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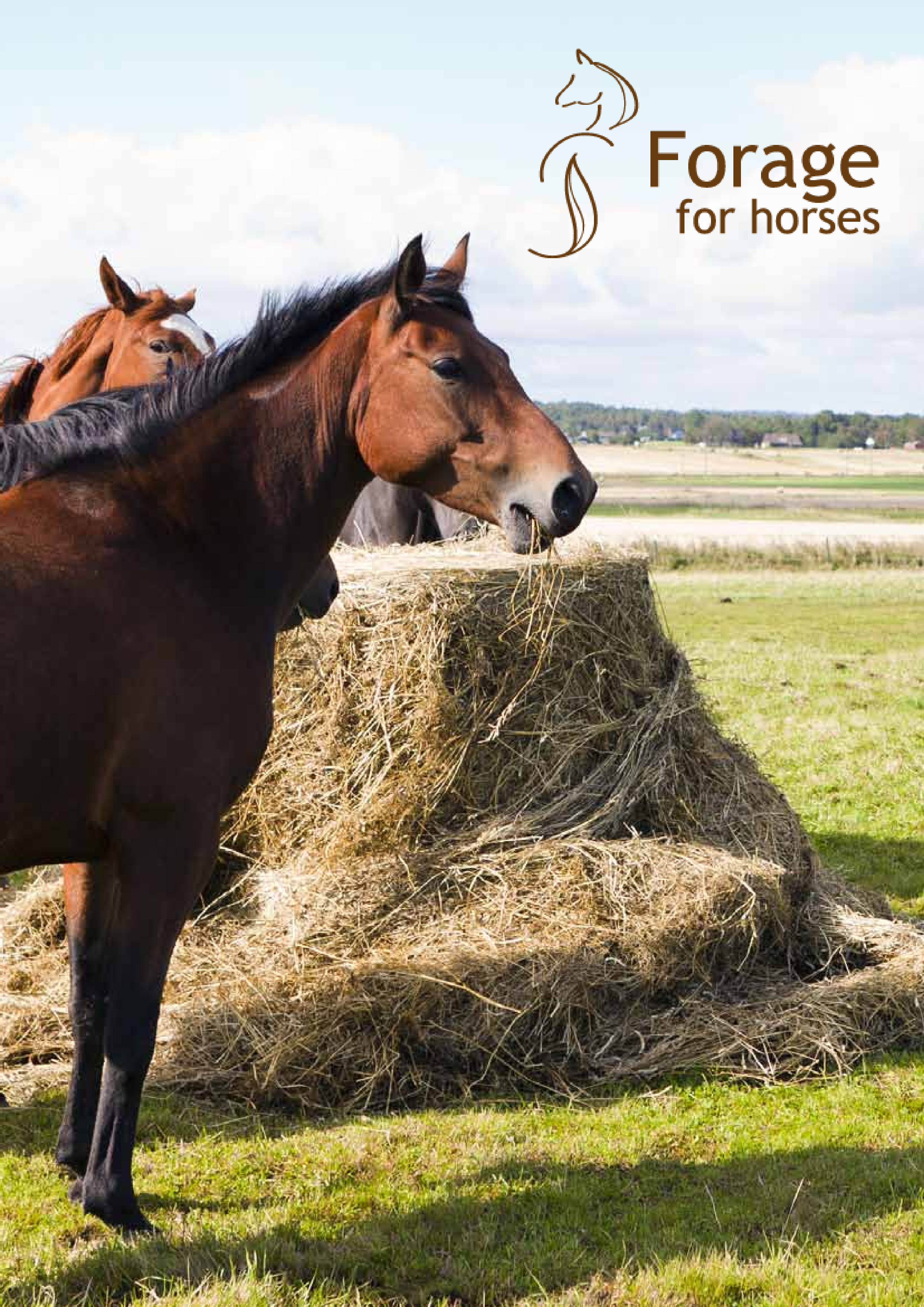
Forage for horses



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Forage For Horses

Preserved forage packaged in bales has in recent years been recognized and increasingly popular as fodder in the horse industry. Thanks to silage higher nutritional value and palatability this has largely replaced cereal diets of many horse owners, and the interest for silage as alternative fodder is steadily increasing in Europe. At Trioplast we have compiled many important aspects of feeding silage to horses in this handbook. We have to our assistance taken help of Sara Muhonen on Equi-Nutrition in order to, in a simple way, provide advice and information based on current knowledge and research. Together with Sara Muhonen we run the website www.forageforhorses.com.

Sara Muhonen received her postgraduate education at the Department of Animal Nutrition and Management, Swedish University of Agricultural Sciences (SLU) with her thesis 'Metabolism and Hindgut Ecosystem in Forage Fed Sedentary and Athletic Horses'. She received her Master of Science degree in agriculture (animal science) also at SLU. She has a lifelong passion for horses and especially the trotter and the trotting sport. For more information on Equi-Nutrition visit the website www.equi-nutrition.com.

