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# Effects of silage and haylage on feed intake, growth and health in two meat type chicken genotypes

Effekter av ensilage och hösilage på foderintag, tillväxt och hälsa hos två olika matfågel genotyper

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**Abstract**
In this project the effect of grass silage and haylage on feed intake (FI), growth and health of two meat type chicken hybrids, Ross 308 and Rowan Ranger were studied. The study was carried out at the Swedish Livestock Research Center, located in Funbo-Lövsta, Uppsala for a period of 42 days. A total of 30 pens were used, 15 pens for each hybrid with eight birds randomly allocated to each pen. Commercial organic feed for the starter period was given at d1-20 in crumble form whereas a pelleted feed was given for the grower period at d20-42. To study the effect of silage and haylage, 15 percent dry matter (DM) of the commercial feed was replaced with either silage or haylage and compared to birds fed only the commercial feed resulting in three treatment groups namely, the control, haylage and silage. Each treatment was assigned randomly to five pens of each hybrids. The overall FI, silage, haylage and pellet intake, bodyweight (BW), feed conversion ratio (FCR) as well as organ weights were measured, gizzard score, sticky droppings, foot pad and litter quality were assessed.

The result showed that the overall FI and pellet intake were lower for the chickens fed haylage compared to chickens fed silage and control feed. The roughage intake was higher for chickens fed silage than those fed haylage. The BW for the chickens in the control group were greater than the chickens in the silage group, but lowest with the haylage group. The FCR was poorer for chickens fed silage or haylage compared to chickens fed the control feed. In regards to genoype, Ross 308 chickens had a higher FI, pellet intake, silage or haylage intake and BW compared to the Rowan Ranger chickens whereas for FCR, Ross 308 started off poorly but later on was improved and Rowan Ranger chickens showed the opposite. The result on organ weights showed treatment effect only on the gizzard. The chickens fed silage and haylage had a heavier gizzard compared to chickens fed the control feed. In addition, breed effect was present where Rowan Ranger chickens had a heavier gizzard as well as crop, spleen, liver, small and large intestine than the Ross 308 chickens. However, no genotype effect was seen for the heart, bursa and proventiculus weights. Foot pad and litter quality were not influenced by treatment nor genotype. Sticky dropping was not affected by treatment but at d42 a genotype effect showed Rowan Ranger chickens with inferior condition compared to Ross 308 chickens.  Feed treatment had no effect on gizzard score, but a tendency (P= 0.08) of superior condition in Rowan Ranger chickens over Ross 308 chickens was found.

In conclusion, feeding diets with 15 percent inclusion of grass silage or haylage decreased growth performance for both Ross 308 and Rowan Ranger hybrids, with a stronger growth reduction with haylage group. However, both these forages did not have any detrimental effect on health parameters.

**Sammanfattning**
I detta projekt studerades effekten av ge ett foder med inblandning av gräsensilage eller hösilage på foderintag, tillväxt och hälsa hos två olika matfågel genotyper, Ross 308 och Rowan Ranger. Studien genomfördes under 42 dagar på Lövsta forskningscenter, Funbo-Lövta, Uppsala. Kycklingarna sattes in som dagsgamla och hölls i moduler med åtta kycklingar per grupp, totalt 30 moduler användes under försöket, 15 moduler för Ross och 15 för Rowan. Kycklingarna fick ett kommersiellt pelleterat ekologiskt startfoder från dag 1-20 och ett kommersiellt pelleterat ekologiskt tillväxtfoder från dag 20-42. För att studera effekten av ensilage och hösilage ersattes 15% av de kommersiella fodren med ensilage eller hösilage, detta jämfördes mot grupper som endast fick kommersiellt foder. Detta resulterade i tre olika foderbehandlingar, kontroll, ensilage och hösilage som slumpvis gavs till 5 grupper av varje genotyp. Totalt foderintag, ensilage, hösilage och pelletsintag, kroppsvikt, foderomvandlingsförmåga samt organvikter mättes, medan muskelmagserosioner, sticky droppings, fothälsa och ströbäddskvalitet bedömdes. Resultaten visade att totala foderintaget och pelletsintaget var lägre hos kycklingar som fått hösilage än de som fått ensilage eller kontroll. Grovfoderintaget var högre för kycklingar som fick ensilage än de som fick hösilage. Kycklingar som fick kontrollfoder vägde mer än kycklingar som fick ensilage och hösilage, och kycklingarna som fick ensilage vägde mer än de som fick hösilage. Foderomvandlingsförmågan var sämre hos kycklingar som fick ensilage eller hösilage jämfört med de som fick kontroll. Jämförelse av de två genotyperna visade att Ross 308 hade högre totalt foderintag, pelletsintag, ensilage och hösilageintag samt en högre kroppsvikt. För foderomvandlingsförmågan så var den bättre hos Rowan än Ross i början av försöket, men i slutet av försöket var det tvärtom. Resultaten av organvikter visade att det endast fanns en effekt av foderbehandling på muskelmagen med tyngre muskelmage hos kycklingarna som fick ensilage eller hösilage än de som fick kontroll. Effekten av genotyp visade att Rowan Ranger hade tyngre kräva, muskelmage, mjälte, lever, tunn- och tjocktarm än Ross 308, men det var ingen skillnad i vikt mellan genotyperna för hjärta, bursa eller körtelmagen. Fothälsa och ströbäddskvalitet var inte påverkade av foderbehandling eller genotyp. Andelen kycklingar med sticky droppings påverkades inte av foderbehandling, men vid dag 42 sågs en effekt av genotyp, där Rowan ranger hade en högre andel med sticky droppings. Andelen muskelmagar med erosioner påverkades inte av foderbehandling, med det fanns en tendens (P=0.08) av mindre erosioner hos Rowan Ranger än Ross 308.

Slutsatsen av projektet är att ett foder med 15% inblandning av gräsensilage eller hösilage försämrar tillväxten för både Ross 308 och Rowan Ranger. Den negativa effekten på tillväxt var större med hösilage än ensilage, men verken ensilge eller hösilage gav några negativa effekter på de hälsoparametrar som studerades.

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## 1.0 Introduction

The growing consumer demand and preference for organic products have increased organic production in many countries (Blair, 2008) and it may be expected to continue to rise in the upcoming years. An increase in organic production also mean an increase in the number of existing organic farms. Adopting an organic production setting requires farmers to follow and comply with certain requirements and conditions. One of the requirement is providing roughage, fresh or dried fodder or silage in the chickens' daily ration (Blair, 2008). This is done to improve chicken welfare as it serves as a foraging material, keeping the chickens busy and prevent them from performing abnormal pecking behaviour. It is due to this requirement that there is a growing research interest on many plant sources where each plant material and its potential as a feedstuff are evaluated.

There are many plant fiber sources that have been studied in poultry nutrition such as oat hulls and silage to name a few. These fiber sources have been considered as a diluent of the diet and often as an anti-nutritional factor (Mateos et al., 2012). Silage and haylage are products of forage conservation. This process involves fermentation of plant materials from plant sources such as alfalfa, maize and grass. They are made mainly to enable feed all year around especially during winter season when there is limited forage available. This feedstuff is mainly common in diets of ruminants; cows, sheep and in horses (non-ruminant but herbivore) (Müller, 2011; Krämer-Schmid et al., 2016; Razmkhah et al., 2017; Johansen et al., 2018). However, there is also a growing interest in their use as a feed for monogastric animals; pigs and poultry (Ranjitkar et al., 2016; Carrasco et al, 2017; Wustholz et al 2017) especially for those in organic production. In the present study, the use of silage and haylage in broiler nutrition will be explored. Broiler is in the current study defined as young poultry raised for meat production.

Dietary fiber (DF) found in plants, is known to be the major constituent that make up the cell wall. Its role is primarily to protect the plant contents from chemical degradation. Since plant materials are also a major component of animal feed, the presence of DF in the diet, its role and effect on poultry performance have been well studied (Mateos et al., 2012**).** It has been realized that the type of DF present in plant materials varies with plant species and the different types of DF are also known to exert different effects on animals, especially in the gastrointestinal tract (GIT). The fiber types can be classified based on their solubility whereby they are either soluble or insoluble DF (Zimonja et al., 2008; Kalmendal, 2012). Though both fiber types affect the GIT, the insoluble fiber is known to have a more apparent effect on the gizzard whereas the soluble fiber has minimal to no effect on the gizzard. Feed structure also play a role in influencing the GIT where studies reported that coarse particles stimulate the gizzard whereas fine particles do not (Hetland et al., 2004). Nevertheless, particle size can be influenced by the nature of the fiber (Mateos et al., 2012) as well as preparation methods such as pelleting (Zimonja et al., 2008).

Silage produced from alfalfa, maize and other plant sources have been studied in broilers, but to the best of our knowledge there is no information available for studies on haylage. It can be assumed though, that the reason for this would be that some studies may consider haylage as silage but with a different DM content. However, since the DM content of these conservation products are different, it is probably best to separate them and define them accordingly. The information produced from studies on these plant products may not necessary be the same and may vary from study to study depending on the type of forage or plant utilized, animals used, harvesting and processing techniques, and other conditions or factors involved (Fulgueira et al., 2007). In addition to the use of roughage, broiler hybrid is also a factor to consider especially when planning to raise chickens in organic production.

Genetic selection has been conducted in the past to produce animals with certain traits. In broilers, intense selection has been applied on production traits such as feed efficiency and growth rate, which has over the past 50 years increased from 25g per day to 100g per day (Knowles et al., 2008). Even though, there is no fine line that differentiate these modern broiler hybrids, many studies have reported broilers as fast growing, medium growing or slow growing (Steenfeldt and Horsted, 2013; Aviagen, 2014a; Aviagen, 2016; Wallenbeck et al., 2017). Slow growing hybrids such as Rowan Ranger have a maximum growth rate of 45g per day when fed ad libitum (Aviagen, 2016) whereas fast growing hybrids grow at a much faster pace but the downside to the breeding program of fast growing hybrids is due to health complications. A study done by Wilhelmsson (2016) showed that when two different hybrids, the fast growing Ross 308 and the slow growing Rowan Ranger were reared in organic production or for six weeks, Ross 308 had a higher FI compared to Rowan Ranger, their weight increased more rapidly which resulted in higher incidence of leg disorder and mortality. Rowan Ranger chickens were more active than Ross 308 but both hybrids decrease their activity with age (Wallenbeck et al., 2017). In addition, previous studies have shown that by changing the nutritional composition of the diet of a fast-growing hybrid such as Ross 308 reared under organic production setting, the average daily growth rate can be reduced to 61g when fed ad libitum (Eriksson et al.,2010). However, changing the diet may lead to an unbalanced feed with deficiency in some of the nutrients, for instance a lack in essential amino acid which may cause an overconsumption of feed and some nutrients that then are excreted and may harm the environment and the chicken health (Fanatico, 2010; Rezaei et al., 2018).

