Motivation for eating roughage in sows – as an indication of hunger

Suggors motivation att äta ensilage som en indikator på hunger

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Examensarbete 334
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PREFACE

This assignment was conducted as a Master‘s thesis in Animal Science at the Department of Animal Nutrition and Management, Swedish University of Agriculture Sciences (SLU). The results from this assignment are a smaller part of a larger project initiated and founded by my supervisor at SLU. The study was carried out at Funbo-Lövsta research center. The research center is a part of the Swedish University of Agricultural Sciences (SLU) and is stationed 10 kilometers east of Uppsala.

I want to give a big thank you to my supervisor Magdalena Høøk Presto and my co-supervisor Per Peetz Nielsen for all your time and patience spent on me. Magdalena, you have been an invaluable support and help, with all your ideas and knowledge during the study, statistical analyses and writing of my work. I also want to give my appreciation to Charlotte Hellgren for giving me invaluable feedback on my work.

Last but not least I would like to give the greatest thanks to my beloved boyfriend Igor. I am grateful for that you have always been there for me.

Tove Bergström, Uppsala 2011

TABLE OF CONTENT

ABSTRACT

Today's feeding methods can determine the domestic pig's abilities to fulfill basic behavioral needs, such as foraging, and the way in which pigs are feed is an important aspect. Feed does not only provide the energy and nutrients critical for survival, but feeding is also associated with a number of other factors contributing to well-being and reproduction. Today the feed for gestated sows is often composed by high energy and low dietary fiber grain products such as wheat. Three kg of this kind of feed can often be consumed by the sow within 20 minutes. Hunger leads to stress which often causes some kind of stereotypic behavior. One way to reduce that kind of behavior and to relieve the feeling of hunger and stress is to allow the sow access to low energy, high fiber feedstuff in the form of roughage. At least half of the sows requirements for energy intake can be covered by roughage without affecting the production and access to roughage gives the sows a possibility to perform a feeding behavior they are highly motivated to perform. The performance of stereotypies has been used as evidence of reduced welfare; when an animal has a high motivation to perform a certain behavior but the environment does not allow the animal to perform this. So how can high motivation to perform a certain feeding related behavior due to hunger, be measured? The aim of this study was to investigate if sows given a lower amount of concentrate feed are more motivated to eat silage. In the study a total of 39 gestated Yorkshire and Yorkshire x Swedish Landrace sows were given either a restricted amount of commercial feed, 60 percentages, or 100 percentage of recommended feed ratio together with free amount of grass-silage. The results showed that the sows with lower commercial feed ratio had a 17 percentage higher frequency of time spend chewing on silage and they also had a 52 percentage lower average duration time from opening the feeding crate after feeding, until chewing on silage for the first time. The results can correspond to that sows given a lower feed ratio have a higher motivation for eating silage due to hunger. During the treatment period weight and backfat thickness gain differed between treatments and was lower among sows given 60 percentage commercial feed ratio. However this did not have any effect on piglet production.

SAMMANFATTNING

I dagens grisproduktion kan utfodringsmetoderna spegla grisens möjligheter att få utlopp för basala beteenden som födosök och hur grisen utfodras är en viktig aspekt. Grisens foder utgörs inte bara av energi och de näringsämnen som behövs för överlevnad, utan det berör även många andra faktorer som bidrar till en bra djurvälfärd och reproduktion. Foder till dräktiga suggor består ofta av spannmål med hög koncentration av energi och lågt fiberinnehåll. Tre kg av denna sorts foder konsumeras ofta av suggan inom 20 minuter. Hunger hos suggan leder ofta till stress vilket i sin tur kan leda till stereotypa beteenden. Ett sätt att minska dessa typer av beteenden och stress är att erbjuda suggan tillgång till grovfoder med lägre energi- och högre fiberinnehåll än spannmål. Åtminstone halva suggans rekommenderade energiintag kan täckas upp av grovfoder utan att påverka hennes smågrisproduktion och tillgången till grovfoder ger henne en möjlighet att utföra ett födosöks beteende hon är starkt motiverad att utföra. Utförandet av stereotypa beteenden har använts som belägg för reducerad djurvälfärd; när ett djur har en stor motivation att utföra ett visst beteende men miljön tillåter inte djuret att genomföra det den vill. Så hur kan motivationen att utföra ett vist födorelaterad beteende, på grund av hunger, mätas? Syftet med denna studie var att undersöka om suggor som ges en mindre mängd kommersiellt suggfoder är mer motiverade att äta ensilage. I studien fick totalt 39 dräktiga Yorkshire och Yorkshire x Lantras suggor endera en begränsad giva av kommersiellt suggfoder, 60 procent, eller den rekommenderade fodergivan, 100 procent tillsammans med fri tillgång till gräsensilage. Resultaten visade att suggor med restriktiv fodergiva spenderade 17 procent mer tid åt att äta ensilage och hade även 52 procent kortare genomsnittstid från det att foderbåsen öppnas upp efter utfodring av kommersiellt suggfoder till att de tuggade på ensilage för första gången. Dessa resultat kan tyda på att suggor som får en lägre kommersiell fodergiva har en högre motivation att äta ensilage på grund av större hungerkänsla. Under försöksperioden skiljde sig den erhållna vikt och späcktjockleken mellan behandlingarna och resultaten visade att det var lägre för de suggor som fick begränsad fodergiva. Däremot påverkade inte vikt eller späcktjockleken suggornas smågrisproduktion.

INTRODUCTION

Background

The pig

The pig (*Sus Scrofa*) is an omnivore and its snout is adapted to root and search for feed. In a natural environment the pig can move several kilometers a day to find feed which consist of plants, leafs and roots but also small animals as birds and frogs. Even though the mainly domestic pig has been in the human care for a long time its, behaviors is highly compatible to the wild boar (Jensen, 2002). In a semi-natural environment adult sows use approximately 50 % of the day sleeping or resting, 15 % eating, rooting or drinking and 30 % traveling. The temperature and time of day affects the level of activity in pigs, they are more active during the winter and less active during the summer and most of the activities take place during sunrise and sunset (Blasetti *et al*., 1988).

