCR of the alternative group A and C are respectively 3.45 and 3.30. The apparent FCR of the Vredelinger broiler pretty good compared to the heavy-breed avian south which FCR =3,68 (Simiz et al., 2011). However, it is not so efficient compared to the Hubbard-JA 957 which had a FCR of 2.85 in 85 days in the same experimental site (Hilderink, 2010).

On day 97, the effective FCR for organic feed of the control group B and D are respectively 3.97 and 3.84, while the alternative group A and C are respectively 3.96 and 3.70. The FCR among the groups do not differ. Tables in appendix 6.
The Vredelinger broiler are now having good performances, similar to heavy breeds such as the avian south. In contrast, they are far from the performances of the specialized broilers for organic production such as the Hubbard-JA 957 within the same time scale of 85 days.

Here comes the interest of the bread crumbs inclusion in the diet. As the proportion of industrial organic feed decreases in the diet, the effective FCR of the alternative broilers A and C can be recalculated considering only the industrial organic feed intake. As can be seen in the following figure, the effective FCR only based on the industrial organic feed of the alternative group A and C are far below the control group B and D, and this difference is increasing with time (fig. 12).

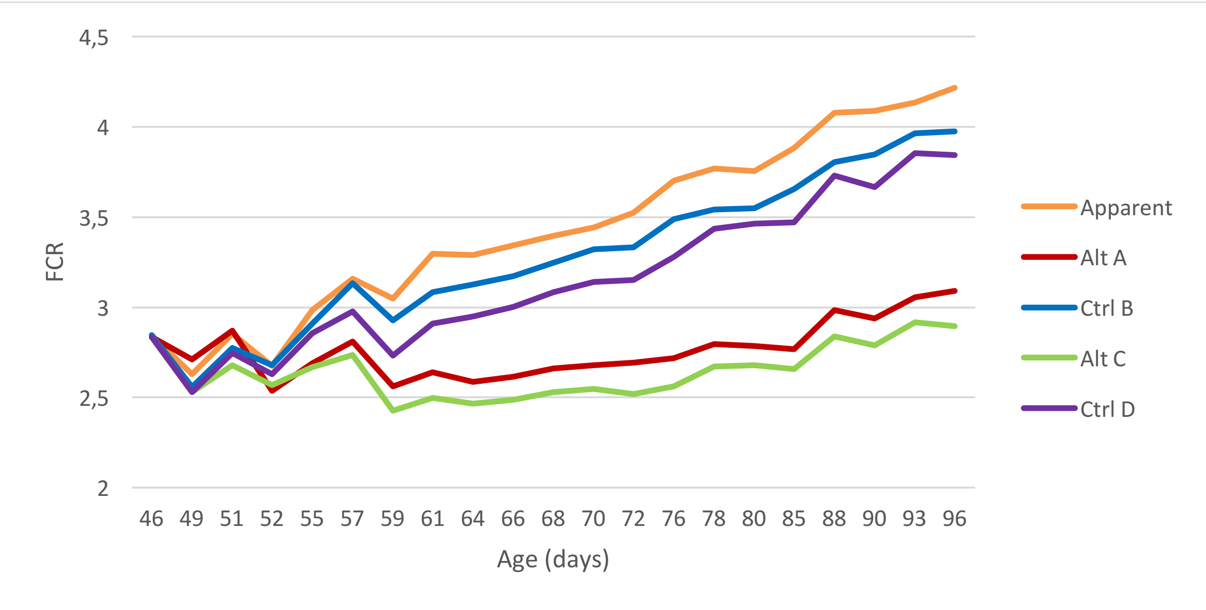

Figure 12. Evolution of the apparent and effective FCR per group, regarding the industrial organic feed only

On day 85, the effective FCR for organic feed of the control group B and D are respectively 3.66 and 3.47, while the alternative group A and C are respectively 2.77 and 2.66. This is good to the Hubbard JA-957 broiler which FCR was 2.85 at 85 days (Hilderink, 2010).
On day 97, the effective FCR for organic feed of the control group B and D are respectively 3.97 and 3.84, while the alternative group A and C are respectively 3.09 and 2.90. This is 30% lower than the control group which is not substantial (fig. 12). Table in appendix 7.

As a reminder, the FCR at the beginning of the experiment on day 46 was 2.84, based on the industrial feed consumption on day 85, the effective FCR has decreased. On day 97 it was in average 2.97 for the alternative groups A and C. The effective FCR increased by 4.4% in 50 days. In contrast, the effective FCR of the control group B and D are in average 3.91, meaning the effective FCR increased 37.5% in 50 days.

Bread crumbs inclusion can make slow-growing dual purpose broiler be competitive in terms of feed conversion compared to highly specialized broiler breed such as the Hubbard. This is a stronger evidence that food-waste inclusion can be valuable in terms of efficiency, thus lowering the costs.

4.6. Feed particle size distribution

4.6.1. Feed given

To get more insights into the feed composition, a granulometric analysis has been conducted to determine the particle size distribution of the industrial organic feed, the bread crumbs pure and the alternative feed with 30% bread crumbs inclusion. The particle size distribution of the organic feed is quite different than of the bread crumbs (fig. 13). Bread crumbs particle are low under 1 mm and quite evenly distributed from 1 mm to more than 4 mm. the organic feed is poor in particle larger than 4 mm and rich in particle bigger than 2 mm. The mix between bread crumbs and organic feed have evenly distributed the particle size and more particle bigger than 4 mm than the control feed.

