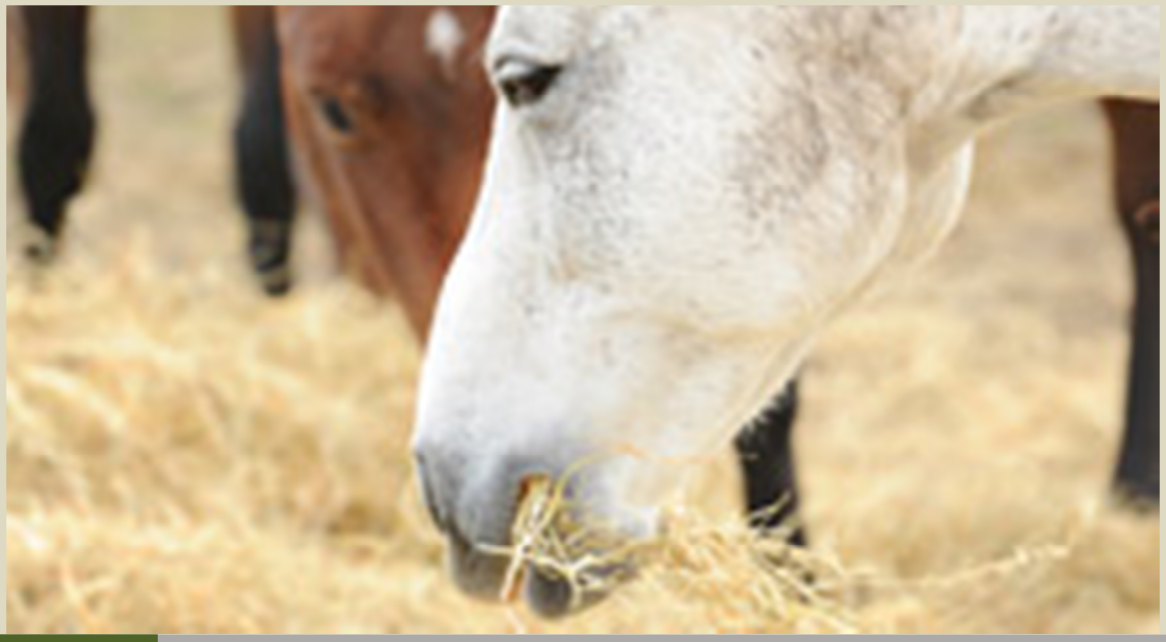


BACHELOR THESIS

COMPARISON OF METHODS USED TO EXTENT THE TIME OF HAY UPTAKE IN HORSES

Anne Nettersheim

Animal Husbandry/Equine Leisure and Sports

10.02.2014 – 03.07.2014

Career Counsellor:
Tom Wiggers, Van Hall Larenstein, Wageningen

Internal Supervisor:
Sandra van Iwaarden, Van Hall Larenstein, Wageningen

External Supervisor:
Dr. Uta König von Borstel, Georg-August Universität, Göttingen

Student Number: 900903001

Anne Nettersheim
An der Hasenhecke 11
D-53902 Bad Münstereifel
anne.nettersheim@wur.nl
+49 1577 96 94 73 9

Handed in on: 3.7.2014
Handed in at: Info Point, Van Hall Larenstein, Wageningen

To Mum

With Love and Gratitude

Abstract

Domesticated horses are often fed in few and big rations, which leads, in total, to a much shorter feeding time than the natural time of 12 to 18 hours per day. In praxis, several methods are used to extent the feeding time of hay uptake. In the present study three methods (4 x 4 cm hay net, hay and straw mixture, and grazing muzzles) and the control method “loose hay” were compared on their effect on the feeding time (min/kg) and the feeding rate (g/min) of hay. The experiment included 12 horses between 4 and 25 years. Each horse was fed with each method for five days twice a day for around 30 minutes. Offering hay in hay nets with a mesh size of 4cm x 4cm has the greatest effect on the feeding time and the feeding rate compared to loosely fed hay and a hay/straw mixture (50:50). The feeding time for the hay net (66.12 minutes needed to feed one kilogram of hay) is almost twice as much as for the loose hay (34.51 min/kg). In correlation to this, the feeding rate for the hay net (17.46 g/min) is around half as much as for the loose hay (31.42 g/min). The effect of mixing hay and straw (37.99 min/kg; 28.74 g/min) is not significant in comparison to the feeding time and feeding rate of loosely fed hay. Nevertheless, a trend towards increased feeding time can be seen. The grazing muzzles turned out to be not useful to extent the feeding time or reduce the feeding rate of hay, as they prevent hay intake. In order to extent the feeding time, hay nets with a mesh size of 4 x 4 cm are recommended. Furthermore, it is recommended to research the effect of different mixing ratios of hay and straw, as well as different mixing intensities. Studies on the long term effects of this method are reasonable.

Table of Content

List of Tables

List of Figures

1. Introduction

The digestive tract of the horse is physiologically designed in order to digest large amounts of fibrous plant material with a low amount of energy. In order to meet their nutritional needs, feral horses spent many hours on grazing. Domesticated horses are mostly fed with high-energy diets which refill their nutrient stores faster than the original low-energy diet. This would ideally imply that domesticated horses should spend less time on feeding in order to not exceed their requirements. Though, the behaviour scheme of feeding many hours seems to be inherited (Zeitler-Feicht, 2008).

The number of obese horses is increasing. In 1998 the National Animal Health Monitoring System (NAHMS) of the United States Department of Agriculture (USDA) found that 4.5% of the American horse population is obese. More recent studies show a strong increase. According to Thatcher *et al.* (2012) 32.3% of the horse population in Southwest Virginia are overconditioned and 18.7% are obese. In the UK, Stephenson *et al.* (2011) found that 20.6% of the horses are overweight. The highest number of obese leisure horses was found in Scotland with 45% (Wyse *et al.*, 2008).

Obesity bears life-threatening risks. The adipose tissue in obese horses is no longer regarded as calorie storage organ but as highly active metabolic organ which produces pro-inflammatory substances (Pratt-Phillips *et al.*, 2014; Meyer and Coenen, 2014). These substances affect the appetite and repletion, as well as the glucose- and lipid metabolism, the regulation of the blood pressure, inflammation and the immune-function (Meyer and Coenen, 2014). Health issues associated with obesity are e.g. laminitis; lipomas, which can cause colic; and the affection of the horse's heat tolerance (Pratt-Phillips *et al.*, 2014). Therefore, horse owners often wish to increase the feeding time for the normal hay ration of their horse, as this satisfies this innate feeding behaviour, and makes it possible to manage the calorie intake and therewith the health of their horse.

The effects of some of the methods used to achieve an increase in the feeding time of hay are investigated in this study. The methods "hay net (mesh size 4 x 4 cm)", "grazing muzzle", "hay/straw mixture (50:50)" and "loose hay" are tested in a quasi-experimental setting with a sample size of 12 horses for 5 days per method. Chapter 2 provides background information with regard to existing literature; the methodology is further described in chapter 3. The results are described and discussed in chapter 4 and 5. Chapter 6 and 7 include conclusions and recommendations.