Animal Welfare

Today's feeding methods can determine the domestic pig's abilities to fulfill basic behavioral needs, such as foraging (Kasanen *et al*., 2010). The way in which pigs are fed is an important aspect. Not only does feed provide the energy and nutrients vital for survival, but it is also associated with a number of other factors contributing to well-being. So what is well-being and can that be interpreted as animal welfare? And if so, what does animal welfare actually mean? Some say that animal welfare is poor if the animal shows subjective feelings, as for example; stress (Broom & Johnson, 1993). For some other reduced animal welfare is experience an unpleasant state of mind and minimizing the pain and suffer under human use (Ishikawa, 2010). McNamara & Houston (1986) argue that an animal should be able to perform a behavior which would lead to the greatest opportunity to survive and reproduce, so called "fitness". According to Dawkins (2004) there are only two things playing a role in the aspect of animal welfare and those are, is the animal healthy and does it have everything it needs to perform its natural behavior? The word "need" does not necessary refer to situations where the animal will die or suffer if it is deprived, but the animal can want something in the sense of being highly motivated to obtain it.

So how can high motivation be measured? One of the arguments from researchers is the animal's liability to perform a certain behavior in the absence of appropriate stimuli (Dawkins, 1990). For example sows have a high motivation to perform nest-building even if no nesting material is present (Jensen, 1993). A high motivation after deprivation is also showed if an animal is prevented to perform a certain behavior. This could be seen in gilts that experienced long rooting deprivation; they had a higher motivation to root when given opportunity (Studnitz & Hjelholt Jensen, 2002). A third and very important aspect is the display of "abnormal behavior" as stereotypies. The performances of abnormal behaviors have been used as evidence of when an animal has a high motivation to perform a certain behavior in a situation where the environment does not allow the animal to perform this behavior. (Dawkins, 1990). Abnormal feeding related behavior is one activity strongly related to that category.

There are very different ideas and opinions about what the definition of animal welfare is, whether we emphasis feelings, functions or natural living. Regarding the issue of feeding, a gestated sow with restricted feeding may have behavioral needs that are not fulfilled. But a sow without restrictions in today's production can get obese, which also can cause serious health problems (Kasanen *et al*., 2010). During lactation a sow is often feed *ad lib*, and can consume up to 9 kg of commercial sow feed a day. Abruptly after weaning the sows is taken

of the high amount of feed and are given only 2-3 kg, i.e. a drastic feed reduction preserved during the whole pregnancy (Ewing, 1998). This lower amount of feed can cause the sow to feel hungry and the motivation to eat might increase.

Saturation and feed intake

In modern production for gestated sows the feeling of saturation is highly important, due to their restricted feed ratio. The feeling of satiety and hunger is regulated by the central- (CNS) and enteric nerves system (ENS), and the gastrointestinal tract (GIT) (Mendieta-Zerón *et al.*, 2008). In the hypothalamus there is a feeding center and satiety centre which receives signals from the body during consumption of food (McDonalds *et al*., 2002).

The intake of feed can be expressed as long- or short-term regulations. Long-term regulation of feed intake is influenced by the CNS and from the body energy stores that express and release leptin in proportion to the amount of body fat (Sjaastad *et al.*, 2003). Many animals have a desire to have a constant bodyweight and the long-term regulation helps the body to obtain constant body fat storage. This is on the other hand not as sensitive in pigs as in other animals due to genetic selection on rapid weight gain (McDonald *et al*., 2002). A meal-to-meal basis, short-term regulation is controlled by several gut hormones such as cholecystokinin (CKK), and also by gastrointestinal filling and glucose concentration in the blood (Sjaastad *et al*., 2003). A rise in concentration and the release of nutrients from the food in the digestive tracts, their absorption and passage through the liver and blood system sends signals to the brain to stop eating and a drop in concentration causes the animal to start eating again (McDonald *et al*., 2002).

In general, the intake of feed occurs for various reasons; energy deficit, high palatability, stress, pain and social reasons and all of these reasons are most likely mediated by different signals and hormones regulating feed intake (Erlandson & Albertsson, 1999) (figure 1). Due to both internal and external stimuli hunger is hard to measure (Haskell *et al*., 1996).

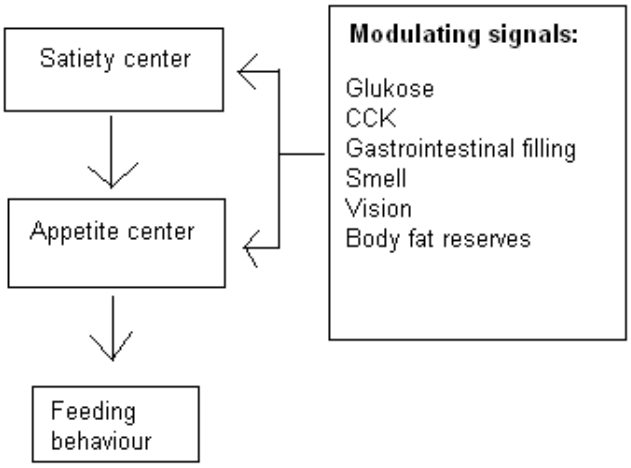

Figure 1. Modulating signals that stimulate feeding behavior.