Though the behavior and performance of the fast and slow growing hybrid, Ross 308 and Rowan Ranger have been reported in earlier studies (Eriksson et al., 2010; Wilhelmsson, 2016; Wallenbeck et al., 2017), data regarding their actual feed intake and performance when provided silage or haylage as a part of their diet is lacking.

The aim of this present study is to measure the intake of silage and haylage and its effects on growth and health parameters in one fast and one slow growing broiler hybrid. It is hypothesized that inclusion of silage and haylage in broiler diets, will stimulate gizzard development and reduce growth rate without causing detrimental effects on health parameters. The effect on growth rate is assumed to be more apparent in Ross 308 chickens than Rowan Ranger.

## 2.0 Literature review

## 2.1 Poultry physiology: The digestive pathway (Figure 1)

### 2.1.1 The beak, mouth and oesaphagus

Sjaastad et al. (2016) stated that because birds lack teeth, they use their beak to first of all peck on feed particles and break them up, then ingest them into their mouth. This action causes tongue movements which allows food to move rapidly backwards in the oral cavity where it is then immediately swallowed. Peristaltic movements then transfer the feed to the crop and down to the proventiculus along the oesophagus.

### 2.1.2 The Crop

The crop acts as a storage area for feed as well as it moisturizes feed prior to grinding and enzymatic digestion further down the digestive tract (Svihus, 2014). Due to the neutral pH in the crop along with the presence of salivary amylase and some bacterial fermentation, starch digestion occurs (Sjaastad et al., 2016).

### 2.1.3 The Proventiculus

The feed also known as ingesta is passed from the crop to the proventiculus known as the glandular stomach, which is where the ingesta is mixed with digestive secretions from the gland cells in the mucosa (Cheeke and Dierenfeld, 2010). These digestive secretions, pepsinogen and hydrochloric acid released in the proventiculus, are used in the same manner as seen in the mammalian stomach (Cheeke and Dierenfeld, 2010). Mucus is released to protect the inner wall of the proventiculus from acid damage (Blair, 2008).

### 2.1.4 The Gizzard

The gizzard is a thick walled highly muscular organ that contains gizzard teeth, which are rods of a hard protein polysacharride that functions the same as the mammalian teeth (Cheeke and Dierenfeld, 2010). The ingesta and enzymes or digestive juices from the salivary glands and proventiculus pass into the gizzard for grinding, mixing and mashing (Jacob and Pescatore, 2015) producing a feed mixture known as chyme.

### 2.1.5 The Small intestine

The chyme is passed from the gizzard and enters the small intestine through the duodenum by gastrointestinal contraction and as most of it is transported, some is refluxed back into the proventiculus, which allows addition of more acid to the chyme (Sjaastad et al., 2016) then returns to the small intestine through the same step. The digestive processes that happens in the small intestine is similar to that in mammals (Cheeke and Dierenfeld, 2010).

### 2.1.6 The large intestine

The large intestine consists of a very short colon with two long caeca. It has very little digestive capacity with some fermentation in the caeca. Reverse peristalsis contractions moves fluids and fine particles from the colon to the caecum (Cheeke and Dierenfeld, 2010). Other functions that the caeca perform include digestion of small food particles, nutrient absorption, production of immunoglobulins and antibodies, microbial action, absorption of water and conversion of uric acid into amino acids as well as they are a site of infection with coccidia, protozoa that causes coccidiosis (Cheeke and Dierenfeld, 2010).

### 2.1.7 The Cloaca

The GIT ends at the cloaca and it is where feces and urine are excreted together. Some backflow of urine into the hindgut may occur by antiperistalsis contractions which lead to enhanced conservation of nutrients. For example, on low protein diets urinary nitrogen is conserved and recycled by this mechanism (Cheeke and Dierenfeld, 2010).

### 2.1.8 The Heart, liver, pancreas, bursa and spleen

All of these organs are crucial in supporting the digestive processes. The heart has four chambers with circulation and function similar to the mammalian heart (Orosz, 2013). The pancreas releases digestive enzymes and bicarbonate to the small intestine, to counter the hydrochloric acid from the proventriculus. Furthermore, the digestive enzymes assist with digestion, primarily protein digestion (Jacob and Pescatore, 2015). The bile released to the small intestine is produced by the liver and stored and released from the gall bladder. The bile is involved in lipid digestion and absorption of fat soluble vitamins A, D, E and K (Jacob and Pescatore, 2015). The bursa is located just above the cloaca (Pendl and Tizard, 2016) and it has a role in immune functions and antibody production (Macwhirter, 2009). The size of the bursa is however reduced as the bird matures (Macwhirter, 2009; Pendl and Tizard, 2016). The bursa is considered as the primary lymphoid organ whereas the spleen is a secondary lymphoid organ and is a site of phagocytosis for senescent or diseased erythrocytes (Powers, 2000).

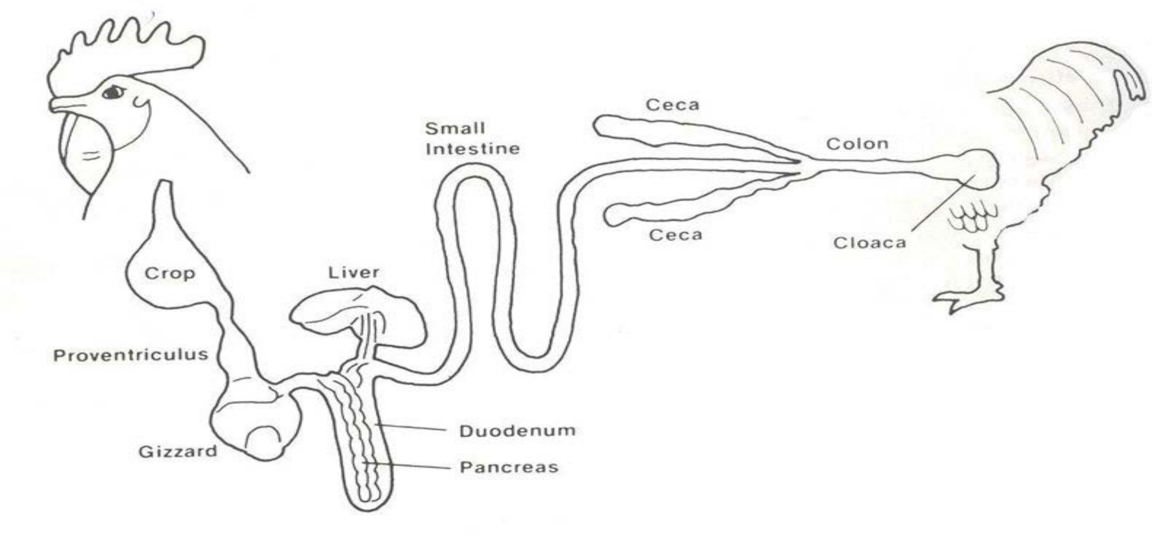


Figure 1: The bird digestive tract. Bird_Gastro_System by ErikBeyersdorf (CC BY-SA 3.0).

## 2.2 Fiber in poultry nutrition

### 2.2.1 Dietary fiber

Dietary fiber (DF) was defined by Trowell (1976) as the residue of plant food resistant to hydrolysis by human alimentary enzymes. However, Macdonald et al. (2011), defined DF as carbohydrates such as polysaccharides, oligosaccharides and the non-carbohydrate lignin, that cannot be digested by monogastric endogenous enzymes in the small intestine, but that may be fermented in the large intestine and promote beneficial physiological effects which will be explained later in the sections of this review.

Polysaccharides make up the bulk of feed carbohydrates. This consist mainly of non-starch polysaccharide (NSP) as well as starch (Choct, 2015). The NSP is divided into three main groups, cellulose which is insoluble in water, non-cellulosic polymers and pectic polysaccharides which are both partially soluble in water (Choct and Kocher, 2000). According to Zimonja (2008) NSP can be classified as either insoluble NSP (insoluble fiber) or soluble NSP (soluble fiber) base on their solubility in water.

### 2.2.2 Fiber analysis

The carbohydrate of the feed can be divided into two fractions, the crude fiber (CF) and the nitrogen free extracts (NFE). The CF content of feed is generally measured by boiling in dilute acid then in dilute alkali. The difference in weight before and after burning is the CF fraction (Henneberg and Stohmann 1859). However, the procedure does not give full representation of the CF in the sample as a proportion of the cell wall material is being dissolved during the process and therefore gives an underestimation of fiber content (Macdonald et al., 2011). Therefore, several other analyze methods for fiber has then been developed and is described by Van soest and Wine (1967). In the method, a dried and ground forage sample is refluxed in a neutral detergent solution, this step solubilizes the proteins and dissolves cell contents (minerals, sugars, starch and pectins). The insoluble residue is known as the neutral detergent fiber (NDF). To get the acid detergent fiber (ADF), NDF is boiled in an acid detergent solution which solubilizes the cell contents as well as dissolve hemicellulose and leaves a residue of lignin, silica and cutin known as ADF.

In addition, methods to determine the NSP and the dietary fiber content have been developed. To be able to distinguish between the insoluble and soluble components of NSP an enzymic chromatographic method is used. The procedure is described by Englyst and Cummings (1984).

### 2.2.3 Fiber and poultry digestion

DF is traditionally regarded as a diluent and an anti-nutritional factor in poultry nutrition (Mateos et al., 2012). In poultry, the fiber in the ingesta follows the normal digestive pathway as described in 2.1. However, fiber have some influence on the digestive processes in poultry especially the function and development of the gizzard. Its impact varies with regards to the particle size and nature of the fiber used (Mateos et al., 2002), and other processes involved in feed preparation such as mashing and pelleting (Engberg et al., 2002).

In the large intestine, anti-peristaltic movements transports the chyme to the paired caeca and as described by Sjaastad et al. (2016) the process is selective as only small particles in the chyme are transported. In the caeca, further fiber digestion through fermentation occurs and volatile fatty acids are produced and absorbed from the caeca to be utilized. The coarser fiber materials are excreted in the faeces.