2. Literature Review

The natural nutrition of horses contains low amounts of energy and high amounts of crude fibre. Therefore they need a long feeding time until their nutrient requirements are met. Horses are used to spend 12 to 18 hours with feeding behaviour per day (Zeitler-Feicht, 2008). During feeding the horses are slowly walking around, up to 10 kilometres per day (Schöning, 2014). Duncan's (1980) observation of semi-free-living camargue horses showed they are foraging between 12 to 15 hours per day. Here the foraging time was mainly influenced by age, gender, season and reproductive status. A study of Boyd *et al.* (1988) determined an average foraging time of 11 hours per day for captive Przewalski horses in a National Zoological Park in the USA. Sweeting *et al.* (1985) found that the time domesticated horses spent on feeding is similar to the foraging time of feral and free-ranging horses. According to Zeitler-Feicht (2008) horses seldom feed less than 12 hours per day even if their nutrient requirements are met as this is an inherited component.

Studies on the feeding rhythm of stabled horses with an *ad libitum* access to roughage show that horses divide their feed into several small meals (around 10) per day (Pirkelmann *et al.,* 2008). This complies with the findings of Krull (1984), as cited by Zeitler-Feicht (2008), who determined the feeding rhythm of horses on pasture. In addition to this, it is important to consider the size of the horse's stomach which is relatively small (15-20 litres) (Meyer and Coenen, 2014). Therefore, they are not able to store feed in the stomach. The feed continuously moves along the digestive tract. The digestive tract always needs to be filled, otherwise health issues, such as gastric ulcers and/or life threatening colics, can occur (Schöning, 2014; Zeitler-Feicht, 2008). Horses which get too less roughage are prone to develop stereotypic behaviour such as crib-biting or air-sucking (Schöning, 2014; Zeitler-Feicht, 2008). Also teeth sharpening and wood chewing are possible consequences of feeding roughage inappropriately (Zeitler-Feicht, 2008).

Moreover, the horse's stomach does not have distension receptors that indicate the filling state. Therefore, another system is needed to give the signal for the horse to stop feeding. This is either done by the motivation to execute another behaviour scheme or by the satisfaction of the chewing need (Zeitler-Feicht, 2008). Consequently, it is necessary to provide horses with enough roughage to enhance the chewing. Horses chew 1 kilogram of hay with around 3256 chews, and 1 kilogram of straw with 3645 chews, whereas 1 kilogram of oats (untreated) is fed with 832 chews, and 1230 chews are needed for crushed oats (Meyer *et al.*, 1975).

Meyer and Coenen (2014) state that horses naturally are able to regulate their energy levels on the long run. Yet this ability is affected by the current diet of the horses, which is not part of the wild horses' diet, such as any kind of concentrates, and further by the changes in their rhythm of feed intake (longer intervals between rations), as well as by the often missing feed alternatives. These factors cause the energy level regulation system to be not effective anymore. Meyer and Coenen (2014) state further, that feed intake is also regulated by the energy density in the feed. This system only works reliably, if the horse is fed with low-energy feed, such as older grass or roughage. In case, the horse is fed with concentrated feed, or young and well digestible grass, this system does not work, which leads to excessive energy intake, and related to this to a higher fat deposition. Especially extensive breeds naturally have a higher physiological fat deposition capacity.

Nowadays, horses are often fed with high-energy roughages in few big rations and varying amounts of high-energy concentrates. This does not comply with their natural feeding behaviour. Another issue are pleasure and sedentary horses that have a high consumption capacity and an increased risk for obesity, unless their forage allowance is restricted (Jansson *et al.*, 2012). In order to keep the horses healthy and to avoid stereotypic behaviour related to an unsatisfied foraging behaviour, they should be fed as appropriate to the species as possible.

In practice, several methods are used to extend the feeding time per ration in order to get closer to the natural feeding time. These methods are amongst others to mix palatable (e.g. hay) with less palatable feed (e.g. straw), or to feed a more fibrous (voluminous) feed containing less energy, or to use grazing muzzles, slow feeders or other saving devices (Zeitler-Feicht, 2008).

Previous studies came to the conclusion that hay nets with small meshes significantly increase the time of hay uptake in horses (Zeitler-Feicht and Walker, 2005; Ellis *et al.*, 2012). In addition, Longland *et al.* (2011) and Longland *et al.* (2012) determined grazing muzzles to be highly effective in reducing the pasture intake of ponies, independent from the season. Whereas, restricted grazing is not effective in ponies, as they are able to more than double their feeding rate (Longland *et al.*, 2011). The use of slow feeding systems also proved to be effective in increasing the intake time of roughage (Hallam *et al.*, 2012), whereas the design of round-bale feeders does not affect the hay intake of horses (Martinson, 2012).

Further, Hallam *et al.* (2012) found that with the use of slow feeders stressful feed times were removed, which had a positive effect on the behaviour and the welfare of the horses. They pointed

out that horses with light to medium work level can be maintained with slow feeding systems offering low energy and high forage roughage.

The aim of this study was to compare and evaluate the effects of 4 x 4 cm hay nets, grazing muzzles and mixtures of hay and straw on the feeding time (min/kg) and the feeding rate (g/min) in healthy non-robust leisure horses.

3. Material and Methods

3.1. Research Design

Desk research was carried out by using mainly primary and secondary literature in order to support this study with a literature review and to compare and evaluate the research results with the existing literature. Furthermore, field research was used by setting up a quasi-experiment. Every horse of the sample participated in every test. The independent variable was the feeding restriction method (hay net, grazing muzzle and hay/straw mixture), and the dependent variable was the feeding time (measured in min/kg), as well as the feeding rate (measured in g/min).

3.2. Data collection

Sample Description

The sample includes 12 horses [n = 12] with the following characteristics:

The horse…

1. must be stabled in a way that it could not be disturbed by other horses during ingestion,
2. must be fed in rations,
3. must be prevented from feeding bedding material during the tests,
4. must have an intact dentition,
5. must be a non-robust breed (e.g. Warmblood, Thoroughbred),
6. must be older than 4 years and younger than 20 years, unless an intact dentition can be ensured.

It was crucial that the horses had an intact dentition, as this has a great impact on the ingestion of the roughage. According to the horse owners the horses did not have any dental issues during the last year, were checked by a veterinarian or a horse dentist regularly, and did not show abnormal feeding behaviour. Very young and older horses were excluded from the research to exclude age-related dental issues, unless it was ensured the horses had no dental issues.

	Yard	Age	Breed	Gender	Average weight	BCS
Horse 1	1	22	Rheinländer	Mare	557,5	3
Horse 2	1	12	Westfale	Mare	596,5	3
Horse 3	1	4	Rheinländer	Mare	503,5	3
Horse 4	1	23	Swedish Warmblood	Gelding	642	3.5
Horse 5	1	25	Malaysian Polohorse	Gelding	547	3
Horse 6	1	21	Mecklenburger	Mare	702	4
Horse 7	2	11	Trakehner	Mare	561,5	3
Horse 8	2	19	Trakehner	Mare	634,5	3
Horse 9	2	19	Trakehner	Mare	621	3
Horse 10	2	5	Trakehner	Mare	530,5	3
Horse 11	2	20	Quarter Horse	Gelding	562	4
Horse 12	2	11	Trakehner	Gelding	601,5	3

Table 1 General data of the test horses (own elaboration)

The test horses (see general data in *table 1*) were stabled in two working equestrian yards; six horses per yard. In total there were eight mares and four geldings. Ten of them were warmblood horses, one polo horse and one quarter horse. The age of the test horses ranges between 4 and 25 years. They had around 500 to 700 kg of live weight, and body condition scores between 3 (good) and 4 (fat) (Carroll and Huntington, 1988). None of the horses showed abnormal feeding behaviour during the data collection. Three of twelve horses are regularly used for riding, the other nine horses are either former breeding or former sport horses and do not have a specific purpose at the moment. Four horses had health issues in their locomotory system and one horse in the respiratory system, which are not considered to be relevant for this study.