Sows have excellent capacity to digest dietary fiber in the hindgut (Noblet and Shi, 1993; Le Goff *et al*., 2002). Studies on feeding motivation trying to measure hunger by 'operant conditioning', where pigs had to press a panel to obtain food rewards, showed that a more fibrous diet gave a reduction in food rewards which showed that a more bulky food reduced feeding motivation (Robert *et al*., 1997). Feed, in the form of roughage that contains high amount of dietary fiber provides the sow with a feeling of saturation due to through a long feeding period (Roberts *et al.*, 1993) and a larger gastrointestinal filling (De Leeuw, 2004). It has been showed that animals are able to adjust the amount of food so that their energy intake remains constant. But a feed with low energy concentration often causes a restriction in feed intake due to gut expansion, and the total energy intake is not fulfilled (McDonald *et al*., 2002).

Feeding motivation

The lack of feed is often associated with signs of hunger such as increase in feeding motivation, activity and redirected oral behaviors, which may develop into stereotypies (Terlouw *et al*., 1991). A stereotypy is a relatively invariate sequence of movements occurring so frequently in a particular context that it could not be considered to form part of one of the normal functional systems of the animal (Broom, 1983).

Stereotypies often appear in close relation to the period of feeding and specially the time close after the pig are being fed (Lawrence & Terlouw, 1993; Spoodler *et al*., 1995; Bergeron *et al*., 2000), and during the meal the body is releasing different positive feedback mechanisms which contribute to the motivation to ingest more (Wiepkema, 1971). Pigs often develop some kind of stereotypic oral behavior due to low feed intake (Jensen, 2002). And it has been seen that gestated sows given diets with a large part of dietary fiber decreased the levels of stereotypical behavior (Peet-Schwering *et al*., 2003). It has also been showed that a high fiber diet gives a significant longer eating time and a reduced time spending on foraging (Danielsen & Verstergaard, 2001). Bergeron *et al.* (2000) has showed that a free access to a low fiber diet gives a reduction in time spent in stereotypes compared to a restricted high fiber diet. Today the feed for gestated sows is restricted and it is often composed by high energy and low dietary fiber grain products. Three kilo of this kind of feed can often be consumed by the sow within 20 minutes (Brouns *et al*., 1994) and it is approximately not more then 40 to 60 percentage of what the sows would eat if they were feed *ad lib.* (Brouns *et al*., 1995). But to obtain a "normal" body condition in gestated sows a reduction in concentrate feed is required (Brouns *et al*., 1995).

Pigs with feed restrictions often get a higher motivation to root in the bedding material which can indicate signs of hunger (Day *et al*., 1995; Beattie & O'Connell, 2002). An increase in the pigs physical behavior combined with a reduced feeding ratio has also been seen, which can be interpreted as hunger (Beattie & O'Connell, 2002) due to that the pig use about 30 % of the day to move around end explore the environment for feed (Blasetti *et al*., 1988).

One way to reduce stereotypies and to relieve the feeling of hunger without causing obesity is to allow the sow access to low energy, high fiber feedstuff in the form of roughage (Nielsen *et al*., 2006). Pregnant sows grazing can consume grass corresponding to approximately half of their energy requirement (Sehested *et al*., 2000).

The effect of straw and roughage

According to Swedish legislations pigs should have some kind of straw or comparable material of appropriate type and good quality. The straw should be of a material the pigs like to root in, chew on and examine and it shall be given in an amount that satisfies the pigs need for occupation and comfort (Jordbruksverket, 2010).

When pigs are supplied with rooting material it reduces their oral manipulation on the interior (Whittaker *et al*., 1998; De Leeuw & Ekkel 2004) and pigs with free access to both straw and silage beside their ordinary amount of concentrate reduced their oral stereotypical behavior compared with the pigs given only straw and concentrate (Olsen, 2001). Høøk Presto *et al.* (2009) also showed that additional roughage also reduced the aggressive behavior among pigs. And when comparing roughage; silage compared to hay and straw gave less aggressive behavior (Persson *et al*., 2004).

Pig production

A sow needs to be in a good body condition before insemination, during gestation, farrowing and lactation. If a sow is thin she can have problems entering estrus, to producing many piglets and to give enough milk (Ewing, 1998). Čechová & Tvrdoň (2006) showed that sows with higher backfat thickness had better litter performance and longer longevity. A to high fat deposition can also lead to reproduction problem and a lower survival in piglets (Dourmad *et al*., 1994). Overweight gilts may also suffer more embryonic mortality (McDonald *et al*., 2002). There is also a connection between the sow's weight gain during gestation and her weight loss during lactation. Sows that are given a high feed ratio during gestation can get a reduced appetite during lactation and thereby lose weight and it may lead to prolonged intervals between weaning and conception (McDonald *et al*., 2002). Zak *et al* (1997) also showed that sows that lost weight during lactation had a longer weaning to estrus interval and also a lower ovulation rate.

Stenberg (1993) showed that after insemination at least half of the sows required energy intake can be covered by roughage without affecting total number of piglets born, total number piglets weaned and the piglets weaning weight. This was also showed by Fernández *et al* (2006) which showed that sows consuming 60 % of their daily energy intake of grass in the summer and 40 % of their daily energy intake of silage in the winter gave birth to on average 12.1 live born and 1.8 stillborn piglets. Mean value of born piglets per sow in commercial herds in Sweden and Denmark during 2009 is 12.7 and 14.1 live born and 1.0 and 1.8 stillborn respectively (Quality Genetics, 2010).

Aim of the study

Gestated sows with feed restrictions can experience a feeling of hunger and stress. An access to low energy and high fiber feedstuff in the form of roughage gives the sows a possibility to perform a feeding behavior they are highly motivated to perform and it eventuate in the feeling of saturation. The aim of this study were to investigate if sows given a lower amount of concentrate feed was more motivated to eat grass-silage compared to sows given full feed ratio. Both treatments were feed *ad libitum* supply of grass-silage, fed additionally together with either 100 or 60 percent commercial feed. We also wanted to follow up the pig production to ensure that the lower amount of concentrate feed did not affect the pig production in a negative direction.