Over the years, reports have been published on fiber in broiler diet and a great amount of these studies look into insoluble fiber (Gabriel et al., 2003; Hetland et al., 2004; Mateos et al., 2012; Adibmoradi et al., 2016) and its influence whereas some studied soluble fiber (Choct et al., 1996, Langhout, 1998; Hetland et al., 2003). The information provided have shown that these fiber types affect the GIT in different ways. The following section will explain findings from these studies.

#### *2.2.3.1 Insoluble fiber and effects of particle size*

According to Hetland et al. (2004), the physical structure of the insoluble fiber is responsible for stimulating the gizzard. In their study they found that coarse particles accumulate in the gizzard and therefore are retained longer than other nutrients, which causes an increase in the volume of the gizzard contents. In 2005, Hetland and his colleagues reported that diets rich in fiber remain in the upper GIT longer and might be digested more completely, due to enhanced peristalsis and the release of hydrochloric acid and other digestive enzymes. However, Hetland et al. (2004) found that 30 percent of coarse particles were still in the gizzard 48 hours after feeding and suggested that this could have been released down the GIT faster if the gizzard had more contents. This emphasizes the role of a full gizzard in enhancing the grinding effect. A study done by Gabriel et al. (2003) observed an increase in gizzard weight in a group of chickens fed a pelleted protein concentrate, with free choice feeding of whole wheat. They suggested that the increase in gizzard weight observed, was due to the enhanced grinding effect reflected by the increased frequency of gizzard contractions. The increase in gizzard weight is important to allow the gizzard to cope with extra grinding, required when processing coarse particles.

Hetland et al. (2003) reported an increase of bile acids and amylase activity in the gizzard, which implies that an increase chyme reflux occurs between the gizzard and the duodenum. The chyme in this case, may be further grinded in the gizzard and then returned back to the duodenum through the normal pathway. Hetland et al. (2003) mentioned that the presence of the bile acid indicate improvement on nutrient digestibility, as they serve as strong emulsifiers and assist in nutrient solubilisation. This is quite important given that an incomplete emulsification of the dietary lipids, will coat nutrients in the lumen and impair nutrient solubility and digestibility. Gabriel et al. (2003) observed that the greater function of the gizzard leads to less intestinal content as indicated by a lower duodenum weight. Since the release of intestinal enzymes is dependent on the mechanical stimulation of the chyme, that passes through the digestive tract, a reduced mechanical stimulation in this case lowers the release of the intestinal enzymes and therefore a reduced enzyme activity in the intestine.

However, whether an insoluble fiber comes as coarse or fine particle, different effect is observed on the GIT. The fine particles pass through the gizzard immediately after intake (Hetland et al., 2004), making the ingesta less exposed to low pH and proteases and allowing it to appear rapidly in the duodenum as a suspension of relatively unchanged particles. Its immediate transition through the gizzard does not stimulate gizzard effect, an effect which is observed with coarse particles. The ingesta however being relatively unchanged creates a favorable feed substrate for microbes, including *Clostridium perfringens* which is known to be a pathogenic agent of necrotic enteritis (Gabriel et al., 2003). Apart from the coarse and fine fiber particles, Mateos et al. (2012) added that the different nature of plant fiber sources, influences particle size, for instance oat hulls comes in a fusiform shape whereas sugar beet pulp are round. Oat hulls have coarser particles and so when ground using the same screen, they mostly pass through the screen unchanged whereas sugar beet pulp particles become smaller as it passes through the screen. However, Svihus (2011) pointed out that regardless of the nature of the fiber, particles should be larger than 1 mm in order to adequately stimulate gizzard function.

#### *2.2.3.2 Soluble Fiber*

Soluble NSPs have a relatively high water holding capacity and viscosity compared to insoluble NSPs (Smits, 1996). An increased viscosity is believed to have an effect on the digestive processes. In the small intestine a high viscosity will inhibit digestion and absorption (Smits and Annison, 1996). A high viscosity impairs feed utilization which is evident in fat digestion where emulsification, a vital step in the digestion process that requires vigorous mixing of digesta, is not satisfied (Hetland et al., 2003). A slower digesta passage rate that result from a high viscosity will cause microbial proliferation in the intestine (Langhout, 1998).

### 2.2.4 Effects of fiber on poultry feed intake, growth performance and health

#### *2.2.4.1 Insoluble Fiber*

Hetland et al. (2005) showed that birds fed a low fiber diet increased their consumption of litter, which indicate that birds do require a certain amount of fiber in their diet. Mateos et al. (2012) reported that an increase in DF content in the diet reduces FI in poultry, but moderate amounts of two to three percent of insoluble DF provided to birds with a low fiber diet, did not affect voluntary FI.

Adibmoradi et al. (2016) reported that insoluble NSP or insoluble fiber in moderate amount, 1.5 percent inclusion rate, improved body weight gain and FCR and thereby improved chicken performance. Since insoluble fiber induces a faster passage rate of the digesta through the distal part of the GIT due to an increase mechanical stimulation of the gizzard, a higher FI is expected and is observed.

Engberg et al. (2002) mentioned that the feed structure and preparation can influence the effect of the insoluble fiber. In their study they found that pelleted feed compared to grinded feed improved broiler growth rate, which they suggested is linked to increased FI and an improved feed conversion efficiency. Engberg et al. (2002) explained that pelleting may have improved nutrient digestibility since granulation, a feed processing step, further exposes the feed particles to degradation by pancreatic enzymes. Pelleting also reduced digesta viscosity (Engberg et al., 2002).

Mateos et al. (2012) reported that inclusion of insoluble fiber in the young chicks' diet based on high protein soybean meal and corn influenced the development of the GIT, with reduced length of the small intestine, a decrease in the weight of the proventiculus, increase in gizzard weight and gizzard content. These are all indications of improved function of the GIT, but unfortunately these changes often result in reduced carcass yield. Studies have reported an improved bird's health, foot health, pecking behavior and plumage condition with fiber inclusion in the diet (Steenfeldt et al., 2007; Kalmendal et al., 2011; Kalmendal and Tauson 2012).

#### *2.2.4.2 Soluble fiber*

In regards to soluble fiber, the high viscosity in the gut, reduces the apparent metabolizable energy of the diet and depress the growth and feed conversion efficiency of the chickens (Choct et al., 1996). The high viscosity also affects feed intake due to slower passage rate, this slow passage rate causes microbial proliferation in the intestine (Langhout, 1998) which affects the chickens' health and performance.

The water binding effect of soluble fiber causes an increase in water consumption in birds, which may result in increased wetting of the litter, reducing hygiene conditions and therefore increasing the risk of foot pad inflammation (Langhout et al., 1999).

## 2. 3 Ross 308 and Rowan Ranger: hybrid difference and management

The Ross 308 broiler hybrid is known to be robust, fast growing, and feed efficient with a good meat yield whereas the Rowan Ranger though is less feed efficient in comparison, have good meat yield but is rather slower-growing (Wallenbeck, 2017). The management of Ross 308 and Rowan Ranger have been carefully studied over the years and information as well as guidelines have been produced and documented for farmers (Aviagen, 2014a; Aviagen, 2014b and Aviagen, 2016). Studies have been conducted to compare growth, behaviour, health and performance of these hybrids in organic production or semi-organic production and it has been found that the Rowan Ranger is more suitable than Ross 308 for organic production setting (Karlsson, 2015; Wilhelmsson, 2016). These studies along with Wallenbeck et al. (2017) reported that Rowan Ranger in organic production settings are more active than Ross 308 as they have a lower weight gain and live weight and an increased willingness to explore their surroundings. Ross chickens, on the other hand, are less active due to a heavier BW and physical conformation that limits their mobility. A shift to raising slower growing hybrids is an alternative for better poultry welfare in organic production (Steenfeldt and Horsted, 2013; Lindholm et al., 2016).

Tickle et al. (2014) explained that genetic selection on fast growth rates have an effect on the chickens respiratory and cardiovascular system. Genetic selection on fast growth results in a reduced size of organs such as the heart, and the fast growth of the breast muscle causes a slower growth of the oblique muscle, responsible for expiration, and a slower ossification of elements of the respiratory skeleton. This might explain why fast growing hybrids are less suitable than slower growing hybrids, when reared for longer periods.

In the past up until 2014, parent stocks of commercial fast growing hybrids were imported to Sweden and used in both conventional and organic production. The demand for slower growing hybrids at the time was small and keeping the parent stock for this hybrid was considered unprofitable. Therefore, only fast growing hybrids were available and used for organic production in Sweden (Eriksson et al., 2010). Since fast growing hybrids have to be reared for a period up to 81 days according to the Swedish regulation (KRAV 2018) the growth rate needs to be restricted. The welfare concerns on fast growing hybrids and the increase in demand for organic products resulted in that the slower growing hybrid Rowan Ranger became available and is commonly used in organic production in Sweden since 2014.

## 2.4 Silage and Haylage

### 2.4.1 What is Silage and Haylage?

Silage and haylage are both products of forage conservation, whereby grass, legumes or other forage crops are being processed and preserved. This is required mainly to keep and maintain availability of good quality forage crops and grass for animal feed, all year round, which is not always possible naturally due to cold climate experienced in many parts of the globe and other environmental conditions affecting consistent grass and forage growth throughout the year (Müller and Udén, 2007). The lack of good quality pasture available or the lack of desire for animals to graze, are also additional reasons to why silage and haylage are being produced (Harris et al., 2017).

### 2.4.2 Processing of Silage and Haylage

Silage and haylage, are processed in a similar manner whereby forage or grass are first being harvested by cutting and chopping off the grasses in the field mainly by mechanical harvesters. Then wilting is applied to reduce moisture content which is necessary to do to increase DM. Haylage has a higher DM content than Silage. The expected moisture content for haylage should be around 40-50 percent whereas for silage 50-75 percent (Haffey, 2010). However, Schroeder (2013a) stated that in certain cases when the moisture content of silage is high, wilting for a period of 4-6 hours may be applied to silage to achieve the required silage moisture content however, for haylage in such cases would need longer time.

The harvested materials, fresh or wilted are then collected, and transported to a silo or stored at less costly storage facilities such as a pit silo, a large above ground pile or more recently compacted or baled and sealed to avoid spoilage. These sealed bales can be left straight on the ground in the field without the need of storage facilities (Falk, 1971). In the storage facility or sealed bales, oxygen is excluded, and therefore, the plant materials start to ferment under anaerobic conditions, a process whereby bacteria responsible for the fermentation process breaks down fiber, starch and sugars to produce acetic and lactic acid (Haffey, 2010). This rapidly reduces pH levels inside the bale or silo to a pH of 4.5 (Haffey, 2010) or 3.8 to 4.2 (Schroeder, 2013b) which is believed to kill harmful microbes as well as stops further bacterial action. A predominant lactic acid environment in the bale or pile most efficiently drops the pH level, and as such, the faster the fermentation is completed implying that more nutrients will be retained resulting in a high quality product (Schroeder, 2013a&b).