Usually, two sorts of self-made organic hay (fertilized with horse manure only and no use of herbicides and pesticides) were fed in turns at the first yard. Both sorts were from the same fields, whereof one was the first and the other one the second cut. The first cut contained more stems than leaves and had long fibres. The second cut hay contained more leaves than stems and had shorter fibres. Both were stored in round bales, whereof some parts were a little bit dusty. At the second yard, only one sort of bought hay was fed, yet in different qualities. The hay in general was also first cut, had more stems than leaves and long fibres, but was softer compared to the first cut hay of the

first yard. The hay was partly polluted with moss, fir cones and soil. The bad quality parts were not fed to the horses.

The two yards had the same feeding interval of 10 hours: the first yard started feeding at 8.00 o'clock and the second one hour later at 9.00 o'clock. During the study, the horses of yard two had access to the pasture between the two feedings in the morning and in the afternoon. They were taken into the boxes around one hour before the test feeding. At yard one the horses were accustomed to the pasture during the last days of the experiment, which resulted in less appetite during the afternoon feeding. At both yards the horses were stabled inside during the nights. Here they had only access to their straw bedding and the rest of their afternoon hay ration. Besides the hay and access to the fields, the horses in both yards were fed with concentrates (oats and barley mixture (1:3) in yard one and herbal muesli in yard two). Additionally all horses received mineral feed.

During the tests the horses were stabled in their boxes; at yard two they were taken out onto their paddock with the box doors closed in good weather (similar to Latin Square design) (see *figure 1*). They were stabled inside during rain in order to prevent the sample hay from getting wet. The straw bedding was a compromise, which had to be taken into account. It turned out to be not relevant in most cases; the horses rarely favoured the straw over the hay.

Figure 1 Example of test 3 (three horses in the front) and 4 (three horses in the back) during good weather outside on the paddock (own picture)

Test Description

There were four tests (see *table 2*) in total which were carried out with every participating horse:

Test 1	Feed 1.5 kg of hay in a net with a mesh size of 4 x 4 cm for about 30 min
Test 2	Feed 1.5 kg of hay while the horse wears a grazing muzzle for about 30 min
Test 3	Feed 1 kg of hay mixed with 1 kg of wheat straw for about 30 min
Test 4 – reference test	Feed 1.5 kg of hay without any feeding restriction for about 30 min

Table 2 Test description (own elaboration)

The hay rations were prepared and weighed before putting them into the stables. Then the horses got around 30 minutes time to feed on the hay. After the time was over, the rest of the hay was taken out of the stables and was weighed again. The horses that were wearing the grazing muzzles showed signs of frustration, such as scratching with the hoof on the ground, and trying to get rid of the grazing muzzle. For these horses the test time was shorter than 30 minutes in order to keep the frustration levels low. In order to weigh the hay in the hay and straw mixture, it needed to be separated from the straw. The remaining straw was weighed, as well, yet the weight was not used to calculate the feeding time and feeding rate for the straw. To ease the process of weighing IKEA shopping bags (*figure 1*) were used. These bags and small tons were used to offer the loose hay or the hay and straw mixture to the horse in order to be able to weigh the smaller particles of the hay as well. In this way the horses could feed in their natural feeding position: head low, one front leg in front of the other (step position); horses prefer to feed from the floor (Webster *et al.*, 2010). The remaining weight was processed with the following formulas (*equation 1* and *2*) into the feeding time min/kg and the feeding rate g/min:

$$\frac{t\ min}{a_1 kg - a_2 kg} = x\ min/kg$$

Equation 1 Feeding Time

$$\frac{a_1 g - a_2 g}{t\ min} = y\ g/min$$

Equation 2 Feeding Rate

The following definitions apply to both formulas:

a_1 = weight of hay ration before feeding,

a_2 = weight of hay ration after set timeframe (t),

t = timeframe in minutes.

The lowest point of the hung up hay net was 30 to 50 cm above the ground (BMELV, 2009). The hay nets were attached in a way that one wall could be used as a support during ingestion. At the first yard the wall was a box panel with horizontal and vertical metal bars. At the second yard the box wall was made of wood without leaving openings.

The grazing muzzle (*figure 2* and *3*) was purchased at Pferdesporthaus Loesdau. It is made of strong rubber, nylon netting and neoprene cushioning. It has four double sided hook-and-loop fasteners that can be attached to the halter of the horse. The rubber on the ground has a hole with approximately three centimetres in diameter.

Figure 2 Grazing muzzle (Pferdesporthaus Loesdau)

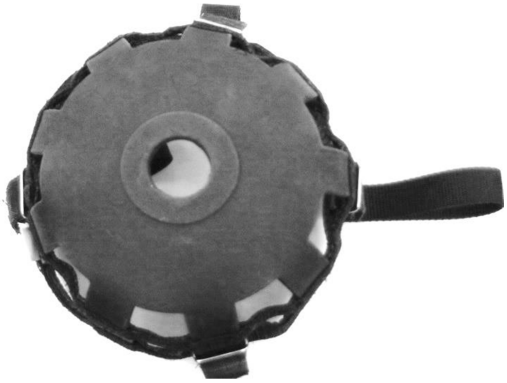


Figure 3 Bottom of the grazing muzzle (own picture)

All participating horses [n=12] joined each of the four tests. Each of the methods was applied to three horses at the same time. This setting was monitored for five days by measuring feeding time and feeding rate twice a day (in the morning and in the afternoon). After five days the methods were switched between the horses and again monitored for five days with two measurements per day. Again, after five days the methods were transferred to the next horses. This procedure followed the rotational structure shown in *table 3*. In total there were 480 measurements.

	Test 1	Test 2	Test 3	Test 4
	4 x 4 cm	Muzzle	Hay/straw	Lose hay
Horse 1	Day 1 - 5	Day 6 - 10	Day 11 - 15	Day 16 - 20
Horse 2	Day 1 - 5	Day 6 - 10	Day 11 - 15	Day 16 - 20
Horse 3	Day 1 - 5	Day 6 - 10	Day 11 - 15	Day 16 - 20
Horse 4	Day 6 - 10	Day 1 - 5	Day 16 - 20	Day 11 - 15
Horse 5	Day 6 - 10	Day 1 - 5	Day 16 - 20	Day 11 - 15
Horse 6	Day 6 - 10	Day 1 - 5	Day 16 - 20	Day 11 - 15
Horse 7	Day 11 - 15	Day 16 - 20	Day 1 - 5	Day 6 - 10
Horse 8	Day 11 - 15	Day 16 - 20	Day 1 - 5	Day 6 - 10
Horse 9	Day 11 - 15	Day 16 - 20	Day 1 - 5	Day 6 - 10
Horse 10	Day 16 - 20	Day 11 - 15	Day 6 - 10	Day 1 - 5
Horse 11	Day 16 - 20	Day 11 - 15	Day 6 - 10	Day 1 - 5
Horse 12	Day 16 - 20	Day 11 - 15	Day 6 - 10	Day 1 - 5

Table 3 Rotation plan (own elaboration)

3.3. Data processing

The data was processed with IBM©-SPSS© Statistics 20 and Microsoft© Office Excel 2010. In order to check, whether the sample is normally distributed, a Kolmogorov-Smirnov test and a Shapiro-Wilk test were performed with SPSS. Then, the sample was tested on the homogeneity of the variances. Furthermore, the one-way ANOVA test was carried out. As the result for *p* in the ANOVA outcome is $p < 0.05$, the Bonferroni test was used post hoc to figure out where exactly the differences are. Furthermore, the descriptive functions of IBM©-SPSS© Statistics 20 and Microsoft© Office Excel 2010 were used in order to support the results with relevant facts and figures.