The hypothesis was that gestated sows with *ad libitum* supply of grass-silage and additionally 60 percentage commercial feed compared to sows given full feed ratio should have a higher motivation to eat silage and in average spend more time eating per day. And the higher motivation to eat silage would compensate the loss in energy from the commercial feed without affecting sow weight and backfat thickness or the piglet production.

MATERIAL AND METHODS

Animals

The study was performed at SLU:s research station Funbo Lövsta. In total 39 Yorkshire and Yorkshire x Swedish Landrace sows was included. The sows' parity number ranged between 4 and 9 and the study was performed during 4 weeks of the gestation period. The sows were divided in four groups (1, 2, 3, 4). Batch 1 consisted of group 1 and 2 and batch 2 of group 3 and 4 (appendix 1, table 1).

Housing, treatment and management

Two different feed treatments were compared in two different time periods, batch 1 from the 8th of February to the 7th of March and batch 2 from the 29th of March to the 25th of April 2010. Each period elapsed over four weeks and included one acclimatization week before the actual treatment period began. A few weeks after insemination each group were moved to indoor large pens with outdoor climate. The same two pens were used during both batches and they consisted of deep straw bedding, one row of individual feeding crates and one water station. The total area of one box was 69 m^2. The temperature varied between -12.0 ºC – 7.4 ºC during batch 1 and between 3.5 ºC – 16.5 ºC during batch 2.

The two treatments compared consisted of *ad libitum* supply of grass-silage which was fed additionally together with either 100 or 60 percent commercial feed (Hullda, Lantmännen) for gestated sows according to the Swedish feeding standards (Simonsson, 2006). The feeding standard is based on sow weight and fat status. Sows were fed two times a day, at 8 – 8.30 and 15.00 - 15.30 and one round bale of silage were placed in the middle of the pen at all time. Group 1 and 4 were given 100 percentage sow feed (treatment 100) and group 2 and 3, 60 percentage sow feed plus 20 g additionally fed minerals per day (treatment 60). Feed samples from the silage was analyzed (appendix 2, table 1) and the amount of metabolizable energy (ME) was calculated (appendix 2, table 2). The silage contained 4.9 MJ/kg ME and the commercial feed for gestating sows 12 MJ/kg ME.

All sows were weighed and the backfat thickness measured ultrasonically on both sides behind the last rib and approximately 7 cm from the midline to calculate a mean backfat value. This was made five times, Monday or Tuesday every week, one day during the acclimatization week, three times during the treatment-period and one time after the treatment-period. Live weight and backfat thickness was used to adjust a correct individual feed ratio every week according to sow body condition.

Behavioral observations

Live observations

Activity behaviors were recorded according to an ethogram (table 1) at three observation weeks. Each week composed of two days (Thursday, Friday) and the sows were observed twice daily, one session at 8.30-10.30 and one at 13.00-15.00. Before each session the observer were standing outside the pens and the observation did not start until the sows were accustomed and paid no attention to the observer. Each session consisted of four sets which lasted for 30 minutes and every other set the observer switched pen. Every second minute, using a digital stopwatch, the observer scanned one pen and recorded how many sows who performed each active behavior. In each set 15 scans were performed according to a recording scheme (table 2).

Table 1. Definition of behaviors registered during live observations

Behavior	Definition
Chewing silage	A sow has silage in its mouth
Waiting for silage	A sow stands with its snout towards the silage bale without any silage in its mouth, and with a maximum range of one sow length from the bale
Rooting in silage	A sow uses its snout or hoof to root in the silage
Rooting in straw	A sow uses its snout or hoof to root in the straw bed
In feeding crate	A sow is either standing or lying in feeding crate
Drinking	A sow stands with its mouth over the water cup, assumed to be drinking
Lying*	A sow is recumbent on its belly or side
Sitting*	A sow is in an upright position, with its back legs bent such that the pig supports its weight on its hind quarters and has its four legs straight
Standing*	A sow is upright on all four legs and stands still
Walking/running*	A sow is upright on all four legs and moves around
Other	Urination, defecation, mounting, biting on interior, aggression etc.

* If a sow is chewing silage while lying, sitting, standing or walking/running chewing silage is given priority

Table 2. Example of an activity behavior recording scheme, with 15 scans per set for treatment 60, group 3, 16th of April at 8.30

Interval	Min	Chew	Wait	Root silage	Root straw	In feed crate	Drink	Lie	Sit	Stand	Walk/ run	Other
1	0	8				1	1					
2	2	9									1	
3	4	9						1				
4	6	9							1			
5	8	8					1		1			
6	10	10										
7	12	9						1				
8	14	8					1		1			
9	16	8					1		1			
10	18	8					1				1	
11	20	8					1	1				
12	22	8					1		1			
13	24	8					1		1			
14	26	8							1	1		
15	28	10										

Video observations

The sows were video recorded 24 hours a day in all four weeks in both batches. Two cameras were attached in the roof above each pen. The cameras were placed in each front corner to cover the whole pen. Video recordings from both morning and afternoon every Thursday and Friday during both treatment-periods was used to observe and analyze the average duration time i.e. how many minutes it took for each individual sow, from when the feeding crates opened up after feeding, until chewing on silage. Actual time was noticed when the feeding crate opened up and then again when the individual sow chewed on silage for the first time. No consideration was taken on what behavior the sow were performing in-between.

Production

All sows were weighed and the backfat thickness was measured before farrowing and after weaning. A follow-up on each sow's production data included number of piglets born, piglets born alive, still-born and cause of death. The total number of weaned piglets and the piglets' individual birth- and weaning weight were also registered.

Statistical analysis

All statistical analyses except for production data were performed with the Statistical Analyzing System (SAS 9.2). A p-value of < 0.05 was considered statistically significant.