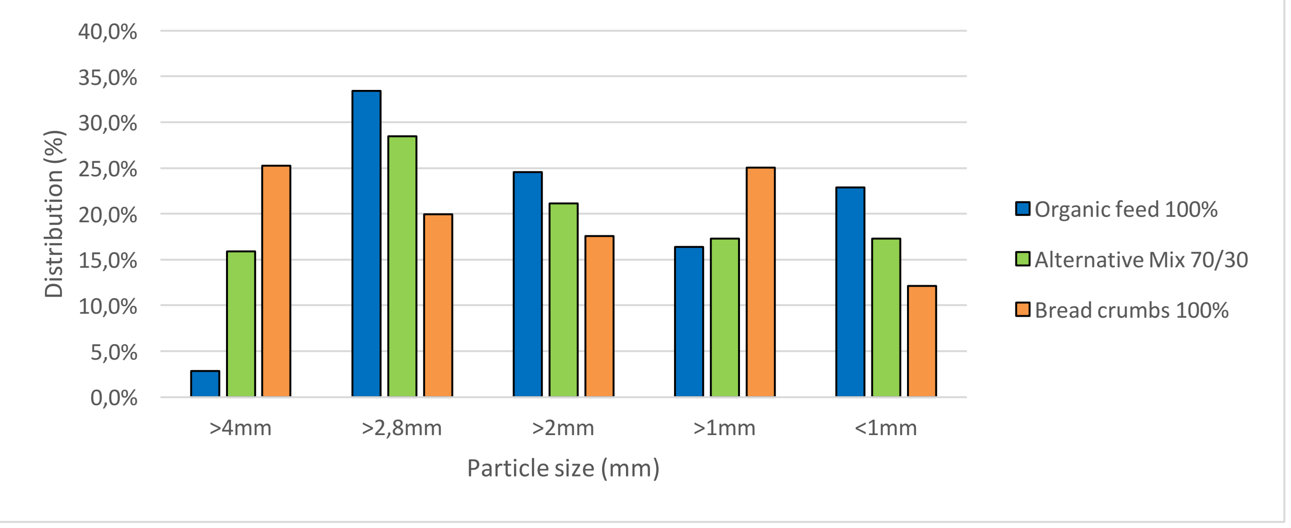

Figure 13.Particle size distribution of the different feed formulation

4.6.2. Feed rejected

To get more accurate data on the feed intake, the feed rejected has been collected, weighed and some samples analyzed to discover the particle size distribution. Over the four groups, a tendency showed up. The broilers of the control group B and D were rejecting much more of the smallest particles and consuming more of the particle from 2 to 4 mm. The alternative group A and C rejected the feed evenly regarding the particle size (fig. 14).

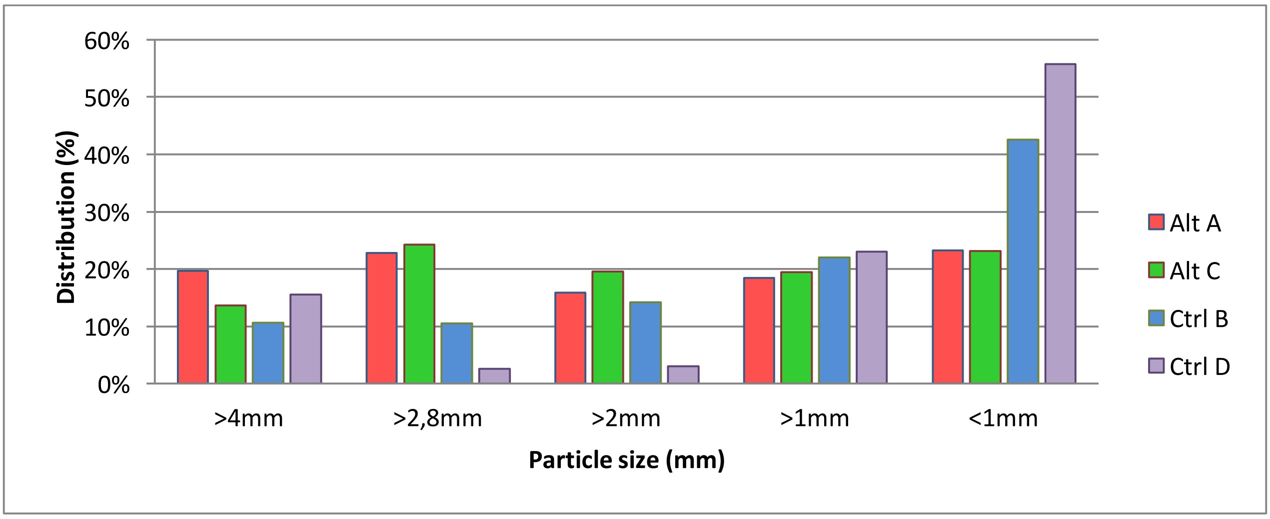

Figure 14.Particle size distribution of the feed rejected per group

Using the particle size distribution and the final feed intake, the feed intake has been calculated regarding the particle size. It shows that the control group B and D rejected mostly the smaller particle <1 mm (fig. 14), however, they consume more of those particle than the alternative groups (fig. 15).