### 2.4.3 Factors affecting silage and haylage quality

In order to produce good quality silage and haylage, factors affecting forage quality has to be taken into account. It is worth noting that according to Fulgueira et al. (2007), there are six major factors affecting forage quality that is, maturity (harvest date), crop species, variety of cultivar, techniques of harvest and storage, environment (moisture, temperature and sunlight) and soil fertility. For instance, Schroeder, (2013b) reported that a delay in harvesting after heads occur in grasses or after the 1/10-bloom stage in alfalfa decrease the quality of the forage as the proportion of fibrous stems increases and the percentage of leaves decreases. The study reported 0.5 percent reduction in crude protein and an increase of 0.7 percent in ADF and 0.9 percent in NDF for each day of delay in harvest. Moreover, the same author reported that the lignin content doubles between the early bud and full bloom. The lignin itself is considered as non-digestible but is also able to bind with other fiber components rendering them non-digestible (Schroeder, 2013a&b).

### 2.4.4 Silage and haylage in poultry nutrition and their effect on animal performance

In 2007, Steenfeldt and others researched the effect of feeding maize silage, barley-pea silage and carrots as supplements on laying hen performance. Their study showed that egg production was high in hens fed either carrots or maize silage whereas hens fed barley-pea silage produced less. Mortality from cannibalism was reduced in the test groups compared to control (no supplement). Ranjitkar et al. (2016) studied effects of different inclusion levels of crimped maize silage (CKMS) in maize based broiler diets and found that the dry matter intake were 7.5 and 6.25 percent higher for broilers fed diets with inclusion of 15 and 30 percent CKMS compared to a control. Moreover, the feed conversion ratio were six and 12 percent lower in the CKMS groups compared to control. The body weight of broilers fed 15 percent CKMS was similar to birds in the control group but the growth rate decreased in birds fed 30 percent inclusion of CKMS. They concluded that CKMS can be included by 15 percent in the diet without any negative effect on broiler growth.

Carrasco et al. (2017) found that broilers can consume up to 30 percent of alfalfa silage of their daily dry matter intake, which improved the proportion of polyunsaturated fatty acids mainly omega-3 and the color of meat was changed. The yellow coloring of the meat and the increased omega-3 content were also reported in studies with layer chickens fed grass or other forage materials either fresh or as silage (Hammershøj and Johansen, 2016). Carrasco et al. (2017) also explored the effect of applied processes on silage through chopping, extrusion or pelleting but found that this had no effect on broiler meat quality.

### 2.5 Sticky dropping, foot pad and litter quality

According to Miles and Johnson (2009) sticky droppings is described as an undesirable gummy consistency of poultry excreta, which may be associated with secondary health problem through respiratory stress from ammonia and coccidiosis. They also mentioned that young birds less than three weeks of age are more susceptible to this feeding disorder. A risk factor for sticky droppings are undigested soluble NSPs that bind with water in the intestinal tract which result in gelatinous droppings that causes fecal matter to stick to the cloacal region of the chickens, dirt and infection in their feet as well as cause damp litter that may increase the risk of diseases (Smits, 1996; Miles and Johnson, 2009).

### 2.6 Gizzard scar

Gizzard scar is observed by a lesion that range from small cracks to severe erosion and haemorrhage. There are several factors that have been reported to be associated with gizzard scar or erosion, and many are related to nutrition such as mycotoxins, copper, biogenic amines, starvation, sulphur amino acid deficiency and fish meal (Contreras and Zaviezo, 2007). Adenovirus may also induce gizzard lesions (Contreras and Zaviezo, 2007). The issue with fish meal arise when the fish is overheated during processing, the histidine or histamine in the meal then react with lysine to form gizzerosine which is ten times as potent as histamine in stimulating acid production by the proventriculus (Contreras and Zaviezo, 2007). A study by Masumara and Sugahara (1984) showed that 6.25mg synthetic gizzerosine/ kg, injected in three day old chicks caused severe gizzard erosions. The impact of gizzard scar was evaluated by Giambrone et al. (2005), they found that about one to five percent of the chicks in the flock had gizzard scars and the affected birds had impaired growth and performance. These affected birds were mostly found to not recover and some were culled.

## 3.0 Materials and Methods

### 3.1 Ethical considerations

Approval was given to perform the research and conduct experimental procedures by the Ethical Committee of Uppsala region and in accordance with the regulations of Swedish animal welfare. ID number: 5.8.18-16271/2017.

### 3.2 Experimental design

The 42 days long study was carried out at the Swedish Livestock Research Center, located in Funbo-Lövsta, outside Uppsala. Two different hybrids of broiler chickens were used and the trial was divided into two subgroups, the fast-growing Ross 308 chickens and the slow-growing Rowan Ranger. There were 15 pens (1.5×0.75 m) used for each subgroup and each pen housed eight chickens. Within each subgroup the three treatment groups silage, haylage and control were randomly assigned resulting in five replicate pens per treatment for each hybrid. The chickens were allocated to their respective pen randomly as day old. Two focal birds from each pen were randomly selected and tagged. The tagging was done using a tagging gun and a paddle fastener with number tags were used inserted by piercing a hole subcutaneously around the dorsal neck area of the birds. Each pen was equipped with a bell drinker (Figure 2) and a feeder (metal plates at the starter stage; Figure 2, and metal troughs at grower stage; Figure 3). Wood shavings were used as bedding material and fresh litter was provided every week after litter scoring.

The house temperature was regulated accordingly by normal routines at Lövsta research facility (Table 1). For the first two days, light was provided for 24 hours, day three to eight, the light was turned off for one hour and from eight to 42 days, six hours of darkness was provided per 24 hours. The birds' body temperature was checked at the beginning of the trial to ensure that the house temperature was in accordance with the need of the chickens.

Figure 2. Metal plate feeder at starter phase (+ bell drinker)

Figure 3. Metal trough (grower phase)

Table 1: Temperature throughout the experimental period

| Age of birds | Temperature |
|---|---|
| **0** | 33 |
| **3** | 32 |
| **6** | 31 |
| **9** | 29.7 |
| **12** | 27.2 |
| **15** | 26.2 |
| **18** | 25.0 |
| **21** | 24.0 |
| **24-42** | 23.0 |

### 3.3 Feed
The chickens in the control group were fed according to the estimated feed intake in the performance objective for Rowan Ranger and Ross 308 (Aviagen, 2014b; Aviagen, 2016) but this was modified for the silage and haylage group whereby 15 percent DM of feed was replaced by silage and haylage.

The starter phase was between day 0-20, and the grower phase from day 20 until the end of the experiment at day 42.

#### 3.3.1 Control group
The control chickens were fed a commercial complete organic crumble starter diet and pelleted grower diets (Lantmännen, Sweden; table 2). The feed residues for each week from each pen were collected in a bag and weighed. The weight of an empty bag was recorded at the start of the trial to get a correct weight of feed residues during the experiment.

#### 3.3.2 Experimental groups
The commercial feeds were mixed with haylage or silage and fed as total mixed ratio (TMR). In the TMR silage or haylage was included with 15 percent of the expected DM intake. The chickens were fed ad libitum throughout the experiment. The feed residues from the silage and haylage groups were collected daily in bags on pen basis and the weight of each bag was recorded. The feed residues were pooled for each week and stored in an uninsulated room until further processing. The feed residues were later separated using a Penn state separator with mesh size, 2 mm. The weight of separated crumbled and pelleted feed, silage or haylage were recorded.

#### 3.3.2 Silage and haylage
The silage and haylage were produced at a farm 40 km outside Uppsala, from a grass type known as Libra 11. This grass seedling was sowed in spring and the harvest was from the third year. Grass for silage was harvested on the 26$^{th}$

September with an initial DM of 34%, wilted, inoculated with $10^8$ *Lactobacillus Plantarum* LP256 per gram and baled (16 layers of wrap). From the same field, grass for haylage was harvested on the 28th September and wilted to 60% DM before it was baled, no inoculum was added. Both Silage and Haylage were ensiled for 11 weeks before they were chopped to 5-10cm and repacked in vacuum bales. These bales were then delivered to the Swedish University of Agricultural Sciences (SLU) where they were opened and further shredded to an approximate length of 0.5 to 1.0cm using a meat grinder and repacked to 1 kg bags, vacuumed and sealed by Genzo ProPack V4 machine.

### 3.4 Water

Water was provided ad libitum in three-liter bell drinkers. The water intake was estimated as the difference between the amount of water provided and the residues on a daily basis. The water measurement was carried out on two randomly selected pens for each combination of hybrid and feed treatment implying a total of six water measurements daily for each hybrid.

### 3.5 Growth, sticky droppings, foot pad scoring and mortality measurements

The chickens were weighed on pen basis on arrival (initial weight) and from then on weighed once every week to monitor growth performance. Sticky droppings present around the cloacal region or on the feathers around the area were scored at days seven to 42, by counting the number of chickens having sticky droppings per pen. At the end of the experiment, the foot pad of the focal birds for both hybrids were examined following a procedure from Ekstrand et al. (2010) with a scoring of 0 to 2 (0 = no lesion, 1 = mild lesion, 2 = severe lesion). Mortality was recorded daily and for each dead chicken, the date of death, pen number and weight was recorded.

### 3.6 Litter quality

Litter quality was judged at d28 to 42. This was done by dividing each pen into four parts and scoring each part on a scale of 1 to 5 (1= dry and 5 = wet or sticky litter).

### 3.7 Organ measurements

At the end of the trial, the focal birds were killed by injecting 2 ml of diluted sodium pentabarbitone intravenously. Each focal bird was dissected and the organs were weighed. The crop, heart, spleen, bursa and proventiculus were weighed with content whereas gizzard, small intestine and large intestine were weighed with and without content. The inner surface of the empty gizzard was evaluated on a scale of 1 to 4 for gizzard scar (1= poor condition, 4 = good condition; Figure 4).