When analyzing the results, behavior parameters 'waiting for silage' and 'walking/running', were merged to a new parameter named 'active', due to a low frequency of recorded behaviors.

Behavioral observations

Live observations

Live observations were analyzed as the average number of sows performing a behavior and were presented as LS-means of percentage of sows. Least square means (LS-Means), p-values and standard errors (SE) were calculated with the Generalized Linear Mixed Model (GLIMMIX) procedure and BIONOMIAL distribution. Treatment (60, 100), week (1, 2, 3) and time of day (AM, PM) were set as fixed effects and batch (1, 2) as random effect. In all behaviors covariance structure, Compound Symmetry (CS) was applied.

Video observations

Mean values, standard deviations, minimum and maximum values were calculated by the MEANS procedure. All dependent variables were examined for normal distribution using PROC UNIVARIATE. Variables showed no normality and therefore the statistical analyses Least square means (LS-Means), p-values and standard errors (SE) were performed in PROC GLIMMIX with GAMMA distribution. Treatment (60, 100) and time of day (AM, PM) were set as fixed effects and batch (1, 2) as random effect.

Weight and backfat thickness

Mean values, standard deviations, minimum and maximum values were calculated by the MEANS procedure. LS-Means, p-values and SE were calculated with the Mixed (MIXED) procedure and BIONOMIAL distribution. In the analysis treatment (60, 100) and pen (1, 2) were set as fixed effects and batch (1, 2) as random effect. Interaction between treatment and pen were tested and no significant variation ($p > 0.05$) was established.

Production

The production data were analyzed in Microsoft Office Excel 2007. Mean values, minimum (min) and maximum (max) values and standard deviation (SD) of weight and backfat thickness, for sows and piglets according to treatment. Four sows, two from each treatment were excluded entirely from the production results due to that they were culled. Further two sows from treatment 100 were excluded from the sow's weight and backfat thickness results at farrowing and weaning due to that either weight or backfat measurements was missing.

RESULT

Live observations

Effect of treatment

Behaviors; Chewing, in feeding crate and lying

The results from the live observations showed that sows in treatment 60 were chewing 17 % more often ($p < 0.001$) and had a lower frequency of sows lying down as well as being in the feeding crates ($p < 0.05$) and $p < 0.001$ respectively) compared to sows within treatment 100 (table 3).

Behaviors; Other

Drinking differed significant between treatments ($p < 0.01$) and had a frequency of performed behavior of 3.51 % within treatment 60 and 2.71 % within treatment 100. No significant differences were found for sitting, standing, rooting silage, rooting straw and active due to that each behavior occurred less than 1.2 % of the time.

Table 3. Effect of treatment on activity behavior with LS-Mean of percent of the behavior that occurred per treatment, standard error (pooled) and p-value

	Treatment			
	60	100	SE	p-value
Chewing	63.7	46.6	4.94	0.001
Lying	25.8	37.0	6.05	0.012
In feeding crate	2.19	7.67	1.38	0.001

Effect of time of day

Behaviors; Chewing, in feeding crate and lying

An effect of time of the day was found for chewing and in feeding crate ($p < 0.05$ and $p < 0.001$ respectively). Chewing on silage was performed more often during the afternoon (PM) and sows were more often in the feeding crates during the morning (AM). No significant difference could be found for the behavior lying (table 4).

Behaviors; Other

The behavior active (waiting and walking/running) differed significantly between time of day ($p = 0.004$). The sows spent more time active during morning compared to the afternoon. No significant differences were found for sitting, standing, lying, rooting silage and rooting straw due to that each of these behaviors had occurred less than 1 % of the time.

Table 4. Effect of time of day on activity behavior with LS-Mean of percent of the behavior that occurred per treatment, standard error (pooled) and p-value

	Time of day			
	AM	PM	SE	p-value
Chewing	50.4	60.2	5.03	0.021
Lying	32.5	29.72	0.19	0.513
In feeding crate	7.16	2.36	0.98	0.001

Effect of observation week

Week did not affect the frequency of behaviors performed. However the result showed that approximately 50 % of the sows in both treatments chewed on silage during all time observed and one third of the sows were lying down. Over all being in the feeding crates showed a small numerical increase in performed behavior during the entire period (table 5).

The behaviors drinking and standing were decreasing during the entire period, from 3.39 % - 2.86 %, and 1.35 % - 0.589 %, respectively. Standing was the only behavior that showed a trend towards a significant difference between weeks ($p = 0.07$). Rooting silage, rooting straw and sitting varied each week, but occurred on average around 0.25 % of the time.

Table 5. Effect of observation week on activity behavior with LS-Mean of percent of the behavior that occurred per treatment, standard error (pooled) and p-value

	Week				
	w.1	w.2	w.3	SE	p-value
Chewing	54.5	50.5	60.9	5.44	0.118
Lying	32.2	35.2	26.4	6.45	0.240
In feeding crate	3.37	4.42	4.74	1.30	0.403

Video observations

The results from the video observations showed that treatment had an effect on duration time ($p < 0.001$) whereas time of day was unaffected ($p > 0.05$) (table 6). Sows in treatment 60 had 52 % shorter duration time from the feeding crates opened until chewing on silage, compared with sows in treatment 100.

Table 6. Effect of treatment (60, 100) and time of day (AM, PM) on duration time from feeding crate until chewing on silage with LS-Means and standard error in minutes and seconds and p-value

	LS-Means	SE	P-value
Treatment			0.001
60	07:16	01:22	
100	15:03	02:53	
Time of day			0.706
AM	10:45	02:03	
PM	10:10	01:56	

According to table 7, sows in treatment 60 had a lower mean value of time elapsing from when the feeding crates opened up until the sows were chewing on silage, both morning (AM) and in the afternoon (PM) compared with sows in treatment 100. No effect of time of day within treatment could be seen.