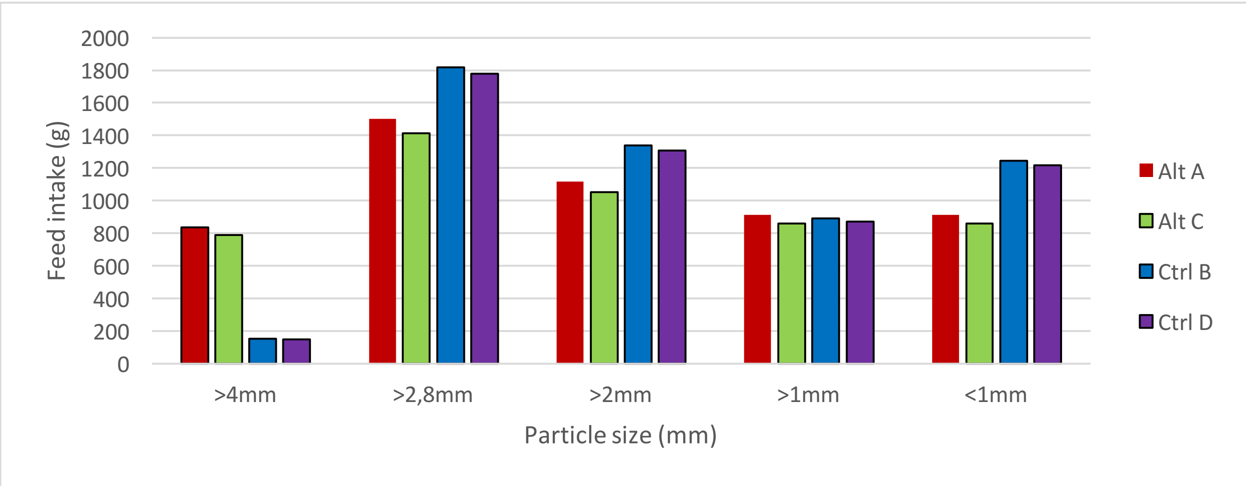

Figure 15..Total feed intake per broiler regarding particle size from day 49 to day 97

Indeed, the alternative group A and C consume more particles bigger than 4 mm, such as the roasted sunflower and pumpkin seeds, both rich in methionine (Piva, 2010; Aguilar et al., 2011). Moreover, bigger particle size feed stimulates the hydrochloric acid, pepsin and mucus secretion in the proventriculus and enhances the grinding action of the gizzard. This also delays the movement in the duodenum up to 3 hours, thus increasing the digestion efficiency of the feed (Hamilton & Proudfoot, 1995; Ruhnke et al., 2015). A hypothesis why the alternative group are rejecting less of the smaller particle size could come from the mixing with the crumbs. The flour from the organic feed would stick to bigger particles from the crumbs (seeds or bread) and be consumed instead of rejected.

4.7. Physio-chemical analysis of the feed

A physio-chemical analysis has been conducted on the different feed sources and regarding the particle size of each feed. The control feed has a lower dry matter (DM) content than the bread crumbs, respectively 87.6% and 91.85%. This may be because of the baking process. The seeds and crusts are roasted in the hoven and lose all their moisture. The alternative diet 70/30 has a DM content of 89.29%. This can be conserved without any process or conditioning.

Table 4. Physio-chemical analysis of the feed

Feed	DM content	N-tot content	Ash-content
Ctrl 100%	87,60%	3,58%	4,80%
Alt 70/30	89,29%	3,49%	4,35%
Crumbs 100%	91,85%	3,12%	3,43%

The N-content corresponds to the Kjehldalh nitrogen content. In protein, the N-content is about 16%, so multiplying the N-content by 6.25 gives an approximation of the crude protein content. The N-content of the control feed is higher than the crumbs with respectively 3.58% and 3.12%, in the alternative feed it is 3.49%. The crude protein content of the control feed is about 22.4%, it is about 19.5% in the crumbs and 21.8% in the alternative feed. This is higher than the 17.6% written in the nutritional value list of this feed (Appendix 2.). This is even higher than the 21.7% of crude protein found in the specialized feed for organic broiler used by Ted Hilderink in 2010. Thus, those values may be overestimated. It can occur because of the error of manipulation during the analysis with small samples. Deeper analysis should be conducted to assess on the nutritional value of the crumbs.

The ash-content in the control feed is 4.80% while it is 3.43% in the crumbs. There are less minerals in the crumbs. In the alternative feed, the ash-content is 4.35%. Those values are lower than the 6.0% ash-content written in the nutritional value list of the feed (Appendix 2).

As the differences in N-content and ash-content did not influence the growth rate, the digestibility of the crumbs may be higher, thus offering less nutrients but that more available. The thermal treatment destroys the anti-nutritional factors and increases the digestibility (Fanatico, 2008; Piva, 2010; Olaiya & Makinde, 2015).