4. Results

General observations

The data of test 2 (horses wearing a grazing muzzle) was not processable. The horses could not manage to feed hay through the grazing muzzles. All horses tried to get rid of the muzzle. Some of them calmed down after a while, and tried to eat, or stood still and waited until the test was finished. Only one horse damaged the grazing muzzle by pushing it onto a dividing box wall and biting into the rubber part (see *figure 4*). It was observed three times that some horses ate single stems of hay through the muzzle. It is presumed that the horses got these stems by coincidence. Therefore, this method was excluded from further analysis.

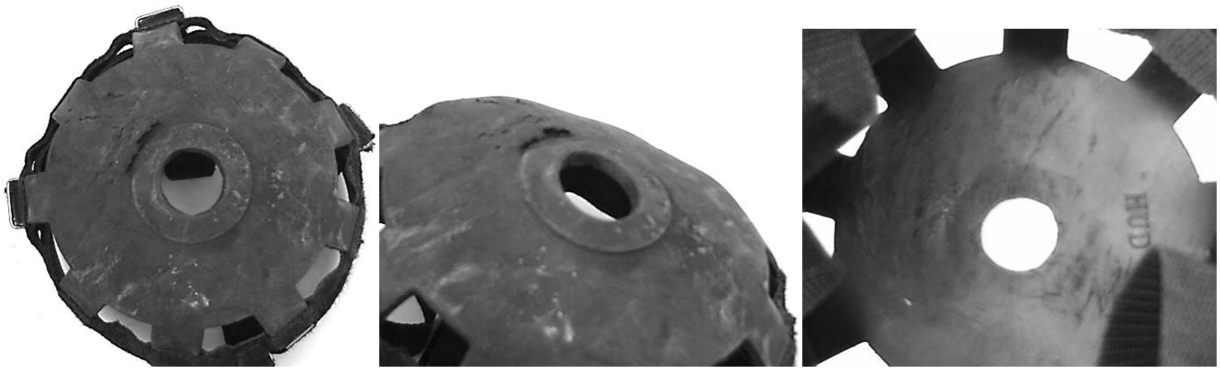


Figure 4 Grazing muzzle with signs of wear and tear (own pictures)

In one case the test horse continuously attacked the hay net by kicking at it with a front hoof during all ten measurements. This was not the case for the hay and straw mixture or the loosely fed hay.

Normal distribution

The Kolmogorov-Smirnov test and the Shapiro-Wilk test were used to check, if the sample is normally distributed. For both tests the p-value accounts p> 0.05; this implies that there is no significant difference between a normal distribution and the distribution of this sample. Therefore, the sample is expected to be normally distributed.

Comparison of means

The comparison of the means comes to the following results and is visualised with the help of box plots in *figures 5* and *6*. The average feeding time (min/kg) for the control group with loose hay is 34.51 min/kg; for the mixture of hay and straw 37.99 min/kg; and for the hay presented in hay nets with a mesh size of 4 x 4 cm 66.12 min/kg. The average feeding rate (g/min) for loose hay is 31.42 g/min; for the hay and straw mixture 28.74 g/min; and for the hay in hay nets 17.45 g/min. Small amounts of straw were fed as well. On average the horses fed less than 100 grams of straw per meal.

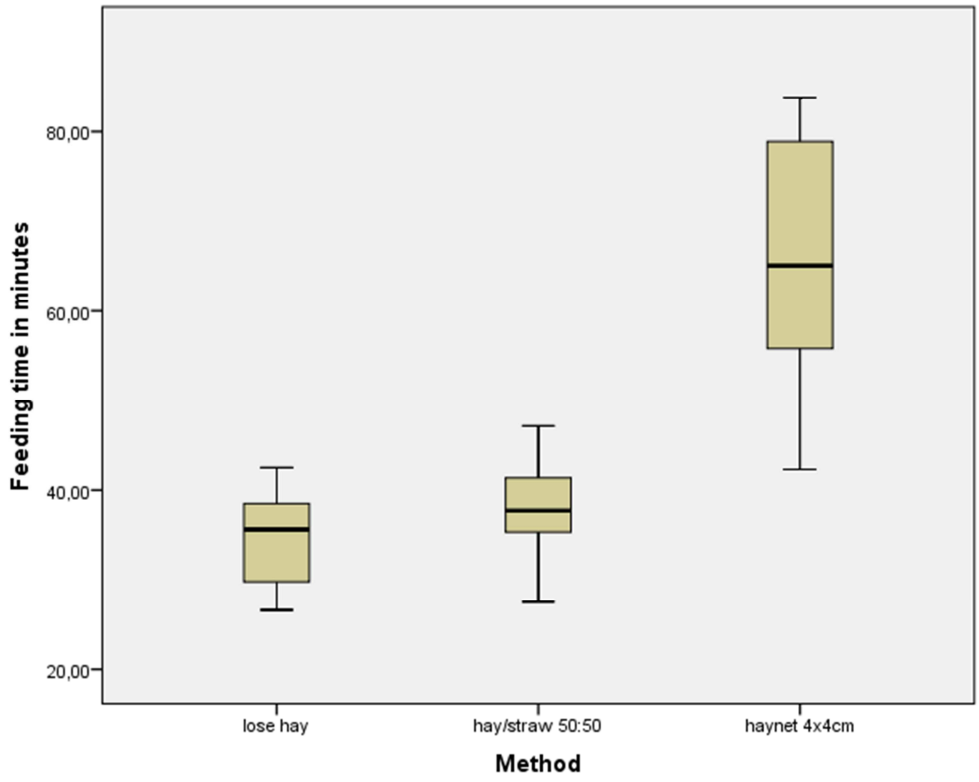


Figure 5 Comparison of the box plots for each feeding method regarding the feeding time (min/kg). The numbers are in minutes and relate to 1 kilogram of hay. (Own elaboration)