Table 7. Mean value, standard deviation, minimum and maximum time in hours, minutes and seconds elapsed from that the feeding crates opened up for sows in treatment (60, 100) and time of day (AM, PM) until chewing on silage

	Mean	SD	Min	Max
AM				
Treatment 60	00:08:44	00:16:04	00:00:17	1:44:30
Treatment 100	00:18:16	00:33:36	00:00:20	3:01:46
PM				
Treatment 60	00:08:15	00:12:51	00:00:12	1:36:38
Treatment 100	00:17:31	00:18:07	00:00:22	1:07:37

Weight and backfat thickness

The results from the weight of sows showed that in total 35 of 39 sows gained weight from the first to the last observation week. The four sows that lost weight was in treatment 60 and the total weight loss was between 1.4 and 9.0 kg. From the first to the last ultrasonic test, 27 of 39 sows lost between 0.5 – 3.0 mm fat thickness. Ten of twelve sows of those who lost backfat thickness were in treatment 60. No interaction between weight- and fat loss could be seen when analyzing the result from the individual sow.

Sow's in treatment 60 had in general a lower average weight gain and backfat thickness gain compared with the sow's in treatment 100 (table 8).

Table 8. Mean value, standard deviation, minimum and maximum weight gain or loss and gained or reduced backfat thickness for sows in treatment 60 and 100, from the first to the last week

	Mean	SD	Min	Max
Treatment 60 %				
Weight (kg)	6.06	7.13	-9.00	19.5
Backfat thickness (mm)	0	1.61	-3.00	3.00
Treatment 100 %				
Weight (kg)	15.6	5.80	1.00	24.0
Backfat thickness (mm)	1.24	1.32	-1.00	4.00

When comparing weight and backfat thickness between treatments, a significant effect was found ($p < 0.05$ for both), with a higher weight- and backfat thickness gain for sows in treatment 100. There were no significant interactions between pens (table 9).

Table 9. Effect of treatment (60, 100) and pen (1, 2) on weight gain or loss and gained or reduced backfat thickness with LS-Mean, standard error (pooled) and p-value

	Treatment		SE	P-value	Pen		SE	P-value
	60	*100*			*1*	*2*		
Weight (kg)	6.56	15.7	1.57	0.002	12.0	10.2	1.57	0.416
Backfat (mm)	0.0	1.22	0.353	0.013	0.272	0.950	0.353	0.153

Production data

Registration of pig production data was only performed to ensure that the lower amount of concentrate feed did not affect the pig production in a negative direction. Therefore this data was not statistically analyzed. The results presented in the work are mean values, standard deviations, minimum and maximum values.

Treatment 60

On average 13.7 piglets were born per litter, including 1.44 stillborn piglets. A total number of 247 piglets were born, of which 26 were stillborn (10.5 %) (table 10). Eleven out of 18 sows gave birth to stillborn piglets and three gave birth to more than two stillborn piglets. One sow gave birth to 20 piglets where of 7 were stillborn and one of those was rotten. In total two stillborn piglets were rotten and one piglet had a malformation on one hind leg, the rest was completely developed.

In total 176 piglets (79.6 %) of the total number live born were weaned and the average weaning weight was 11.2 kg (table 10).

All sows lost body weight during lactation except for one that kept the same weight during the whole lactation period. On average the sows lost 13 kg from farrowing to weaning and lost 3.1 mm backfat thickness (table 10). All sows except two lost backfat thickness that ranged between 1 – 6.5 mm.

Table 10. Mean values, standard deviations, minimum and maximum values for total number of basic production traits for sows within treatment 60

	Treatment 60				
	N[1)]	Mean	SD	Min	Max
Piglets					
Total number born	18	13.7	2.37	11	20
Number live born	18	12.3	1.64	8	15
Number stillborn	18	1.44	1.82	0	7
Number weaned	18	9.80	1.99	4	12
Birth weight (kg)	18	1.78	0.466	0.440	20.6
Weight weaning, 5 w (kg)	18	11.2	0.547	3.30	18.3
Sow					
Weight farrowing (kg)	18	273	23.0	231	314
Backfat farrowing (mm)	18	16.7	3.80	11.0	28.0
Weight weaning (kg)	18	260	24.3	216	305
Backfat weaning (mm)	18	13.6	3.38	7.0	21.5

1) N is the number of sows the results are based on.

Treatment 100

On average 14.4 piglets were born per litter, including 1.35 stillborn piglets. A total number of 244 piglets were born, of which 23 were stillborn (9.4 %) (table 11). Eleven out of 16 sows gave birth to stillborn piglets and four sows gave birth to more than two stillborn piglets.

Three sows gave birth to one mummified piglet each. In total four stillborn piglets were rotten and the rest was completely developed.

In total 169 piglets (77.2 %) of the total number live born were weaned and the average weaning weight was 10.7 kg (table 11).

All sows lost body weight during lactation except for two that kept the same weight during the whole lactation. In average the sows lost 15 kg from farrowing to weaning and gained 1.6 mm backfat thickness (table 11). Only five sows lost backfat thickness that ranges between 2.5 – 7.5 mm.

Table 11. Mean values, standard deviations, minimum and maximum values for total number of basic production traits for sows within treatment 100

	Treatment 100				
	N[1)]	Mean	SD	Min	Max
Piglets					
Total number born	16	14.4	2.42	7	17
Number live born	16	12.9	2.52	6	16
Number stillborn	16	1.35	1.46	0	5
Number weaned	16	9.94	2.11	6	14
Birth weight (kg)	16	1.59	0.209	0.400	2.64
Weight weaning, 5 w (kg)	16	10.7	1.06	3.90	15.4
Sow					
Weight farrowing (kg)	15	277	20.0	249	320
Backfat farrowing (mm)	15	15.6	1.49	13.0	17.5
Weight weaning (kg)	15	262	23.6	222	304
Backfat weaning (mm)	15	17.2	5.0	9.0	25.0

1) N is the number of sows the results are based on.