A more accurate physio-chemical analysis has been conducted on N-content and ash-content regarding the particle size of each feed source. Compared to the crumbs, the N-content is higher in the fine particle lower than 2 mm in the control feed, and lower in particles bigger than 2 mm. The N-content in the crumbs is evenly distributed among the different particle size (fig. 16).

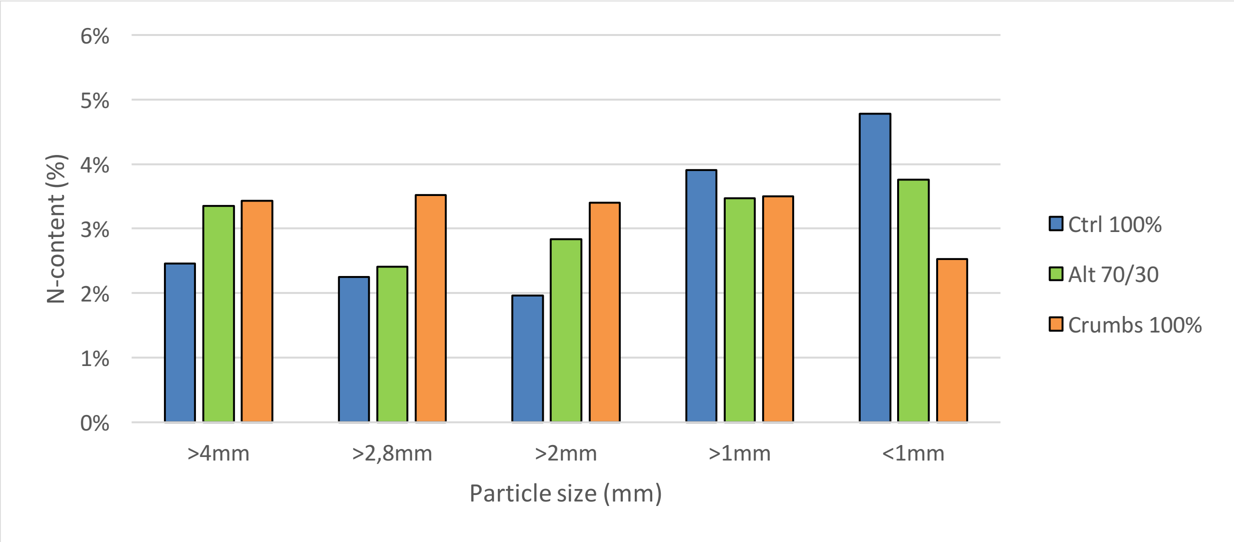

Figure 16. N-content regarding the particle size distribution of each feed source

If compared to the granulometry of the particle rejected, it can be seen that the control group B and D rejected more of the fine particle size (fig. 14), which are the richest part in N-content (fig. 16). The alternative group A and C rejected the feed evenly, and the N-content is also evenly distributed among the particle size. The N-content of the bread crumbs, thus the alternative feed, is higher for the all the particles bigger than 2mm compared to the control feed. This shows that the bigger particles of the bread crumbs, mainly the pumpkin, sunflower, flax and sesame seeds, may contain more nitrogen, thus protein, than the organic feed from Van Gorp.

The ash-content of the control organic feed is higher for each particle size than the crumbs and the alternative feed. As for the N-content, the finest particles of the control feed contain most of the ash-content, up to 10% (fig. 17). These are the particle that are the most rejected by the broilers eating only this feed (fig. 14), the most nutritional part of the feed is wasted. This feed may be not adapted for slow-growing organic farming system, as it contains to many fine particle, which are partially rejected, and not enough big particle over 4 mm. The particle size distribution of the feed rejected should be monitored for each breed to adapt the diet formulation optimally.