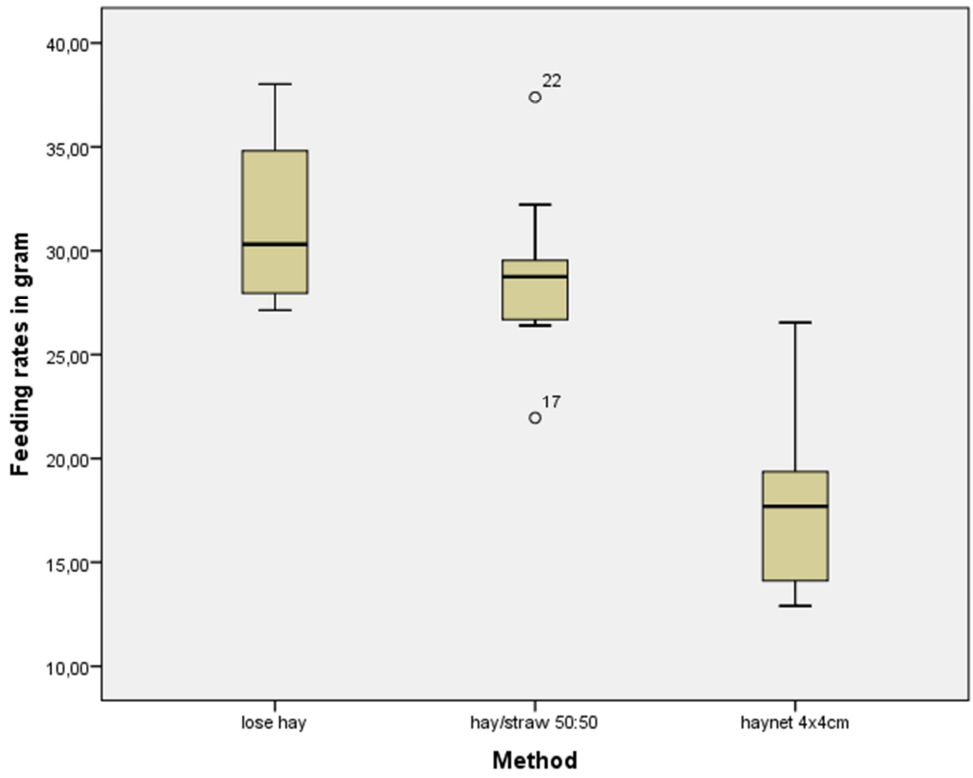


Figure 6 Comparison of the box plots for each feeding method regarding the feeding rate (g/min). The numbers are in gram and relate to 1 minute of feeding. (Own elaboration)

Variance homogeneity

The Levene's test was used in order to check the requirements (variance homogeneity) for the analysis of variances (ANOVA). The result for the feeding rate in the Levene's test is $p>0.05$, which means, this sample fulfils the requirements for the ANOVA, as it ensures variance homogeneity for this variable. This is not the case for the feeding time, here the p-value lies below the significance level ($p<0.05$). This means, that the variances of this variable are not homogeneous. Nevertheless, this result can be neglected because inhomogeneous variances are only a problem for uneven group sizes, which is not the case for the present sample.

Analysis of variances (ANOVA)

The ANOVA test gives $p < 0.001$ for both of the variables, the feeding time and the feeding rate. This means that there is a significant difference between the three groups. A Bonferroni test was conducted to figure out where exactly the differences are. According to the test, there are significant differences for both variables between the methods "loose hay" and "hay net" ($p< 0.001$), as well as between "hay/straw" and "hay net" ($p< 0.001$). Nevertheless, the two box plot charts in *figure 5* and *6* support the idea of a trend towards increasing the feeding time with hay/straw mixtures.

Spread of data

The error bars in *figure 7* indicate the spread of the data per measurement and method (see different colours). There is a chance of 95% that the gathered data points are within the range which is given by the lines of the error bar. The spread of the feeding time data for the hay net is greater than for the two other methods. This applies to the feeding rates respectively (see *error bar chart feeding rate* in the Annex p.22).

The number of the measurements is constructed as follows: the first cipher stands for the day of measurement (1 = day one (for this method); 2 = day two; […]), and the second one for the measurement on that day (1 = morning measurement; 2 = afternoon measurement). So, the number 11 stands for day one and measurement one.

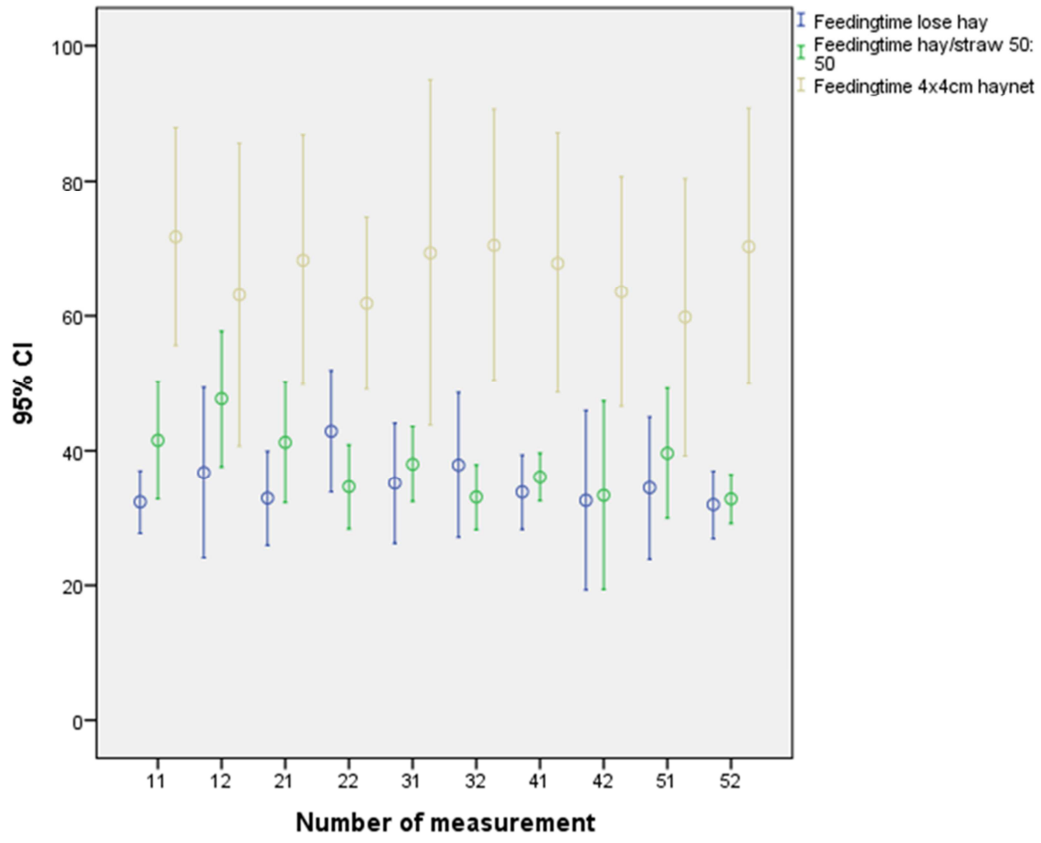


Figure 7 Error bar chart showing the spread of the data per method and with regard to time (the measurements). The level of significance is 95%. (Own elaboration)

Outcome in short

These results show, that the method "hay net" significantly increases the feeding time, and significantly decreases the feeding rate of hay uptake, in comparison to loosely fed hay. Moreover, the "hay net" significantly increases the feeding time, and significantly decreases the feeding rate of

hay uptake, in comparison with the hay/straw mixture. The spread of the hay net data is greater than for the methods “loose hay” and “hay/straw”. When comparing the methods “loose hay” and “hay/straw” the differences turned out to be not significant. The method “grazing muzzle” was excluded from further analysis because it turned out that the horses could not manage to feed roughage during the tests. Therefore, no usable data could be gathered.