### 3.8 Chemical composition analysis

The proximate analysis of the starter diet, grower diet and the haylage and silage were performed at the Department of Animal Nutrition and Management, SLU. DM was determined by drying at 103°C for 16 h, ash after ignition at 600°C for 3 h (Jennische & Larsson, 1990), crude protein (nitrogen × 6.25) was determined by the Kjeldahl method (NMKL, 2003), crude fiber was determined according to Jennische and Larsson (1990) and ether extract according to The Official Journal of European Communities (1998). Starch including maltodextrines, free glucose and fructose and water soluble carbohydrates were analysed with an enzymatic method where the starch was degraded with amylase (also amyloglucosidase) and analysed as glucose, the free glucose is substracted and is not included in the starch. This method was described by Larsson and Bengtsson (1983). In addition, the amino acid compositions of the starter and grower diets were analyzed at Eurofins laboratory according to US ISO 13903:2005.

### 3.8 Calculations

The FI, silage or haylage intake, pellet intake, accumulated FI, accumulated silage or haylage intake, BW, body weight gain (BWG) and FCR were all measured in grams and on a group basis and thereafter an average per bird was calculated. FI was measured by subtracting the weight of the feed residue from the weight of the feed provided. The silage or haylage and pellet intake were provided as individual weights after separation from the pooled sample. The accumulated FI, silage or haylage and pellet intake, were calculated by adding continuing weights on to previous weights. For instance, accumulated FI for d14 resulted from the total FI of week 7 and 14 whereas d21 resulted from a total FI at d7, 14 and 21. It should be noted though that FI at d7 remained the same as accumulated FI for d7. BW was measured once per week and BWG was calculated by subtracting the weight from each week with initial weight measured on the first day the chickens arrive. For example, BWG at d14 resulted from BW d14 minus initial BW and BWG for d21 was due to subtracting BW at d21 with initial BW. The FCR for each week was calculated by dividing weight of feed with BWG. To calculate energy on commercial feed (starter and grower), the following formula was used; Metabolizable energy (MJ/KG) = 0.1551 x % CP + 0.3431 x % crude fat + 0.1669 x % starch + 0.1301 x % total sugar expressed as sucrose (Swedish Board of Agricultural, 2006) and energy calculation for silage and haylage followed a formula from Janssen (1989); AMEn (KJ/Kg) = 8.115 x Crude protein + 12.42 x Crude fat (Janssen, 1989). The result was later divided by 1000 to convert the KJ/Kg unit to MJ/Kg.

### 3.8 Statistical analysis

All data provided were statistically analyzed using the software (SAS) version 9.4. The effects of treatment, hybrid and their interaction on FCR, FI, body weight and relative organ weights were investigated using Proc Mixed with the following model.

$y_i = \mu + \text{treatment} + \text{breed} + \text{treatment*breed} + e$,

In this model, the class variables were treatment and breed, and random variable was the pen number. Sticky droppings, expressed as percentage of birds per pen, was arc sin transformed before analyzed since the data did not have a normal distribution and was then analyzed with the same model as the other data.

Gizzard score was analyzed using the Proc Glimmix procedure (logistic regression) and presented as mean values in the results section. In the logistic regression, score 4 in the scoring of gizzards was relabeled to “1” and scores 1, 2 and 3 were relabeled to “0”.

# 4.0 Results

## 4.1 The composition of feed

The composition of the commercial feed (table 2 and 3), silage and haylage (table 4) are presented in percentage as fed basis. The silage had a lower DM content than the haylage, which when expressed on as-fed basis resulted in a lower content of all analysed components. The differences in chemical composition of the commercial feed, the silage and haylage, especially the high crude fiber content of silage and haylage, had an influence on energy content.

Table 2: Ingredients in the commercial starter and grower feed (Lantmännen, Sweden)

| INGREDIENTS | STARTER | GROWER |
|---|---|---|
| Wheat | 67 | 62 |
| Oats | . | 12 |
| Barley | . | 3 |
| Soy expeller | 14 | 7 |
| Fishmeal | 7 | 7 |
| Rapeseed cake | 4 | . |
| Potato Protein | 3 | 2 |
| Maize Gluten meal | 2 | . |
| Rapeseed | . | 2 |
| Malt sprouts | . | 3 |
| Minerals, salt and vitamins | 3 | 2 |

Table 3: The chemical composition of the commercial starter and grower feed (in % as fed basis)

| Nutrients | Analysed values | | Optimised (calculated) values | |
|---|---|---|---|---|
| | **Starter** | **Grower** | **Starter** | **Grower** |
| DM | 89.1 | 89.1 | . | . |
| Ash | 5.02 | 4.8 | . | . |
| Crude protein | 22.5 | 20.5 | 21.2 | 19.4 |
| Crude fiber | 3.6 | 3.6 | . | . |
| Ether extract | 3.5 | 3.5 | . | . |
| Water soluble carbohydrates | 2.7 | 2.2 | . | . |
| Free glucose+fructose | 0.1 | 0.2 | . | . |
| Starch including maltixrides | 41.4 | 43.0 | . | . |
| Metabolisable energy (MJ/Kg)* | 11.6 | 11.6 | 12.3 | 12.3 |
| **Amino acid** | | | | |
| Alanine | 1.1 | 0.9 | . | . |
| Arginine | 1.3 | 1.0 | . | . |
| Asparagine | 1.9 | 1.6 | . | . |
| Cysteine+ cysteine | 0.4 | 0.3 | . | . |
| Glutamine | 4.6 | 3.9 | . | . |
| Glycine | 1.1 | 0.9 | . | . |
| Histidine | 0.5 | 0.4 | . | . |
| Hydroxiproline | <0.05 | <0.05 | . | . |
| Isoleucine | 0.9 | 0.7 | . | . |
| Leucine | 1.7 | 1.4 | . | . |
| Lysine | 1.2 | 1.0 | 1.2 | 1.1 |
| Methionine | 0.5 | 0.4 | 0.4 | 0.4 |
| Ornithine | <0.01 | <0.01 | . | . |
| Phenylalanine | 1.1 | 0.9 | . | . |
| Proline | 1.6 | 1.3 | . | . |
| Serine | 1.1 | 0.9 | . | . |
| Threonine | 0.9 | 0.7 | 0.9 | 0.8 |
| Tyrosine | 0.8 | 0.7 | . | . |
| Valine | 1.1 | 0.9 | . | . |
| Methionine + cysteine | . | . | 0.8 | 0.7 |
| **Other** | | | | |
| Calcium | . | . | 0.8 | 0.8 |
| Phosphorus | . | . | 0.6 | 5.5 |
| Sodium | . | . | 0.2 | 1.6 |
| Linoleic acid, C18:2 | . | . | 0.1 | 2.1 |

*Calculated

Table 4: The chemical composition of silage and haylage (in % as fed basis)

| Nutrient | Silage | Haylage |
|---|---|---|
| DM | 45.0 | 71.5 |
| Ash | 3.6 | 6.4 |
| Crude protein | 4.8 | 7.7 |
| Crude fiber | 11.4 | 18.6 |
| Ether extract | 1.5 | 1.6 |
| Water soluble carbohydrate | 4.9 | 8.2 |
| Free glucose + fructose | 3.3 | 6.4 |
| Starch | 0.6 | 0.9 |
| Calculated Metabolisable energy (MJ/Kg) | 0.6 | 0.8 |

### 4.2 Relative organ weights

The relative organ weights for both hybrids and dietary treatments are presented in Table 5. The result showed that the relative organ weights for all organs except the heart, bursa and proventriculus were significantly higher for Rowan Ranger than Ross 308. Dietary treatments had a significant effect on the relative weight of the full and empty gizzard, with significant higher weights in haylage and silage groups compared to the control group. No other significant difference in organ weights between the experimental diets were observed. A tendency effect of dietary treatment was observed on the relative weight of crop. There were no significant interactions between treatment and hybrid, but there was a tendency to interaction for weight of the crop.

Table 5: Relative weight of organs (in % of body weight), standard error of means (SEM) and p-values

| Organ | Ross | Rowan | Dietary treatment | | | SEM[1] | | P-values | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | C[5] | H[6] | S[7] | B | T | T[2] | B[3] | T*B[4] |
| Crop full | 1.5 | 3.8 | 2.0 | 2.8 | 3.2 | 0.6 | 0.7 | 0.060 | 0.003 | 0.069 |
| Gizzard full | 2.8 | 4.3 | 3.1 [B] | 3.8 [A] | 3.7 [A] | 0.4 | 0.4 | 0.026 | <0.001 | 0.131 |
| Gizzard empty | 1.8 | 2.8 | 2.1 [B] | 2.5 [A] | 2.4 [A] | 0.2 | 0.3 | 0.029 | <0.001 | 0.115 |
| Intestine | 7.1 | 9.3 | 7.6 | 8.8 | 8.1 | 0.9 | 0.9 | 0.144 | 0.030 | 0.753 |
| Heart | 0.7 | 0.7 | 0.7 | 0.6 | 0.7 | 0.04 | 0.1 | 0.550 | 0.966 | 0.902 |
| Spleen | 0.2 | 0.3 | 0.2 | 0.2 | 0.2 | 0.03 | 0.03 | 0.500 | <0.001 | 0.356 |
| Liver | 2.4 | 3.3 | 2.9 | 2.7 | 2.9 | 0.1 | 0.1 | 0.455 | <0.001 | 0.540 |
| Bursa | 0.3 | 0.4 | 0.3 | 0.3 | 0.3 | 0.1 | 0.1 | 0.320 | 0.173 | 0.878 |
| Proventriculus | 0.5 | 0.5 | 0.5 | 0.5 | 0.5 | 0.04 | 0.04 | 0.334 | 0.121 | 0.067 |
| Small Intestine (SI) | 9.5 | 14.5 | 11.7 | 12.2 | 12.1 | 1.1 | 1.1 | 0.704 | <0.001 | 0.189 |
| Large intestine (LI) | 2.5 | 3.6 | 3.0 | 3.1 | 3.0 | 0.3 | 0.3 | 0.952 | 0.007 | 0.118 |
| SI empty | 2.8 | 3.5 | 3.0 | 3.3 | 3.1 | 0.3 | 0.3 | 0.241 | 0.013 | 0.507 |
| LI empty | 0.6 | 0.8 | 0.7 | 0.7 | 0.7 | 0.1 | 0.1 | 0.926 | 0.023 | 0.803 |

[1]Standard error mean, [2]treatment, [3] breed, [4] treatment and breed interaction [5] Control [6]Haylage [7]Silage
[AB]Least square means within the same row (for Dietary treatment) with different superscripts were significantly different ($P < 0.05$).