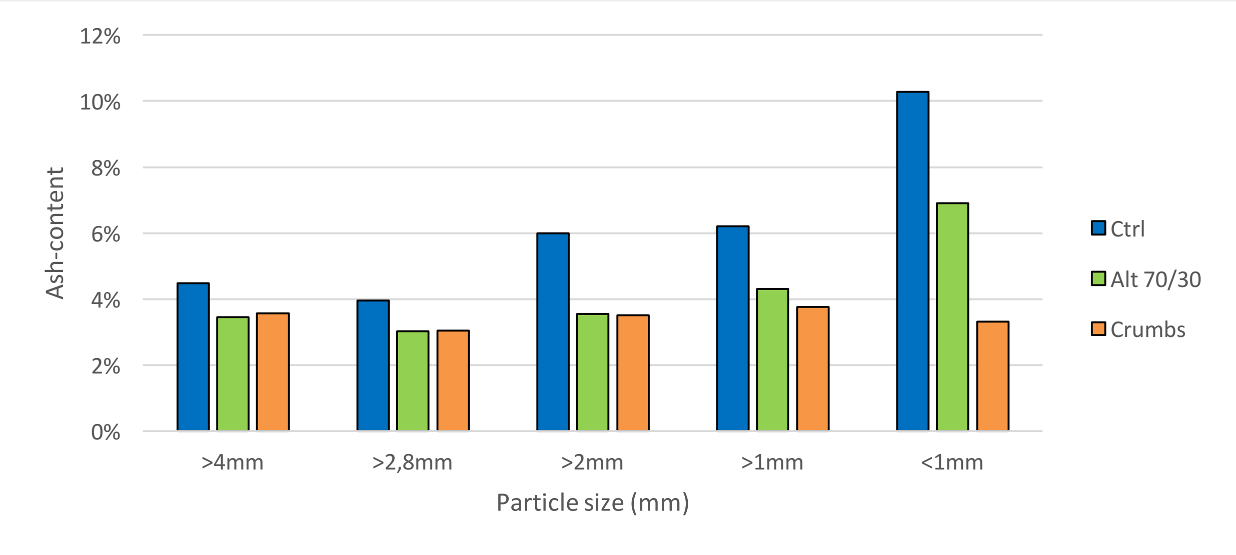

Figure 17. Ash-content regarding the particle size of each feed source

4.8. <u>Economics</u>

A short economic assessment has been conducted for the feed costs. The organic feed costs 0.56€/kg, while the bread crumbs are free. From day 1 to day 85, the apparent cost of the broiler fed only organic feed is 6062 g x 0.56 = 3.39€/ broiler. The effective cost of the control broilers B and D are respectively 3.26€ and 3.27€. The feed rejected represents in average 0.14€/broiler, which is 3.67% of the organic feed cost. On day 85, the effective cost of the alternative broilers A and C is respectively 2.56€ and 2.51€. This represents an economy of 30% per broiler.

On day 97, the apparent feed cost is 7757 g x 0.56 = 4.34€/ broiler. The effective cost of the control broilers B and D are respectively 4.16€ and 4.14€. The feed cost of the control broilers increased by 27% from day 85 to day 97. The feed rejected represents in average

0.20€/broiler, which is 4.82% of the total feed cost. On day 97, the effective cost of the alternative broilers A and C is respectively 3.16€ and 3.12€.

On day 85, the effective feed cost per kilo of live weight of the control B and D are respectively of 1.93€/kg and 1.89€/kg while the alternative A and C are respectively 1.60€/kg and 1.54€. On day 97, the effective feed cost per kilo of live weight of the control B and D are respectively of 2.15€/kg and 2.09€/kg while the alternative A and C are respectively 1.65€/kg and 1.61€/kg. The cost of the alternative broilers after 97 days, is lower than the cost of control broilers even at 85 days. As the feed can represent 70% of the production costs (Catala-Gregori et al., 2009), bread crumbs offer a valuable opportunity to substantially reduce the production costs without influencing the performances for slow growing broilers in organic farming.

5. Conclusions

As a conclusion for this dual purpose experiment. The Vredelinger chickens has underwent a breeding program to increase the growth rate of the broilers so the breed can be dual-purpose. The growth rate increased significantly since the beginning of the experiment. At the 8th generation, the daily average gain is about 25.9 g/ day, with a FCR of 3.6 at 85 days and 3.9 at 97 days. To reach a target live weight of 2.4kg is would take 17 weeks. This is similar to others heavy slow growing breeds; however, it is far from the specialized breed such as the Hubbard JA-957. Regarding the feeding behavior on the organic feed given, the broiler rejected partially the finest particles, which are the richest in nitrogen and minerals. Thus, the feed formulation may not be perfectly adapted for the broilers of the Vredelinger breed. Indeed, this organic feed is designed for chicken from 6 to 17 weeks, hens and broilers together. Other organic feeds, for example the 453 ECO*Vleeskuikenmeel*2, are specially designed for organic broiler growth. Therefore, they should be tested to get more accurate data. The variability in the broiler live weight is high and may cause problem to be slaughtered in standardized slaughter houses.

Regarding the inclusion of bread crumbs at 30% in the diet, the results of this experiment are surprising. No significant effect on the growth rate and the FCR has been assessed for the broilers fed with the alternative feed. The alternative broilers consumed bigger particles, which stimulates the action of the proventriculus and the gizzard, thus enhancing the digestibility of the feed. This may be due to the high content in roasted seeds in the crumbs.

The particles of crumbs bigger than 2 mm are mainly composed with pumpkin, sunflower, flax and sesame roasted seeds. The roasted seeds are highly digestible, rich in nutrients, especially in proteins, which can substitute soybean meal. However, it is supposed that crumbs lack lysine compared to soybean. Regarding the literature, this could be fixed with insect meal inclusion such as black soldier fly larvae.

Using bread crumbs reduces up to a third of the production costs and recycle food waste, that would have otherwise been junked. Regarding arable land used, bakery and feed production are in harsh competition and the prices are volatile.

This diet experiment should be conducted on other breeds reared in organic conditions. A deeper analysis of the nutritional value of the crumbs and of the broiler meat should be implemented to assess any differences, for instance in alpha linoleic acid. Different inclusion rates should also be tested to assess the optimal one.

There are thousands of bakeries in the Netherlands. A part of their waste could be a potential substitute for imported soybean and corn based diet. Chicken production doesn't need much space to be set up, $4m^2$/bird of outdoor access. The Vredelinger dual purpose breed and the use of bread crumbs is an opportunity to boost backyard farming and small scale farming. Generating incomes go beyond the economic interest of organic chicken farming, there are many social benefits that could flow from such initiative.