5. Discussion

The determined feeding time of loose hay (34.51 min/kg) shows small differences to the numbers published by Zeitler- Feicht and Walker (2005) of 40 min/kg and Meyer *et al.* (1975) with 31 min/kg for leafy hay and 38.9 min/kg for stemmier hay. The average of the two feeding times of Meyer *et al.* (1975) is 34.95 min/kg. This is very similar to the average feeding time of the present study. This can be explained by the fact, that three sorts of hay were used, whereof one had more stems and one had more leaves. According to Meyer *et al.* (1975) ponies with 200-280 kg body weight need twice as long as big horses to ingest 1 kilogram of hay. They indicate that this might be due to the smaller chewing surface of the ponies’ teeth. Further, Meyer *et al.* (1975) found that the feed intake time is extended when the hay is shredded to chopped hay or hay meal because the horses are cautious about feeding these smaller particles and often interrupt the feed intake. This is not related to an extensive chewing activity.

Meyer and Coenen (2014), as well as Ellis *et al.* (2012) state that feeding hay in hay nets with a small mesh size (2.5cm x 2.5cm and 3cm x 3cm) increases the feeding time by 5min/kg on average in comparison to hay nets with larger meshes (7.5cm x 7.5 cm). Zeitler-Feicht and Walker (2005) indicate that there is no significant difference in the feeding rate between large meshed hay nets and loosely fed hay. Therefore, it is assumed that there is no significant difference in the correlating feeding time, as well. According to their study results and the present ones, the average difference in feeding time between loose hay and the small meshed hay net (4cm x 4cm) is much higher: 46 min/kg (loose hay 40 min/kg; hay net 86 min/kg) (Zeitler-Feicht and Walker, 2005) and around 32 min/kg in the present study. Therefore, the statement of Meyer and Coenen (2014), and Ellis *et al.* (2012) cannot be supported.

Furthermore, Glunk *et al.* (2014) compared the effect of different sized hay nets on the forage consumption. They found that in the same time period (4 hours) the horses consumed on average 95% of the hay offered loosely, 95% of the hay offered in large hay nets (15.2 x 15.2 cm mesh size), 89% of the hay offered in the medium (4.4 x 4.4 cm mesh size), and 72% of the hay offered in the small hay nets (3.2 x 3.2 cm mesh size). The horses feeding loose hay from the floor required less time than the horses feeding from hay nets. Whereas, the consumption rate for the control group and the large hay net group was the same. In contrast, the consumption rate decreased with the mesh size; the smaller the meshes, the slower the horses fed. These results are in line with the findings of Zeitler-Feicht and Walker (2005) mentioned above.

There is no data available to compare the present findings on the feeding time of the hay/straw mixture. No significant differences were found in comparison to the feeding time of loose hay. This might be due to the mixing intensity. For the present study it was crucial to be able to separate the two roughages from each other again, to weigh the rest of the hay and to find out, if straw was fed as well. Therefore, they were mixed bunch-wise. Only little amounts of straw were ingested. It is assumed, that the feeding time would be longer, when hay and straw are mixed with a higher intensity in a way that the horses have to separate stem-wise and not bunch-wise. Meyer *et al.* (1975) indicate that the stemmier the roughage the longer horses need to ingest it. For straw they give a feeding time of 45 min/kg, for stemmy hay 38.9 min/kg. This is also shown in the chews per kilogram, as shown in chapter 2.

Both, the measured feeding rate for loose hay and the hay net, show differences to the findings of Zeitler-Feicht and Walker (2005). For loose hay a feeding rate of 31.42 g/min was found, whereas Zeitler-Feicht and Walker (2005) measured 25.7 g/min. For the hay net the relation looks similar: 17.45 g/min in the present study and 12.3 g/min in Zeitler-Feicht and Walker (2005). The maximum values given by both studies are close to each other. Therefore, the differences in the average feeding rates are considered to be within the scope. Based on the large differences per measurement, it seems reasonable to divide the horses in groups regarding their feeding motivation, as Zeitler-Feicht and Walker (2005) did in their study.

It is presumed that the stems of first and second cut hay are too long to be handled by horses wearing grazing muzzles. Another important factor is the position of the stems. They are rarely lying upright on the floor, as grass does grow on the fields. Therefore, they are not easily accessible through a hole with 3cm in diameter. In relation to this, it is possible that also small feed particles,

such as concentrates cannot be accessed through the grazing muzzle. Moreover, it is assumed that leaving horses with fitted grazing muzzles in their box might bear a risk of injuries, especially when they are unobserved. Next to this, the grazing muzzle might hinder the horse from drinking out of automatic drinking troughs or buckets which are small in diameter. Then, there is the possibility that the grazing muzzle might get blocked with the roughage.

Ellis *et al.* (2012) found acclimatisation to the hay nets over time. This cannot be confirmed by the present study, neither for the hay/straw mixture nor the grazing muzzle. It must be taken into account that the study of Ellis *et al.* (2012) was established over a 10 day period, whereas the present study only observed the effects over five days. Moreover, Ellis *et al.* (2012) measured the results in grams/bite, which was not the case in this study. Also, Zeitler-Feicht and Walker (2005) found out that horses adapt to the use of hay nets when these are offered for three hours on four subsequent days. This cannot be compared to the present results as the adaptation time of in total twelve hours was not reached in the present study.

6. Conclusions

The results of this study concerning the feeding time and the feeding rate of loosely fed hay are in line with the findings of other studies.

It can be concluded, that offering hay in hay nets with a mesh size of 4cm x 4cm has the greatest effect on the feeding time and the feeding rate compared to loosely fed hay and a hay/straw mixture (50:50). The feeding time for the hay net (66.12 min/kg) is almost twice as much as for the loose hay (34.51 min/kg). In correlation to this, the feeding rate for the hay net (17.46 g/min) is around half as much as for the loose hay (31.42 g/min).

The effect of mixing hay and straw is not significant in comparison to the feeding time of loosely fed hay. Nevertheless, a trend towards increased feeding time can be seen.

The grazing muzzles turned out to be not useful to extent the feeding time or reduce the feeding rate of hay, as they prevent the hay intake.

7. Recommendations

In order to extent the feeding time, hay nets with a mesh size of 4 x 4cm are recommended. It is an effective tool to increase the feeding time of one hay ration and control the calorie intake of horses.

In the present study, adaptations to the different feeding restriction methods could not be observed. Trends that could indicate an adaptation were not found either. This might be due to the horses' daily condition or to the length of the experiment. Longer term studies are recommended in order to scrutinize the hay/straw mixture for adaptations. These should include at least 12 hours of observation (see Zeitler-Feicht and Walker, 2005). In order to receive reliable data, it is recommended to use the Latin Square design for further studies. In addition, the research design should be independent from weather conditions. Besides feeding in rations, pasture intake should be prevented, as this influences the appetite and feeding motivation. Additionally, the differences between feeding the horses only with the restriction methods with no "normal" feeding afterwards and with the "normal" feeding afterwards are another factor that could be taken care of.

Furthermore, it is recommended to research the effect of different mixing ratios of hay and straw. In the present study a 50:50 mixture was used. It is possible that a mixture containing more straw than hay has a greater effect on feeding time and rate than the present one. It is also suggested, to test different mixing intensities. Another possibility is to offer the hay and straw mixture in hay nets, instead of offering it on the floor.