### 4.3 FCR, BW and FI

The average initial weight for Ross 308 was 32g and where sourced from mothers that were 26 weeks whereas Rowan Ranger had an average initial weight of 38g and were sourced from mothers of 38 weeks. The lower weight for Ross 308 was assumed to result from having young parents. Table 6 presents information on FCR, BW and FI on both hybrids. The data showed a significant treatment effect on FCR at d21, 35 and 42 and a tendency to effect at d28 were observed between the experimental diets and the control. FCR was higher in the haylage and silage groups within respective hybrid, compared to the control. No significant effect was present for d7 and 14 or between the experimental diet groups. A significant effect of breed on FCR was present at d14, 35 and 42. At d14 Ross had a higher FCR than the Rowan group but at d35 and 42 Ross had lower FCR than Rowan. An interaction effect was present at d7 where Ross 308 chickens receiving control feed had a lower FCR than Ross 308 chickens receiving haylage and Rowan chickens receiving the control feed. Moreover, Ross 308 fed haylage had a higher FCR than Rowan Ranger fed haylage whereas there was no effect of diet within the Rowan Ranger chickens.

Treatment effect on FI was significant at all ages. The differences observed were due to a lower FI in haylage groups than in the silage and control groups. There was no difference in FI between the control and silage groups. At d7 the FI was not significantly different between hybrids. From d14 to 42 the FI was significantly higher for Ross 308 than for Rowan Ranger. An interaction effect for FI was observed at d21 where FI was higher in Ross 308 control and Ross 308 silage compared to all other combinations of hybrids and treatments.

The BW was significantly affected by the treatment at d7, 21, 28, 35 and 42 and a tendency was shown at d14. Until d35 the observed effect was due to a lower BW for birds in the haylage groups than the silage and control. However, at d42 BW was significantly higher in chickens on control diet compared to the other treatments, and chickens feed silage diet had a higher BW than chickens fed haylage diet. Hybrid also had a significant effect at d7, 21, 28, 35, and 42. At d7 the Rowan Ranger group had a higher BW compared to the Ross 308 group and at d14 no breed effect was observed. However, starting at d21 up until d42 the Ross 308 group showed a higher BW compared to Rowan Ranger.

An interaction effect on BW was observed at d7, 21, 28 and 35. At d7, it was due to that the Ross 308 haylage group had a lower BW compared to all other treatment groups. At d21 and d28 no significant difference was observed between Ross 308 control group and Ross 308 silage group however, both these groups had a significant higher BW than the other groups. At d35, there was significant differences between treatment groups within the Ross 308 hybrid with the control group exhibiting the highest BW, followed by Ross 308 silage and then Ross 308 haylage. However, within the Rowan Ranger group, the BW in all treatment groups were lower than in Ross 308, and there was no difference on BW between the treatment groups.

Table 6. Weekly broiler chicken production performance, FCR, BW, FI. Standard error of mean (SEM) and p-values

| Item | Ross | | | Rowan | | | | P-values | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | H | S | C[5] | H[6] | S[7] | SEM[1] | T[2] | B[3] | T*B[4] |
| **FCR** | | | | | | | | | | |
| D7 | 1.7$^{c}$ | 2.1$^{a}$ | 1.8$^{abc}$ | 2.0$^{ab}$ | 1.7$^{bc}$ | 1.8$^{abc}$ | 0.1 | 0.762 | 0.650 | 0.011 |
| D14 | 2.2 | 2.4 | 2.2 | 2.0 | 1.9 | 1.9 | 0.1 | 0.722 | <0.001 | 0.318 |
| D21 | 1.7$^{B}$ | 1.9$^{A}$ | 1.8$^{A}$ | 1.8$^{B}$ | 1.9$^{A}$ | 1.9$^{A}$ | 0.1 | 0.011 | 0.312 | 0.117 |
| D28 | 1.8 | 1.9 | 1.8 | 1.9 | 1.9 | 1.9 | 0.1 | 0.093 | 0.403 | 0.207 |
| D35 | 1.6$^{B}$ | 1.8$^{A}$ | 1.8$^{A}$ | 1.9$^{B}$ | 1.9$^{A}$ | 2.1$^{A}$ | 0.1 | <0.001 | <0.001 | 0.232 |
| D42 | 1.7$^{B}$ | 1.8$^{A}$ | 1.8$^{A}$ | 1.9$^{B}$ | 2.0$^{A}$ | 1.8$^{A}$ | 0.1 | 0.027 | 0.001 | 0.940 |
| **FI (in grams)** | | | | | | | | | | |
| D7 | 116$^{A}$ | 106$^{B}$ | 130$^{A}$ | 119$^{A}$ | 107$^{B}$ | 121$^{A}$ | 4.3 | <0.001 | 0.639 | 0.407 |
| D14 | 494$^{A}$ | 396$^{B}$ | 496$^{A}$ | 382$^{A}$ | 349$^{B}$ | 382$^{A}$ | 15.0 | <0.001 | <0.001 | 0.054 |
| D21 | 980$^{a A}$ | 758$^{b B}$ | 986$^{a A}$ | 737$^{b A}$ | 735$^{b B}$ | 781$^{Ba}$ | 44.3 | 0.012 | 0.001 | 0.045 |
| D28 | 1818$^{A}$ | 1389$^{B}$ | 1669$^{A}$ | 1344$^{A}$ | 1271$^{B}$ | 1344$^{A}$ | 74.2 | 0.008 | <0.001 | 0.076 |
| D35 | 2738$^{A}$ | 2376$^{B}$ | 2809$^{A}$ | 2108$^{A}$ | 2028$^{B}$ | 2146$^{A}$ | 101.6 | 0.029 | <0.001 | 0.255 |
| D42 | 4134$^{A}$ | 3411$^{B}$ | 3970$^{A}$ | 3157$^{A}$ | 2924$^{B}$ | 3061$^{A}$ | 138.0 | 0.006 | <0.001 | 0.180 |
| **BW (in grams)** | | | | | | | | | | |
| D7 | 102$^{aA}$ | 82$^{Bb}$ | 103$^{aA}$ | 100$^{Aa}$ | 102$^{Ab}$ | 106$^{aA}$ | 3.5 | 0.003 | 0.019 | 0.009 |
| D14 | 258 | 198 | 256 | 235 | 231 | 248 | 15.7 | 0.053 | 0.977 | 0.204 |
| D21 | 627$^{aA}$ | 443$^{bcB}$ | 579$^{acA}$ | 463$^{bA}$ | 452$^{Bb}$ | 484$^{bA}$ | 29.5 | 0.006 | 0.002 | 0.024 |
| D28 | 1059$^{aA}$ | 761$^{bB}$ | 971$^{aA}$ | 776$^{bA}$ | 729$^{Bb}$ | 773$^{bA}$ | 40.6 | <0.001 | <0.001 | 0.016 |
| D35 | 1793$^{aA}$ | 1352$^{cB}$ | 1580$^{bA}$ | 1166$^{dA}$ | 1090$^{dB}$ | 1073$^{dA}$ | 55.8 | <0.001 | <0.001 | 0.011 |
| D42 | 2509$^{A}$ | 1960$^{C}$ | 2256$^{B}$ | 1785$^{A}$ | 1578$^{C}$ | 1648$^{B}$ | 72.7 | <0.001 | <0.001 | 0.078 |

[1]Standard error mean, [2]treatment, [3] breed, [4] treatment and breed interaction [5] Control [6]Haylage
$^{abc}$=Least square means within the same row (for interaction) with different superscripts were significantly different ($P < 0.05$). $^{ABC}$ = Least square means within the same row (for Dietary treatment) with different superscripts were significantly different ($P < 0.05$).

## 4.4 Silage, haylage and pellet intake

Table 7 presents information on silage, haylage and pellet intake of both hybrids. The result showed that treatment effect was significant from d7 until d42. The difference observed showed that roughage intake was higher when provided as silage than as haylage. At d7 the Rowan Ranger groups had a higher silage and haylage intake than the Ross 308 groups, whereas no hybrid effect was observed for d14 and 21. However at d28 up until d42, Rowan Ranger chickens had a lower silage and haylage intake compared to Ross 308. At d28, 35 and 42, Ross 308 silage had a higher intake than Rowan Ranger silage which both had higher intake than the haylage groups. For pellet intake presented in table 7 showed that d7 to 42 chickens receiving the haylage diet had a lower pellet intake than the control and silage groups. No significant difference was observed between the silage and the control groups. At d7, the chickens showed no significant difference on pellet consumption between the hybrids. From d14 to d42 Ross 308 had a higher pellet intake than the Rowan Ranger groups. No significant interactions on pellet intake was seen but at d42 a tendency for interaction was observed.

Table 7: Silage, haylage and pellet intake for both hybrids, the standard error of means (SEM) and p-values

| **Item** | **Ross** | | | **Rowan** | | | **SEM[1]** | **P-Values** | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | **C** | **H** | **S** | **C[5]** | **H[6]** | **S[7]** | | **T[2]** | **B[3]** | **T*B[4]** |
| **Silage and Haylage intake (in grams)** | | | | | | | | | | |
| D7 | . | $0.001^{B}$ | $19^{A}$ | . | $1^{B}$ | $23^{A}$ | 1.0 | <0.001 | 0.023 | 0.334 |
| D14 | . | $16^{bB}$ | $107^{aA}$ | . | $26^{bB}$ | $92^{aA}$ | 5.4 | <0.001 | 0.632 | 0.036 |
| D21 | . | $17^{b}$ | $200^{a}$ | . | $57^{bcB}$ | $181^{aA}$ | 13.8 | <0.001 | 0.446 | 0.051 |
| D28 | . | $111^{cB}$ | $455^{aA}$ | . | $133^{cB}$ | $312^{bA}$ | 26.0 | <0.001 | 0.034 | 0.006 |
| D35 | . | $263^{cB}$ | $826^{aA}$ | . | $250^{cB}$ | $568^{bA}$ | 52.2 | <0.001 | 0.020 | 0.033 |
| D42 | . | $407^{cB}$ | $1130^{aA}$ | . | $388^{bC}$ | $786^{bA}$ | 72.4 | <0.001 | 0.024 | 0.041 |
| **Pellet intake (in grams)** | | | | | | | | | | |
| D7 | $117^{A}$ | $106^{B}$ | $121^{A}$ | $119^{A}$ | $106^{B}$ | $110^{A}$ | 4.2 | 0.026 | 0.427 | 0.287 |
| D14 | $495^{A}$ | $401^{B}$ | $448^{B}$ | $383^{A}$ | $342^{B}$ | $339^{B}$ | 14.2 | <0.001 | <0.001 | 0.125 |
| D21 | $981^{A}$ | $786^{B}$ | $928^{AB}$ | $737^{A}$ | $703^{B}$ | $716^{AB}$ | 38.4 | 0.020 | <0.001 | 0.109 |
| D28 | $1818^{A}$ | $1574^{B}$ | $1746^{AB}$ | $1345^{A}$ | $1177^{B}$ | $1209^{AB}$ | 64.9 | 0.015 | <0.001 | 0.570 |
| D35 | $2738^{A}$ | $2583^{B}$ | $2971^{A}$ | $2109^{A}$ | $2185^{B}$ | $2330^{A}$ | 97.9 | 0.026 | <0.001 | 0.390 |
| D42 | $4135^{A}$ | $3500^{B}$ | $3976^{A}$ | $3158^{A}$ | $3190^{B}$ | $3359^{A}$ | 128.7 | 0.034 | <0.001 | 0.053 |

[1]Standard error mean, [2]treatment, [3] breed, [4]treatment and breed interaction [5] Control [6]Haylage [7]Silage $^{abc}$=Least square means within the same row (for interaction) with different superscripts were significantly different (P < 0.05). $^{ABC}$ = Least square means within the same row (for Dietary treatment) with different superscripts were significantly different (P < 0.05).