DISCUSSION

Animal welfare in today's society is an important aspect. We get more and more aware of how animals in our surroundings are taken care of (Broom & Johnson, 1993). Good welfare for many people is if the animal has possibilities to perform a natural behavior and don't experience suffering (Fraser *et al*., 1997). The pig is a very curious animal and most of their active time they explore their surroundings by rooting, sniffing or chewing and their distinct purpose is either to find food or an attractive place to lie down (Wood-Gush & Vestergaard, 1989). The feeding regimes in today's production of gestated sows often eventuate with a feeling of hunger and a need to perform a feeding behavior directly after feeding (Rushen, 1985). Mostly because the sows are given a restricted amount of concentrate feedstuff and the feeling of saturation is not fulfilled (Brounse *et al*., 1995).

Sows in this project in treatment 100 spent 46.6 % of the time chewing. That is almost half of the time spent on feeding which can be an expression of that their feeding behavior was not fulfilled although the sows received a full feed ratio which is acceptable in today's sow production. This is also showed by Brouns *et al.* (1995) that a normal feed ratio of approximately 3 kg is not more then 40 to 60 percentages of what the sows would eat if she were fed *ad lib.* The sows in treatment 60 differed from treatment 100 and they spent almost 20 % more of the time chewing which indicate that these sows were more motivated to eat silage due to lower feed ratio. This data is also consisted with those of Lawrens *et al.* (1988) who performed studies on feeding motivation trying to measure hunger by 'operant conditioning', where pigs have to press a panel to obtain food rewards. Their results showed that pigs given a lower amount of their normal daily feed ratio had a higher motivation to perform the behavior.

Very few registrations of sows rooting during the live observations in our study were seen and no differences could be seen between treatments, time of day or observation week. It is possible that the *ad lib.* access to silage reduced the need for just rooting because the silage was easy to manipulate and chew.

More sows were 'active' during the morning compared to the afternoon. The behavior 'active' could be a sign of that after a night of sleep the sows are hungry and more motivated to perform a feeding related behavior. Almost at all times after the sow had been eaten the commercial feed she ended up moving from one feeding crate to one other, performing an oral manipulation on the interior and floor in each feeding crate. Brouns *et al.* (1994) showed that sows fed with restriction searched for food on the ground for at least one hour after that she had consumed her feed. That supports the oral manipulation of interior and floor performed after commercial feeding in our study.

When comparing part of the day the results showed that the sows spent almost 5 percentages more time in the feeding crates and 10 percentages less time chewing on silage in the morning compared with the afternoon. The reason that the sows spent more time in the feeding crates in the morning is hard to explain. It could be a combination of that the sows were more active during the morning as well and moved from one feeding crate to another. One other explanation could be that some sows spent time lying down in the feeding crate during a very long period after feeding and it is possible that this behavior occurred more during the morning. To get a more accurate result it should be taken into account whether the sows were in the feeding crate in the purpose of feeding related behavior or something else.

The higher frequency of drinking behavior in treatment 60, could be due to that the sows ate more roughage. However, the results could be misleading because the behavior had a high invalid standard error due to that only one sow could drink at the time and the results were only based on the number one and zero, i.e. if a sow was drinking or not. Our results is not comparable to the results by Pollmann *et al*. (1979) who could not see any significant differences between treatments regardless if the sows were given 90 percentage alfalfa hay or only corn- and soybean meal.

Observation week did not affect any behavior. This might indicate that one week acclimatization period was enough to get the sows used to the silage. Otherwise more changes might have appeared as the weeks passed. The only behavior that had a trend towards significance between weeks was standing, with only half as much sows standing in week three compared to week one and two. What this depends on is hard to say. But because 'stand' is a position which occurs just a short moment before walking or doing something else, it might probably not be more than a coincidence that it tended to be significant. This is because the pens were scanned only every second minute and it is possible that the sows that was standing still started to perform another behavior directly after the scan was made.

The results from the video observation showed that the sows in treatment 60 had a shorter average duration time from that the feeding crates opened up until chewing on silage both morning and afternoon. Their average duration time was half of the mean value for the sows within treatment 100. When comparing the amount of feed reward in operant conditions with pigs receiving 100 or 60 percentage of their *ad libitum* amount of concentrate feed there is a significant difference in food rewards, where the pigs with the lower amount has three times as much food reward one hour post feeding (Lawrence & Illius, 1989). The shorter duration time in our study could indicate that the sows given a lower amount of commercial feed were more hungry compared to the sows given full feed ratio and therefore more motivated to eat silage.

At almost all time the sows that didn't eat silage directly after the feeding crates had opened, almost always went to sleep. Pigs fed with a more fibrous diet compared to a low fiber diet with the same total daily energy intake have an increased time spent lying down (Robert *et al.*, 1993; Bergeron *et al*., 2000). Bergeron *et al*. (2000) also showed that sows given *ad lib.* access to a low fiber diet compared with sows on restrictions with high fiber diet spent significantly more time lying down. This could indicate that the *ad lib.* access to silage in our study gives a calming effect and assumptions can be drawn that lying down could be a sign of satiety. In this project the live observations showed that sows in treatment 100 had significantly more time lying down compared to treatment 60. The higher frequency of lying down in treatment 100 in our study could therefore be a sign of that the sows given treatment 60 needed more time chewing on silage (which they also had) to obtain the same amount of filling in the stomach and to get the feeding motivation obtained before lying down. In the afternoon all sows ate silage in combination with a period of sleeping. This could be due to that they had a larger filling in the stomach and a feeling of saturation. Meunier-Salaün *et al*. (2001) showed that sows given fibrous diets indicate a more constant nutrient absorption and greater microbial fermentation which might increase satiety. Because the sows in our study were given *ad libitum* access to high fiber diet it might have given them saturation, in theory all day round, with an increased feeling of satiety.