References

1. Boyd, L.E., Carbonaro, A.D. and Houpt, K.A. (1988) The 24-hour time budget of przewalski horses. *Applied Animal Behaviour Science*, **21**, pp. 5-17

2. Carroll, C.L. and Huntington, P.J. (1988) Body condition scoring and weight estimation of horses. *Equine Veterinary Journal,* **20**, pp. 41-45

3. Duncan, P. (1980) Time-budgets of camargue horses: II. Time-budgets of adult horses and weaned sub-adults. *Behaviour*, **72**, pp. 26-49

4. Ellis, A.D., Fell, M., Luck, K., Gill, L., Gregory, A. and Harris, P. (2012) Effect of forage presentation on feed intake behaviour in stabled horses. *Forages and grazing in horse nutrition*, EAAP publ. No. **132**, pp.181-183

5. Glunk, E.C., Hathaway, M.R., Weber, W.J., Sheaffer, C.C., Martinson, K.L. (2014) The effect of hay net design on rate of forage consumption when feeding adult horses. *Journal of Equine Veterinary Science* [Online] Available at: http://www.j-evs.com/article/PIIS0737080614001737/abstract [Accessed at: 03.06.2014]

6. Hallam, S., Campbell, E.P., Qazamel, M., Owen, H. and Ellis, A.D. (2012) Effects of traditional versus novel feeding management on 24 hour time budget of stabled horses. *Forages and grazing in horse nutrition*, EAAP publ. No. **132**, pp. 319-321

7. Jansson, A., Saastamoinen, M., and Lindberg, J.E. (2012) Forage feeding systems. *Forages and grazing in horse nutrition,* EAAP publ. No. **132**, pp. 289-303

8. Longland, A.C., Barfoot, C. and Harris, P.A. (2012) The effect of wearing a grazing muzzle vs. not wearing a grazing muzzle on intakes of spring, summer and autumn pastures by ponies. *Forages and grazing in horse nutrition*, EAAP publ. No. **132**, pp. 185-186

9. Longland, A.C., Ince, J., Newbold, J.C., Barfoot, C. and Harris, P.A. (2011) Pasture intake in ponies with and without grazing muzzle and over time. In: *Proceedings of the 15th ESVCN Congress*, Zaragoza, Spain, 14-16 September 2011. Zaragoza, Spain: Unidad de Nutrición Animal, Dpt. Producción Animal y Ciencias de los Alimentos, p. 149.

10. Martinson, K., Wilson, J., Cleary, K., Lazarus, W., Thomas, W. and Hathaway, M. (2012) Round-bale feeder design affects hay waste and economics during horse feeding. *Journal of Animal Science*, **90**, pp. 1047-1055

11. Meyer, M., Ahlswede, L. und Reinhardt, H.J. (1975) Untersuchungen über Fressdauer, Kaufrequenz und Futterzerkleinerung beim Pferd. *Deutsche Tierärztliche Wochenschrift*, **82**, pp. 54-58

12. Meyer, H. und Coenen, M., (2014) *Pferdefütterung* 5. Auflage Stuttgart: Enke Verlag

13. National Animal Health Monitoring System (NAHMS) (1998) *Equine Morbidity and Mortality*. Fort Collins: United States Department of Agriculture (USDA)

14. Pirkelmann, H., Ahlswede, L. und Zeitler-Feicht, M.H. (2008) *Pferdehaltung* Stuttgart: Eugen Ulmer KG

15. Pratt-Phillips, S. (2014) Health Concerns Related to Equine Obesity. *The Horse* [Online] Available from: http://www.thehorse.com/articles/33375/health-concerns-related-to-equine-obesity [Accessed: 24.06.2014]

16. Referat für Tierschutz (2009) *Leitlinien zur Beurteilung von Pferdehaltungen unter Tierschutzgesichtspunkten*. Bonn: Bundesministerium für Ernährung, Landwirtschaft und Verbraucherschutz (BMELV)

17. Schöning, B. (2014) *Pferdeverhalten* Stuttgart: Franckh-Kosmos Verlags- GmbH und Co. KG

18. Stephenson, H.M., Green, M.J., and Freeman, S.L. (2011) Prevalence of obesity in a population of horses in the UK. *Veterinary Record*, **168**, p. 131

19. Sweeting, M.P., Houpt, C.E. and Houpt, K.A. (1985) Social facilitation of feeding and time budgets in stabled ponies. *Journal of animal science,* **60**, pp. 369-374

20. Thatcher, C.D., Pleasant, R.S., Geor, R.J., and Elvinger, F. (2012) Prevalence of Overconditioning in Mature Horses in Southwest Virginia during the Summer. *J Vet Intern Med*, **26**, pp. 1413-1418

21. Webster, V., Ellis, A.D. (2010) Preference of forage feeding position in stabled horses: a pilot study. *The impact of nutrition on the health and welfare of horses*, EAAP publ. **128**, p. 87

22. Wyse, C.A., McNie, K.A., Tannahill, V.J., Murray, J.K., and Love, S. (2008) Prevalence of obesity in riding horses in Scotland. *Veterinary Record*, **162**, pp. 590-591

23. Zeitler-Feicht, M. H., (2008) *Handbuch Pferdeverhalten* 2. Auflage Stuttgart: Eugen Ulmer KG

24. Zeitler-Feicht, M.H. und Walker, S. (2005) Zum Einsatz eines speziellen Heunetzes in der Pferdefütterung aus ethologischer Sicht. *Pferdeheilkunde*, **21** (3), pp. 229-233

Pictures:

Front page: Pferd frisst Heu [Online] Available at: http://www.bmel.de/DE/Tier/4_Tierernaehrung/tierernaehrung_node.html [Accessed: June 2014]

Figure 3: Product picture [Online] Available at: http://www.loesdau.de/Fressbremse.htm?websale7=loesdau&pi=8102&ci=04-fressbremsen [Accessed: June 2014]

Annex

Descriptives

Descriptives					
Method				Statistic	Std. Error
Feedingtime mean	loose hay	Mean		34,5090	1,44260
		95% Confidence Interval for Mean	Lower Bound	31,3339	
			Upper Bound	37,6841	
		5% Trimmed Mean		34,5076	
		Median		35,5145	
		Variance		24,973	
		Std. Deviation		4,99731	
		Minimum		26,54	
		Maximum		42,51	
		Range		15,97	
		Interquartile Range		9,31	
		Skewness		-,161	,637
		Kurtosis		-1,133	1,232
	hay/straw 50:50	Mean		37,9992	1,54125
		95% Confidence Interval for Mean	Lower Bound	34,6069	
			Upper Bound	41,3914	
		5% Trimmed Mean		38,0785	
		Median		37,6150	
		Variance		28,505	
		Std. Deviation		5,33905	
		Minimum		27,44	
		Maximum		47,13	
		Range		19,69	
		Interquartile Range		6,80	
		Skewness		-,092	,637
		Kurtosis		,387	1,232
	haynet 4x4cm	Mean		66,1192	3,76326
		95% Confidence Interval for Mean	Lower Bound	57,8363	
			Upper Bound	74,4020	
		5% Trimmed Mean		66,4607	
		Median		65,0950	
		Variance		169,945	
		Std. Deviation		13,03631	
		Minimum		42,30	
		Maximum		83,79	
		Range		41,49	
		Interquartile Range		23,93	
		Skewness		-,201	,637
		Kurtosis		-,868	1,232