### 4.5 Sticky droppings

No significant effect was observed for treatment or interaction. However, a significant effect was seen for hybrid at d42 where Ross 308 showed a higher percentage of birds with sticky droppings compared to Rowan Ranger. There was a tendency of hybrid effect at d35 (Table 8).

Table 8: Percentage of chickens per pen with sticky droppings, the standard error of mean (SEM) and p-value

| Item | Ross | | | Rowan | | | SEM[1] | P-Values | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | C | H | S | C[5] | H[6] | S[7] | | T[2] | B[3] | T*B[4] |
| **Sticky droppings** | | | | | | | | | | |
| D7 | 5.7 | 21.2 | 9.2 | 5.4 | 8.0 | 15.8 | 5.0 | 0.299 | 0.542 | 0.145 |
| D14 | 6.0 | 8.9 | 12.1 | 6.0 | 3.8 | 11.4 | 4.5 | 0.487 | 0.722 | 0.783 |
| D21 | 10.3 | 19.3 | 11.8 | 11.9 | 11.5 | 20.7 | 7.3 | 0.697 | 0.716 | 0.371 |
| D28 | 11.7 | 21.3 | 14.3 | 7.1 | 9.6 | 25.5 | 6.7 | 0.372 | 0.802 | 0.208 |
| D35 | 21.3 | 28.3 | 38.3 | 11.3 | 18.3 | 27.0 | 7.1 | 0.192 | 0.073 | 0.979 |
| D42 | 21.3 | 24.3 | 35.7 | 7.7 | 12.3 | 27.0 | 7.6 | 0.149 | 0.039 | 0.758 |

[1]Standard error mean, [2]treatment, [3] breed, [4] treatment and breed interaction [5] Control [6]Haylage [7]Silage

### 4.6 Gizzard score

Table 9 showed result on gizzard score where no significant effect of treatment was shown but a breed tendency effect was observed. Figure 4 provides a visual description of the gizzard scoring.

Table 9: Gizzard scar score for both hybrids

| Item | Breed | | Dietary treatment | | | SEM[1] | | P-value | |
|---|---|---|---|---|---|---|---|---|---|
| | Ross | Rowan | C[4] | H[5] | S[6] | B[3] | T[2] | B | T |
| Gizzard scar score | 0.3 | 0.6 | 0.3 | 0.5 | 0.5 | 0.1 | 0.1 | 0.079 | 0.559 |

[1]Standard error mean, [2]treatment, [3] breed, [4] Control [5] Haylage [7]Silage

Figure 4. On the left side a gizzard in good condition scored as ´4´. On the right side a gizzard with a poor condition scored ´1´.

### 4.7 Foot pad scoring

The footpad of the focal birds at time of observation showed no signs of poor foot pad health. They all scored a ‘0’.

### 4.8 Litter assessment

The litter quality observed for both hybrids from week 4 to 6 scored a ‘1’ and ‘2’ which indicated dry litter which was considered as a good condition.

### 4.9 Mortality

The mortality that occurred during the experiment is shown in Table 10. Birds that died three days' post arrival were excluded from the data since their death might be related to poor chick quality rather than the diet. Moreover at d10 birds that were 2.0 standard deviations lighter than the mean for Ross and 2.5 standard deviations lighter than mean for Rowan were culled, and those birds are not included in Table 10. The data for mortality was not statistically analyzed.

Table 10: The number of dead birds from each breed and treatment groups

| Item | Ross | | | Rowan | | |
|---|---|---|---|---|---|---|
| | C[1] | H[2] | S[3] | C | H | S |
| D7 | 0 | 2 | 1 | 0 | 0 | 1 |
| D14 | 0 | 1 | 0 | 0 | 0 | 0 |
| D21 | 1 | 0 | 0 | 1 | 0 | 0 |
| D28 | 0 | 1 | 0 | 0 | 1 | 1 |
| D35 | 0 | 0 | 0 | 0 | 0 | 0 |
| D42 | 0 | 0 | 0 | 0 | 0 | 0 |
| Total no. of dead birds (D7 – 42) | 1 | 4 | 1 | 1 | 1 | 2 |

[1]Control [2]Haylage [3]Silage

### 4.8 Water consumption

The data presented in table 11 showed water intake for Ross 308 and Rowan Ranger within the different dietary treatment groups. The water consumption was measured daily from the start of the trial up to the end and was presented in table 11 on a weekly basis. The data however were not statistically analysed.

Table 11: The amount of water (in liters) consumed per selected group of birds per breed.

| **Item** | **Ross** | | | **Rowan** | | |
|---|---|---|---|---|---|---|
| | **C** | **H** | **S** | **C** | **H** | **S** |
| D7 | 2.0 | 2.1 | 2.2 | 1.6 | 2.0 | 1.9 |
| D14 | 3.9 | 3.5 | 4.2 | 3.0 | 3.0 | 3.8 |
| D21 | 9.2 | 5.6 | 7.1 | 5.1 | 5.2 | 5.6 |
| D28 | 9.8 | 6.6 | 8.0 | 7.8 | 9.2 | 7.8 |
| D35 | 12.4 | 9.0 | 8.8 | 7.8 | 9.2 | 8.1 |
| D42 | 10.1 | 11.3 | 17.4 | 9.4 | 10.8 | 10.1 |
| **Total** | 47.4 | 38.1 | 47.7 | 34.7 | 39.4 | 37.3 |

## 5.0 Discussion

### 5.1 Feed composition

The composition of the feed influences the amount of energy from the feed that can be utilized by the bird. In this case the calculated energy in the commercial feed were higher compared to the silage and haylage feedstuff. The reason that accounts to this difference was the high crude fiber content of silage and haylage compared to the commercial feed. Furthermore, the low energy content of silage and haylage influences the energy content of the feed when presented as TMR. This has been observed in other studies (Steenfeldt et al 2007; Ranjitkar et al 2016) where diets including silage in TMR form presented lower energy values than the control diet without silage. The difference in energy values between silage and haylage was due to the DM content as it was higher for haylage (see Table 5).

Comparing the commercial organic starter and grower feed with the optimum nutrition specification outlined by Aviagen (2014c) for Ross 308 normally kept in conventional settings, and for Rowan Ranger raised in organic production (Aviagen, 2016), the energy values and some nutrients were slightly lower. For instance, amino acids such as methionine, lysine and isoleucine in the grower diet were slightly lower and leucine in the starter diet was higher than the nutrient recommendation (Aviagen 2014c; Aviagen 2016). In addition, comparing the analysed with the optimized values (Lantmännen, Sweden; Table 4), the crude protein was slightly higher for both diets, lysine in the grower diet was slightly lower, the methionine was slightly higher in the starter diet but lower in the grower diet and the threonine content was slightly higher in starter diet but lower in grower diet. The differences observed between the analysed and the optimized feed composition might be due to the raw materials of the feed and their individual nutrient composition which contribute to the overall composition of the feed. Coskutuna et al. (2008) mentioned that even varieties of the same plant species such as wheat have different composition. This might also be true for other plant sources.

Since the feed used was organic, it did not include added synthetic amino acids as their use is not permitted in organic feed. The use of synthetic amino acids such as tyrosine, tryptophan and threonine were observed to correct for the reduced performance of pigs caused by the diet with reduced dietary crude protein (Kerr et al., 1995). Fanatico (2010) reported that in organic poultry feed methionine and cysteine were the most limiting amino acids, these amino acids are commonly known as sulfur amino acids and are involved in many complex metabolic processes. However, in general, only about 75 percent of the total sulfur amino acid requirement is met by the content in the feedstuffs and 25 percent is normally supplemented by synthetic methionine (Fanatico, 2010). Therefore, the amount of methionine provided in organic feed might not be sufficient to support metabolic processes and could result in a reduced poultry performance. The silage and haylage feedstuff also show a low crude protein content which might also indicate a low amount of the essential amino acids. The silage and haylage groups certainly had lower protein content in their diets compared to control as their feed became diluted. However, Edmonds et al. (1984) reported a study done in broilers where they found that regardless of the amount of the crude protein content, the right amount of the essential amino acids must be met otherwise supplementation of amino acids is required. The inclusion of grass silage and haylage in the diet would lower the amounts of some of the essential nutrient component of the feed and increase others such as crude fiber when fed as TMR.

**5.2 Relative Organ weights**

The result showed that relative organ weights for all organs except the heart, bursa and proventiculus were significantly higher for the Rowan Ranger hybrid than for Ross 308 and the inclusion of silage and haylage causes an increase in gizzard weight which have been reported in many studies due to an increase in mechanical stimulation of the gizzard (Svihus et al., 1997; Engberg et al., 2002; Steenfeldt et al., 2007; Ranjitkar et al., 2016). This indicated that the higher weights of the organs observed in this study for the Rowan Ranger chickens might reflect an increased activity occurring in their digestive tract compared to the Ross 308 chickens. Another explanation for the difference would be the higher BW of Ross 308 chickens, since the organ weights were expressed as percent of BW, thereby giving Ross 308 lower relative organ weights than Rowan Rangers. However, expressing the organ weights in relation to BW make the values comparable. It is known that both hybrids develop at different paces, the fast growing hybrids have been selected for fast growth rate and their breast muscles grow faster than the rest of their body, and as a result of such selection, the major organs become relatively smaller (Tickle et al., 2014). The Rowan Ranger on the other hand, are a slower growing hybrid and their muscles grows at a slower pace than the fast growing hybrids and therefore larger organs in relation to BW can be expected. The dietary treatments on the other hand, did not have a significant effect on the organs except the gizzard, this difference was observed between the experimental diets and control which further emphasize the importance of the gizzard in fiber digestion.