Communication to the consumers on the recycling use of bakery waste may push them to look for information on chicken production. Nowadays, scandals are hitting the livestock sector. This kind of clean and transparent production may assure the consumers on the premium quality. Some marketing and sensory analysis should be conducted to assess the behavior of consumers in front of this alternative meat.

Bread crumbs as a feed substitute shows again that using agroecological principles, a territory offers many opportunities to close nutrient loops efficiently, thus increasing feed sovereignty and diversity of production.

References

Aguilar Y. M., Yero O. M., Navarro M. I. V., Hurtado C. A. B., Lopez J. A. C., Mejla L. B. G., 2011. Effect of squash seed meal (*Cucurbita moschata*) on broiler performance, sensory meat quality, and blood lipid profile. Brazilian Journal of Poultry Science, 13:219-226

Alleman, F., and B. Leclercq. 1997. Effect of dietary protein and environmental temperature on growth performance and water consumption of male broiler chickens. Br. Poult. Sci., 38:607–610.

Ayanrinde O. J., Owosibo A. O., Adeyemo A. A., 2014. Performance characteristics of broiles fed bread waste based diets. International Journal of Modern Plant & Animal Sciences, 2:1-11

Castellini C., Dal Bosco A., Mugnai C., Bernardini M., 2002. Performance and behaviour of chickens with different growing rate reared according to the organic system. Anim. Sci. Vol.1, 291-300

Catala-Gregori P., Garcia V., Madrid J., Orengo J., Hernandez F., 2009. Inclusion of dried bakery product in high fat broiler diets : effect on pellet quality, performance, nutrient digestibility and organ weights. Asia-Australian Journal of Animal Science, 22:686-693

Cobanoglu F., Kucukyilmaz K., Cinar M., Bozkurt M., Catli A.U., Blintas E., 2014. Comparing the profitability of organic and conventional broiler production. Brazilian Journal of Poultry Martinez Y., Valdivie M., Martinez O., Estarron M., Cordova J., 2010. Utilization of pumpkin (*Cucurbita moschata*) seed in broiler chicken diets. Cuban Journal of Agricultural Science, 44:387-392

Collins K. E., Kiepper B. H., Ritz C. W., McLendon B. L., Wilson J. L., 2014. Growth, livability, feed consumption, and carcass composition of the Athens Canadian Random Bred 1955 meat-type chicken versus the 2012 high-yielding Cobb 500 broiler. Poult. Sci., 93:2953-2962

ECOCERT, 2012. Organic Poultry Farming guideline n°23 : rules for organic poultry production in accordance with EU Regulation (EC) no.834/2007 and (EC) no.889/2008

Fanatico A., 2008. Organic poultry production in the United States, ATTRA – National Sustainable Agriculture Information Service

Farrell D., 2009. The role of poultry in human nutrition – the nutritional benefits of chicken meat compared with other meats. Crops and Food Science, 16:89-96

Grashorn M. A., Serini C., 2006. Quality of chicken meat from conventional and organic production. Research Gate. Hohenheim University

Hamilton R. M. G., Proudfoot F. G., 1995. Ingredient particle size and feed texture : effets on the performance of broiler chickens. Animal Feed Science and Technology, 51:203-210

Hilderink T., 2010. Effects of two levels of supplemental feed on growth performance and foraging behavior of organic broilers housed in mobile ark. Thesis Applied Animal Science. Van Hall Larenstein

Jia W., Slominski B. A., 2010. Means to improve the nutritive value of flaxseed for broiler chickens : the effect of particle size, enzyme addition, and feed pelleting. Poult. Sci., 89:261-269

Küçükyilmaz K., Bozkurt M., Cathi A.U., Herken A.N., Cinar M., Blintas E., 2012. Chemical composition, fatty acid profile and colour of broiler meat as affected by organic and conventional rearing systems. South African Journal of Animal Science, 42:360-368

Mahmoud K. Z., Obeidat B. S., Ishmais M., 2015. Roasted sesame hulls improve broiler performance without affecting carcass characteristics. Italian Journal of Animal Science, 14:494-501

Makkar H. P. S., Tran G., Heuzé V., Ankers P., 2014. State-of-the-art on use of insects as animal feed. Animal Feed Science and Technology, 197:1-33

Mridula D., Kaur D., Singh Nagra S., Barnwal P., Gurumayum S., Kumar Singh K., 2015. Growth performance and quality characteristics of flaxseed-fed broiler chicks. Journal of Applied Animal Research, 43:345-351

Olaiya O. D., Makinde O. J., 2015. Response of broiler chickens fed diets containing differently processed sesame (*Sesame indicum L.*) seed meal. Academic Research Journal of Agricultural Science and Research, 3:13-20

Piva G., 2010. Nutritional value of sunflower seed and sunflower meal for livestock animal. Instituto di Science della Nutrizione, Piacenza, Italy.