Feedingrate mean	loose hay	Mean		31,4164	1,07627
		95% Confidence Interval for Mean	Lower Bound	29,0475	
			Upper Bound	33,7852	
		5% Trimmed Mean		31,2860	
		Median		30,3077	
		Variance		13,900	
		Std. Deviation		3,72830	
		Minimum		27,13	
		Maximum		38,05	
		Range		10,92	
		Interquartile Range		7,46	
		Skewness		,508	,637
		Kurtosis		-1,045	1,232
	hay/straw 50:50	Mean		28,7458	1,06860
		95% Confidence Interval for Mean	Lower Bound	26,3939	
			Upper Bound	31,0978	
		5% Trimmed Mean		28,6431	
		Median		28,7700	
		Variance		13,703	
		Std. Deviation		3,70175	
		Minimum		21,93	
		Maximum		37,41	
		Range		15,48	
		Interquartile Range		3,08	
		Skewness		,739	,637
		Kurtosis		2,686	1,232
	haynet 4x4cm	Mean		17,4567	1,12792
		95% Confidence Interval for Mean	Lower Bound	14,9741	
			Upper Bound	19,9392	
		5% Trimmed Mean		17,2080	
		Median		17,6750	
		Variance		15,266	
		Std. Deviation		3,90723	
		Minimum		12,86	
		Maximum		26,53	
		Range		13,67	
		Interquartile Range		5,95	
		Skewness		,929	,637
		Kurtosis		1,446	1,232

Tests of Normality

Tests of Normality

	Method	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
Feedingtime mean	loose hay	,156	12	,200*	,950	12	,634
	hay/straw 50:50	,127	12	,200*	,975	12	,956
	haynet 4x4cm	,150	12	,200*	,952	12	,661
Feedingrate mean	loose hay	,200	12	,200*	,914	12	,243
	hay/straw 50:50	,230	12	,081	,914	12	,238
	haynet 4x4cm	,141	12	,200*	,912	12	,223

*. This is a lower bound of the true significance.
a. Lilliefors Significance Correction

Test of Homogeneity of Variances

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Feedingtime mean	8,285	2	33	,001
Feedingrate mean	,244	2	33	,785

ANOVA

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Feedingtime mean	Between Groups	7208,472	2	3604,236	48,395	,000
	Within Groups	2457,664	33	74,475		
	Total	9666,136	35			
Feedingrate mean	Between Groups	1317,801	2	658,900	46,110	,000
	Within Groups	471,565	33	14,290		
	Total	1789,366	35			

Post Hoc – Bonferroni

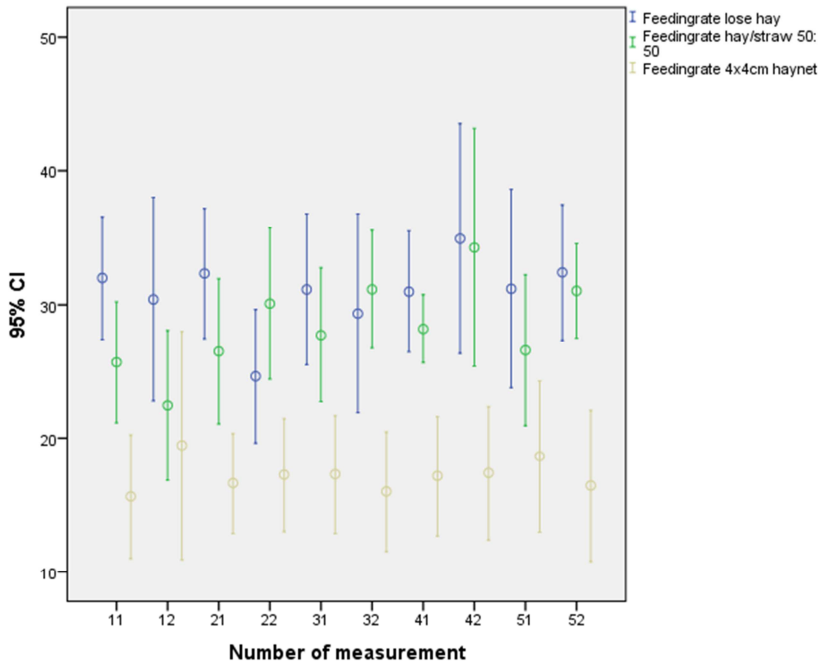
Multiple Comparisons

Bonferroni

Dependent Variable	(I) Method	(J) Method	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Feedingtime mean	loose hay	hay/straw 50:50	-3,49016	3,52313	,987	-12,3762	5,3959
		haynet 4x4cm	-31,61016*	3,52313	,000	-40,4962	-22,7241
	hay/straw 50:50	loose hay	3,49016	3,52313	,987	-5,3959	12,3762
		haynet 4x4cm	-28,12000*	3,52313	,000	-37,0061	-19,2339
	haynet 4x4cm	loose hay	31,61016*	3,52313	,000	22,7241	40,4962
		hay/straw 50:50	28,12000*	3,52313	,000	19,2339	37,0061
Feedingrate mean	loose hay	hay/straw 50:50	2,67053	1,54326	,279	-1,2219	6,5630
		haynet 4x4cm	13,95970*	1,54326	,000	10,0673	17,8521
	hay/straw 50:50	loose hay	-2,67053	1,54326	,279	-6,5630	1,2219
		haynet 4x4cm	11,28917*	1,54326	,000	7,3967	15,1816
	haynet 4x4cm	loose hay	-13,95970*	1,54326	,000	-17,8521	-10,0673
		hay/straw 50:50	-11,28917*	1,54326	,000	-15,1816	-7,3967

*. The mean difference is significant at the 0.05 level.

Error Bar Chart Feeding Rate



Data Collection Sheet

Day	1	Measurement	1

I = Yard 1, II = Yard 2

Site	Horse	Method used	Weight before	Time starts at	Time ends at	Weight after	Notes
I	Horse 1 – Donna						
	Horse 2 – Lotte						
	Horse 3 – Fine						
	Horse 4 – Fabbe						
	Horse 5 – Champ						
	Horse 6 – Amber						
II	Horse 7 – Solea						
	Horse 8 – Highlight						
	Horse 9 – Scarlet						
	Horse 10 – Lena						
	Horse 11 – Reffles						
	Horse 12 - Finkat						

General Data Collection Sheets

General Data

Number	Name	Breed	Gender	Age	Use	Type Exercise	Amount Exercise	Health Issues	Weight (Tape)
Horse 1									
Horse 2									
Horse 3									
Horse 4									
Horse 5									
Horse 6									
Horse 7									
Horse 8									
Horse 9									
Horse 10									
Horse 11									
Horse 12									

Number	Height	Length	Girth line	Weight (Formula)	BCS	Bedding	R Type/Quality	R Weight	R Frequency
Horse 1									
Horse 2									
Horse 3									
Horse 4									
Horse 5									
Horse 6									
Horse 7									
Horse 8									
Horse 9									
Horse 10									
Horse 11									
Horse 12									

Number	R Weight Total	R Time	C Type	C Weight	C Frequency	C Weight Total	C Time	Supplements Y/N
Horse 1								
Horse 2								
Horse 3								
Horse 4								
Horse 5								
Horse 6								
Horse 7								
Horse 8								
Horse 9								
Horse 10								
Horse 11								
Horse 12								