**5. 3 FI, and silage and haylage intake**

Throughout the study, FI was lower for the haylage group while the silage and control group showed no significant difference. A study done by Ranjitkar et al. (2016) showed an increased FI for chickens in the silage groups fed 15 and 30 percent crimped kernel maize silage (CKMS) when compared to the control. The difference observed between that and our study might be due to the different fiber sources used. Mateos et al. (2012) stated that the effects of DF on voluntary FI, growth and behavior of the bird would differ depending on the source of fiber. However, in the study by Ranjitkar et al. (2016) the composition of CKMS was not analysed and therefore comparison of the composition with grass silage was not possible. The low FI in the haylage group might indicate that broilers were reluctant to consume feed mixed with haylage. The possible explanations might be related to reasons such as, its smell and taste and the DM content of the feed in which haylage has higher DM compared to silage which may contribute to its texture, rough and dry. Jones and Roper (1997) stated that birds can smell and that olfaction has a potential role in the control of feeding. A study done for horses showed that they prefer silage over haylage and hay after smelling and tasting it (Müller and Udén, 2007). The same could be assumed for the haylage and silage groups in the present study. It might also be speculated that silage were softer in texture whereas haylage was drier and rougher. In this sense, birds might prefer softer feed since it is more palatable and easier to consume and digest. The pellet intake was also lower throughout the experiment for the haylage group than for the control and silage. This could be due to the fact that the feed was presented as TMR and so their reluctance in feeding on haylage also affects their interest in consuming pellets.

The effect of hybrid on the overall FI was significant from d14 to d42 where it was shown that Ross 308 had a higher FI than Rowan Ranger which was in agreement with a study done by Wallenbeck et al. (2017). Lindholm et al. (2016) found that Ross 308 spend on average, twice as much time on feeding behaviours than Rowan Ranger. At d7, the FI was not significantly different between the hybrids, which explains that the first week both hybrids ate similar amount of feed. At d7 the Rowan Ranger had a higher roughage intake (that is both silage and haylage) than Ross 308 but later at d28 to 42 the opposite was seen. The observation at d7 might be due to the difference in the initial body weights of the chickens where Ross 308 have a lower initial body weight compared to Rowan Ranger. The change or shift observed at d28 might explain that Ross 308 are being acclimatized or are getting used to the feed. The pellet intake for Ross 308 was higher than the Rowan Ranger at d14 to 42. This was expected since Ross 308 have a higher energy requirement than Rowan Ranger, therefore their FI should be higher. Ferket and Gernat (2006) stated that broilers are well known to consume feed to meet their energy requirements and once the dietary energy is diluted due to inclusion of fiber content of the diet, they acclimatize to new condition by increasing their FI.

At d21, Ross 308 silage and control groups had a higher FI than the other groups, while the Rowan Ranger seem to have a similar FI no matter of the feed provided. Though another explanation might suggest that Ross 308 seem better in consuming silage than the Rowan Ranger and is poor in consuming haylage, which might be a result of different requirements of these hybrids. Both hybrids fed silage had a higher roughage intake compared to those fed haylage, this has been explained previously as the chickens' preference of silage over haylage.

### 5.4 BW and FCR

The result showed that the BW of the birds was associated with their FI. It was observed that the haylage group had a lower BW compared to the silage and the control groups for all days except d14, which could be explained by the lower FI of the haylage group compared to the other groups. It is known that feeding broilers pelleted diets compared to mash have a significant effect on BW, since it increases FI and improves feed utilization (Engberg et al., 2002). Unfortunately, chickens in the haylage group did not consume the pellets in the mixture to the same extent as the other groups and the reason to this might be because it was mixed with haylage. As mentioned previously, broilers might not prefer the texture, and possibly the smell and taste of haylage and so it seem to affect the entire TMR feed intake. A higher BW was observed at the first week for the Rowan Ranger group, however as birds grew older the opposite effect was observed with higher weights for Ross 308. The BW change observed for Ross 308 suggests an effect of the feed as well as compensatory growth. Ross 308 require a nutrient dense diet to meet its energy requirement for optimal performance, however the feed provided was organic and diluted with silage or haylage, and certainly did not meet the demand for Ross 308. Summers (2008) stated that restricted animal growth due to a low nutrient intake that results from a low quality diet or environmental stress will exhibit an increased rate of gain and enhance feed utilization when the stress is eliminated. The lower BW for Ross 308 seen at the beginning might be due to Ross 308 having younger mothers and therefore being of lower initial weight, which affected their initial performance. Also, other stress factors such as transportation to the research station as well as the new environment might have affected the genotypes to different extent. The first week was probably difficult for Ross 308 and that was spent adjusting to the feed but as mentioned by Ferket and Gernat (2006), broilers will acclimatize by increasing their FI.

The FCR for the silage and haylage groups were higher than the control at d21, 35 and 42. The finding agrees with Ranjitkar et al. (2016) where they also found an impaired FCR when 15 percent and 30 percent CKMS were provided. However, other studies such as Hetland et al. (2003) showed that inclusion of insoluble fiber sources such as oat hulls and wood shavings improved FCR. González-Alvarado et al. (2007) reported that fiber source used might have different effect on FCR. They studied broilers for 42 days and found an improvement on FCR when 30g of oat hulls was included in a diet low in fiber, an improvement was also observed for the inclusion of 30g sugar beet pulp but this was observed only for the first 10 days.

Ross 308 had a higher FCR than Rowan Ranger at d14. However, at d35 and 42 it was the opposite. The difference observed might be due to the underfeeding of Ross as previously described, resulting in compensatory growth and improved FCR in the later growth period (Summers, 2008).

An interaction effect at d7 was present indicating that Ross 308 chickens had a poorer FCR when fed haylage diet compared to the Rowan Ranger chickens fed haylage, whereas the Ross 308 control group had a lower FCR than the Rowan Ranger control group. This suggest better feed utilization by the Ross 308 on the pelleted diet which was expected, however the haylage diet clearly had a stronger negative influence on Ross 308 than Rowan Ranger performance.

**5.5 Sticky droppings, foot pad and litter quality**

Ross 308 showed a significantly higher number of birds with sticky droppings at d42 and a tendency at d34 compared to the Rowan Ranger. However, sticky dropping is more prevalent in young chicks than older chickens (Miles and Johnson, 2009) and it cannot be excluded that at the older ages dirt (manure) was by mistake scored as sticky droppings. None of the birds showed signs of foot pad dermatitis as all scored a ‘0’. The assessed litter quality throughout the experimental period mostly scored a 1 and 2 which indicated dry litter and good condition, however this measurement is rather biased since more litter was added once every week after litter condition scoring. However, for instance, Ranjitkar et al. (2016) stated that the inclusion of CKMS improved litter quality and foot pad condition. In addition, studies on insoluble fiber improve litter quality (Rezaei et al., 2011; Hoeven-Hangoor et al., 2014).

Ekstrand et al. (2010) mentioned that if a certain food causes more wet droppings, this likely results in wetter litter and thus to a higher prevalence of foot pad dermatitis. Wet litter observed at d42 could neither be related to the inclusion of silage or haylage because birds become bigger in size with age, and with that the space in the pen becomes smaller and a possibility of water spillage might occur since bell drinkers were used instead of nipples. In this case the research facility might therefore not be optimal for this type of measurement.

### 5.6 Gizzard scar score

There was no significant effect of treatment present for gizzard scar score but a hybrid tendency effect was observed where the Rowan Ranger had a higher mean score, indicating a better condition, than Ross 308. Gizzard scars observed in this study have been reported as a condition known as gizzard erosion. Several factors result in this condition but the most reported cause is fish meal in poultry diets (Johnson and Pinedo, 1971; Okazaki et al., 1983; Masumura and Sugahara, 1984). The present study used an organic feed which contained fish meal (see Table 2). According to Johnson and Pinedo (1971) feed rations containing over 12 percent fish meal of deteriorated quality may induce the problem. According to KRAV regulations (2018) maximum of 10% fishmeal is allowed in organic diets in Sweden, and in the feeds used in this study, 7 percent fishmeal was included (Table 2). Therefore, it is not likely that fishmeal caused the gizzard scar observed in the present study.

### 5.7 Water intake

It is known that the soluble fiber rather than the insoluble fiber increases the water consumption in birds, due to its water binding effect (Langhout et al.,1998). However, the fiber source in the grass silage and haylage used in the present study was mainly insoluble fiber (Bach Knudsen, 1997). Measurement of water intake was only done on two groups per treatment and hybrid and the results should therefore only be considered as indicative. The results indicated that Ross 308 chickens had a higher water intake than the Rowan Ranger chickens, this is likely due to the higher FI of the Ross 308 chickens. Likewise, Ross 308 fed haylage had a lower FI compared to Ross 308 fed silage and the control feed, and indications of a lower water intake. However, in the Rowan Ranger group the differences between diets was much smaller. The difference in observation between these hybrids might suggest that there are other factors involved such as hybrid difference, level of activity and many more that can influence water intake.

### 5.8 Mortality

The mortality was not statistically analysed, since only a few number of birds died, and the results should only be considered as indicative. Although the total number of birds that died was considered low, there were a higher number of chickens fed haylage that died compared to the chickens fed silage and the control feed. This could possibly be due to the chickens' reluctance to feed on haylage. Most birds died during the first week and from d29 and onwards no birds died. Other studies reported that inclusion of supplements, maize silage, barley-pea silage or carrots reduced mortality (Steenfeldt et al., 2007).

## 6.0 Conclusion

Feeding diets with 15 percent inclusion of grass silage or haylage in a 42-day period decreased the growth performance for both Ross 308 and Rowan Ranger hybrids and the growth reduction was stronger with haylage than silage inclusion. In regards to broiler hybrids, both seem to prefer silage over haylage. Ross 308 had a higher FI, including the actual silage and haylage intake, which resulted in a higher BW and better FCR compared to Rowan Ranger. Rowan Ranger on the other hand, had heavier relative organ weights than Ross 308. Inclusion of silage and haylage stimulated the gizzard development in both hybrids. No effect of silage and haylage inclusion on foot pad condition, litter quality, sticky droppings or gizzard scar were seen for any of the hybrids, which indicate that the forages had no detrimental effects on the health parameters included in the study.

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