Rama Rao S. V., Raju M. V. L. N., Panda A. K., Reddy M. R., 2006. Sunflower seed meal as a substitute for soybean meal in commercial broiler chicken diets. Brit. Poult. Sci., 47:592-598

Renema R., A., 2007. Implications of changes to commercial broiler and broiler breeder body weight targets over the past 30 years. World's Poultry Science Journal, 63:459-472

Rodenburg T.B., Van Harn J., Van Krimpen M.M., Ruis M.A.W., Vermeij I., Spoolder H.A.M., 2008. Comparison of three different diets for organic broilers : effects on performance and body condition. Bri. Poult. Sci., 49:74-80

Ruhnke I., Röhe I., Krämer C., Goodarzi Boroojeni F., Knorr F., Mader A., Schulze E., Hafeez A., Neumann K., Löwe R., Zentek J., 2015. The effects of particle size, milling method, and thermal treatment of feed on performance, apparent ileal digestibility, and pH of the digesta in laying hens. Poult. Sci., 94:692-699

Schader C., Muller A., El-Hage Scialabba N., Hecht J., Isensee A., Erb K-H., Smith P, Makkar H.P.S., Klocke P., Leiber F., Schwegler P., Stolze M., Niggli U., 2015. Impacts of feeding less food-competing feedstuffs to livestock on global food system systainability. *J.R Soc Interface* 12.

Senkoylu N., Dale N., 1999. Sunflower meal in poultry diets : a review. World's Poultry Science Association, 55:153-174

Simiz E., Bogden A. T., Drinceanu D., Stef L., Julean C., Luca I., Simiz F., 2011. Growth paremeters of heavy-breed avian south fed organic system. Animal Science and

Biotechnologies 44-1

Syafwan S., Wermink G. J. D., Kwakkel R. P., Verstegent M. W. A., 2012. Dietary self-selection by broilers at normal and high temperature changes feed intake behavior, nutrient intake, and performance. Poult. Sci., 9:537-549

Ugbesia Igene F., Obiko A., Okoruwa M. A., 2013. Bread and biscuit wastes as alternative dietary energy sources in broiler chicken diets. International Journal of Modern Plant & Animal Sciences, 2:1-11

Van Knegsel A. T. M., Van Krimpen M. M., 2008. Energie- en eiwitbehoefte van biologisch gehouden pluimvee. Rapport 122. Animal Sciences Group. Wageningen UR

Vieira S.L., Lemme A., Goldenberg D.B., Brugalli I., 2004. Responses of growing broilets to diets with increased amino acids to lysine ratios at two dietary protein levels. Poult. Sci., 83:130-1313

Waldroup P. W., 2004. Chickens : Broiler nutrition management. Encyclopedia of Animal Science, 1:208-210

Appendixes

Appendix 1. Brooding temperature recommended at chick's height (Source: Primefacts)

Age (days)	Temperature at chick height (°C)
1	33
2	33
3	33
4	32
7	30
14	26
21	22
28	20

<u>Appendix 2. Feed composition</u> **473.*ECO* OPFOKKUIKENMEEL 2**
Translation : Seth Kyter
Fodder permitted allowed and accepted for organic agricultural usage (834/2007).
Fodder composition:

- Organic agricultural 96%
- In conversion 0%
- Inorganic agricultural 4%
- Agricultural 96.7%

Additional Remarks:
With Eco-social soy and a minimum of 20% regional sources
Manufacture and produced date: 5 month before expiry date

Ingredients
Wheat organic
Corn organic
Soy scatters
Peas organic
Sun seed scatter organic
Alfalfa organic
Triticale organic
Oats organic
Corn gluten flower 59
Wheat semolina organic
Potato protein
Premix
Molasses organic
Small Chalk stones
Monocal phosphate
Sesame scatter organic
Natrium bicarbonate

Nutritional values	
Crude Protein	17.6%
Crude Fat	3.5%
Crude cell substance	0.57%
Crude ashes	6.0%
Calcium	1.0%
Phosphorus	0.57%
Sodium	0.16%
Methionine	0.32%
Lysine	0.80%
OE kcal	2830
Minas gr/kg	176

Nutritional supplements per kg	
Vitamin A (E672)	15000 IE
Vitamin D3 (E671)	3000 IE
Vitamin E	50 mg
Iron(II) sulphate monohydrate E1	70 mg
Iodine(Ca-iodate) E2	1 mg
Copper(II)sulphate penthydrate E4	10 mg
Manganese(II)sulphate E5	60 mg
Zinc sulphate monohydrate E6	50 mg
Selenium(Na-selenite) E8	0.35 mg

Appendix 3. Growth rate table

Age	Liveweight (g)
1	42
5	54
7	63
13	100
15	117
20	171
22	201
26	255
29	295
34	374
38	468
41	526
45	663

Age	Alt A	Ctrl B	Alt C	Ctrl D
46	670	671	669	671
51	784	762	805	814
52	834	857	833	847
55	882	913	904	919
57	889	916	896	941
59	974	1021	979	1055
61	1004	1053	1020	1082
64	1108	1149	1109	1174
66	1158	1197	1163	1227
68	1214	1242	1214	1277
70	1286	1313	1281	1352
72	1321	1348	1331	1405
76	1395	1450	1409	1502
78	1429	1467	1451	1500
80	1508	1542	1527	1568
85	1604	1693	1634	1726
88	1658	1697	1712	1750
90	1722	1766	1743	1814
93	1810	1803	1805	1842
96	1883	1870	1912	1963
97	1919	1939	1934	1979