During the treatment periods sows from treatment 60 had in average lower weight– and backfat thickness gain compared to treatment 100. Stenberg (1993) showed that even if sows

were given the same energy intake, sows given 50 percentages of recommended commercial feed ratio and silage lost more weight than sows fed with only commercial feed. When comparing the results from the production data the average values did not differ much between treatments. Stenberg (1993) showed that there was no effect on total piglets born and weaned and the piglets weaning weight on sows given only commercial feed or 50 percentage commercial feed and free access to silage. In our project the average total number piglets born was numerically lower among sows in treatment 60 compared with sows in treatment 100 but the mean value for piglet birth weight was higher in treatment 60 compared to treatment 100. When comparing our mean values, on total piglets born, with the results from commercial herds (Quality Genetics, 2010), it was found that both treatment 60 and 100 had a higher number of born piglets, 13.7 and 14.4 respectively, compared to 12.7 in the commercial herds. However, more stillborn piglets, 1.44 and 1.35 respectively, was found in our study compared with the commercial 1.0. Our results also indicates a lower number of piglets weaned (9.8 and 9.9 vs. 10.5). Thus, in total 20.4-22.8 % piglets died before weaning in our study compared to 17 % in commercial herds. Considerations should be taken into account that our study was performed on a research station and our production data was not statistically analyzed. It might therefore not be completely comparable.

Lodge *et al*. (1961) found that weight gain during gestation fallowed a pattern but a fluctuation in rate of gain got more marked with each succeeding pregnancy and there was a consistent increase in rate of gain during the fourth week. Everts (1994) suggested that a moderate net body weight gain of sows is approximately 34 kg for first parity, 29 kg for 2nd parity sows, 25 kg for 3rd parity sows and 20 kg for older sows. In our study some sows lost weight. This could indicate that some sows had a harder time compensating the loss in energy from the commercial feed with silage.

In total, 22 of 34 sows had one or more stillborn piglets. Maes *et al.* (2004) showed a significant correlation between low backfat in the end of the gestation with a high percentage of stillborn piglets, and sows which had 14 – 15.5 mm backfat or more had a lower percentage of stillborn piglets. In this study, only 5 of 22 sows with stillborn piglets had a backfat lower than 14 mm. LeCozler *et al.* (2002) showed that a reduction in the average birth weight of the litter, and many piglets born alive, increased the risk of having mummified piglets. The sows in our study that gave birth to mummified piglets had 15, 15 and 12 total piglets born and the average birth weight of the litters was 1.49, 1.28, 1.54 kg, respectively. These values didn't vary much from the other sows, however due to unanalyzed and small number of data, no conclusions on mummifications can be made.

CONCLUSIONS

The sows given 60 percent of recommended feed ratio spent more time chewing on silage and had twice as short duration time from that the feeding crates opened up until chewing on silage for the first time. This indicates that sows given a lower feed ratio had a higher motivation to eat silage compared to the sows given full feed ratio. Weight and backfat thickness gain differed and was lower among sows in treatment 60. However this did not have any negative effect on piglet production.

The conclusion is that sows given a lower amount of commercial feed can compensate their energy intake due to a higher motivation to eat silage and probably also fulfill a feeling of satiety. The lower feed ratio had no major effect on the pig production. It should be taken in consideration that the sows were fed the different diets in no more than total four weeks of their pregnancy. Therefore the production results can be deceptive. To get a more accurate result the diets should be given during their whole pregnancy.

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APPENDIX 1

Table 1. Information on gestation week when the study began, parity number and additional information for each sow in the study

Number of sows	Gestation week	Parity number	Additional information
Group 1, 100 %			
1	5	9	
2	4	9	
3	4	9	
4	4	9	
5	5	9	
6	4	7	
7	4	9	
8	4	9	
9	x	7	Returned to estrus 100227
Group 2, 60 %			
1	9	4	
2	5	6	
3	4	6	
4	5	4	
5	3	6	
6	5	4	
7	x	4	Returned to estrus 100218
8	8	4	
9	3	6	
10	x	6	Not pregnant, culled
Group 3, 60 %			
1	7	7	
2	7	7	
3	7	7	
4	x	7	Returned to estrus 100419
5	9	6	
6	x	6	Not pregnant, culled
7	3	8	
8	5	6	
9	3	9	
10	9	6	
Group 4, 100 %			
1	x	4	Not pregnant, culled
2	4	4	
3	9	4	
4	6	4	
5	x	4	Not pregnant, culled
6	10	4	
7	3	4	
8	5	4	
9	4	4	
10	10	4	

APPENDIX 2.

Table 1. Chemical composition of grass silage (g/kg DM)

Grass-silage, g/kg DM			
DM 62.6 %			
Ash	Crude protein	Crude fiber	Crude fat
65	80	308	13

DM = Dry matter

Table 2. Calculations for MJ/kg DM and MJ/kg (Simonsson, 1994)

	g/kg DM		Dig. coeff		Dig. subst.		kJ/g dig. subst.		kJ	
CP	80	x	45	=	3600	x	18.4	=	66240	
EE	13	x	40	=	520	x	32.7	=	17004	
NFE	534	x	60	=	32040	x	16,8	=	538272	
CF	308	x	35	=	10780	x	14,7	=	158466	
									779982	= 7.8 MJ/kg DM
										= 4.9 MJ/kg

CP = Crude protein, EE = Ether extract (Crude fat), NFE = Nitrogen free extract (1000 – ash – CP – EE - CF), CF = Crude fiber

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