Appendix 4. Total feed intake par broiler table

Age	Apparent	Alt A	Ctrl B	Alt C	Ctrl D
46	1 785	1 785	1 785	1 785	1 785
49	1 951	1 951	1 951	1 951	1 951
51	2 118	2 118	2 118	2 118	2 118
52	2 118	2 118	2 118	2 118	2 118
55	2 507	2 507	2 507	2 507	2 507
57	2 674	2 674	2 674	2 674	2 674
59	2 840	2 748	2 743	2 677	2 769
61	3 174	2 974	3 016	2 873	3 026
64	3 507	3 253	3 336	3 152	3 336
66	3 729	3 476	3 558	3 374	3 558
68	3 979	3 726	3 808	3 624	3 808
70	4 285	4 031	4 113	3 930	4 114
72	4 507	4 186	4 294	4 068	4 295
76	5 007	4 635	4 766	4 503	4 785
78	5 229	4 857	4 988	4 726	5 007
80	5 507	5 135	5 266	5 003	5 285
85	6 062	5 691	5 821	5 559	5 840
88	6 590	6 218	6 349	6 087	6 368
90	6 868	6 403	6 545	6 223	6 496
93	7 312	6 847	6 989	6 667	6 940
96	7 757	7 231	7 434	7 112	7 385

Appendix 5. Organic feed intake per broiler table

Age	Apparent	Alt A	Ctrl B	Alt C	Ctrl D
46	1 785	1 785	1 785	1 785	1 785
49	1 951	1 951	1 951	1 951	1 951
51	2 118	2 068	2 118	2 068	2 118
52	2 118	2 068	2 118	2 068	2 118
55	2 507	2 340	2 507	2 340	2 507
57	2 674	2 457	2 674	2 457	2 674
59	2 840	2 509	2 743	2 459	2 769
61	3 174	2 667	3 016	2 596	3 026
64	3 507	2 863	3 336	2 792	3 336
66	3 729	3 018	3 558	2 947	3 558
68	3 979	3 193	3 808	3 122	3 808
70	4 285	3 407	4 113	3 336	4 114
72	4 507	3 515	4 294	3 433	4 295
76	5 007	3 830	4 766	3 738	4 785
78	5 229	3 985	4 988	3 893	5 007
80	5 507	4 180	5 266	4 088	5 285

85	6 062	4 569	5 821	4 477	5 840
88	6 590	4 938	6 349	4 846	6 368
90	6 868	5 067	6 545	4 941	6 496
93	7 312	5 378	6 989	5 252	6 940
96	7 757	5 647	7 434	5 563	7 385

Appendix 6. Total Feed Conversion Ratio Table

FCR	Apparent	Alt A	Ctrl B	Alt C	Ctrl D
46	2,84	2,84	2,85	2,84	#DIV/0!
49	2,63	2,71	2,56	2,53	#DIV/0!
51	2,85	2,94	2,78	2,75	2,75
52	2,67	2,60	2,68	2,63	2,63
55	2,98	2,88	2,91	2,86	2,86
57	3,16	3,06	3,13	2,98	2,98
59	3,05	2,81	2,93	2,64	2,73
61	3,30	2,94	3,08	2,76	2,91
64	3,29	2,94	3,13	2,78	2,95
66	3,34	3,01	3,17	2,85	3,00
68	3,40	3,11	3,25	2,94	3,08
70	3,44	3,17	3,32	3,00	3,14
72	3,52	3,20	3,33	2,99	3,15
76	3,70	3,29	3,49	3,08	3,28
78	3,77	3,41	3,54	3,24	3,43
80	3,76	3,42	3,55	3,28	3,46
85	3,88	3,45	3,66	3,30	3,47
88	4,08	3,76	3,80	3,56	3,73
90	4,09	3,71	3,85	3,51	3,67
93	4,14	3,89	3,96	3,70	3,85
96	4,21	3,96	3,97	3,70	3,84

Appendix 7. Organic Feed Conversion Ratio table

Age	Apparent	Alt A	Ctrl B	Alt C	Ctrl D
46	2,84	2,84	2,85	2,84	2,84
49	2,63	2,71	2,56	2,53	2,53
51	2,85	2,87	2,78	2,68	2,75
52	2,67	2,54	2,68	2,57	2,63
55	2,98	2,69	2,91	2,67	2,86
57	3,16	2,81	3,13	2,73	2,98
59	3,05	2,56	2,93	2,43	2,73
61	3,30	2,64	3,08	2,50	2,91
64	3,29	2,59	3,13	2,47	2,95
66	3,34	2,61	3,17	2,49	3,00
68	3,40	2,66	3,25	2,53	3,08
70	3,44	2,68	3,32	2,55	3,14
72	3,52	2,69	3,33	2,52	3,15
76	3,70	2,72	3,49	2,56	3,28
78	3,77	2,80	3,54	2,67	3,43
80	3,76	2,79	3,55	2,68	3,46
85	3,88	2,77	3,66	2,66	3,47
88	4,08	2,98	3,80	2,84	3,73
90	4,09	2,94	3,85	2,79	3,67
93	4,14	3,05	3,96	2,92	3,85
96	4,21	3,09	3,97	2,90	3,84