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Göran Ericson
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Content

The Horse – An Herbivore

The horse is a large grass eating animal, an herbivore, and free-living horses graze 14-18 hours of the day. The horse relies on hindgut fermentation which means that its caecum and colon is inhabited by microorganisms (bacteria, protozoa and fungi) that degrades fibre. The rest products of the microorganisms are short-chain fatty acids that are absorbed and utilised by the horse as energy, without its extensive microflora the horse would not be able to feed on grass. With a diet consisting of mainly forage or only forage the short-chain fatty acids are the horse's largest energy source.

However, the microbial flora inhabits the entire equine gastrointestinal tract, high counts of total anaerobic bacteria has been found throughout the digestive tract and even in higher numbers in the stomach than the small intestine. Concentrations of the fibre-degrading bacteria, as cellulolytic bacteria, are high in the hindgut and low in the stomach and small intestine which shows that fibre degradation takes place in the hindgut. The horse's diet has an impact on the composition of the microflora and therefore also which types of short-chain fatty acids that are produced. A diet consisting of mainly forage or only forage results in higher acetate concentrations and lower propionate concentrations. Acetate is a weaker acid than propionate and therefore it does not decrease pH as much. High intakes of starchy concentrate results in high production of propionate but also lactate and can lead to a rapid decrease in pH and highly increased risk of intestinal disturbances and colic.

The Ensiling Process

Silage production implies that feed is conserved through an ensiling process. The ensiling process means that lactic acid producing bacteria, LAB, produces lactic acid during carbohydrate degradation. The lactic acid lowers the pH value in the feed and the goal with the ensiling process is to lower the pH enough to inhibit all microbial activity and the silage is then stable for storage during air tight conditions. For the lactic acid bacteria to dominate the ensiling process anaerobic conditions are required in the bales or the silo.

What is Fibre?

Fibre is an umbrella term for structural carbohydrates and together with lignin they form the cell walls of plants. Cell walls are composed of cellulose fibre, hemicellulose, pectin's and cell wall protein. The fibre fermenting bacteria and fungi in the gastrointestinal microbial flora enables the horse to digest fibre. The rest products of the microbial flora are the short-chain fatty acids and on a high forage or forage-only diet they constitute the horse's largest energy source. The fermentability of fibre can vary, for example are pectin's which are included in hemicellulose more easily fermentable and cellulose less fermentable. The later the developmental stage of the plant the more lignified is the cell wall, which means that the plant's digestibility decreases. The earlier the crop is harvested the higher the digestibility of the forage.

Proteins are Composed of Amino Acids

An amino acid is a chemical compound that has at least one amino group (NH2) and one carboxyl group (COOH). There are about 20 different amino acids that are building blocks in animals and plants and when they are many joined in a chain they are called proteins. The gastrointestinal bacterial flora metabolises many different nitrogen compounds, for example amino acids, from the diet, dead intestinal cells and dead intestinal bacteria which results in the production of ammonia and short-chain fatty acids. Ammonia is re-utilized to a large extent by the bacterial flora but when the concentration of ammonia in the intestine increases it is absorbed through the intestinal wall into the blood and transported to the liver. In the liver the ammonia is converted to urea which mainly is excreted via the urine. But urea can also recirculate to the intestine where it is taken care of by the bacterial flora which converts it into microbial protein or ammonia.

Differences in Digestibility Between Hay and Silage

A study with trotters in training has shown differences in digestibility between hay and silage. The hay and the silage were an early first harvest from the same lay, they were harvested on the same day and dried to different dry matter (DM) levels (the hay 82 % DM, the silage 45 % DM). The only thing separating the two forages was the conservation method.

The digestibility of the forages' DM, the fibre fraction ADF (acid detergent fibre) and crude protein was higher for the silage than for the hay. The digestibility of the fibre fraction NDF (neutral detergent fibre) did not differ between the two forages. The NDF fibre fraction contains more soluble fibre than the ADF fraction.

The higher digestibility of the silage might be due to lower leaf losses during handling in the field. At hay production the grass is dried longer and the finer more nutritious leafs then becomes more brittle and easier falls off and stays on the ground. It is also possible that the ensiling process might increase the solubility of the silage's fibre fraction which then could increase digestibility.

Digestibility (mean values in %) for DM, the fibre fractions NDF and ADF and crude protein of hay and silage harvested on the same day from the same ley.

	Hay (82 % DM)	Silage (45 % DM)
Dry matter (DM)	66	68
NDF	61	61
ADF	53	60
Crude protein	70	73

Haylage or Silage – Any Effects on Exercise Response?

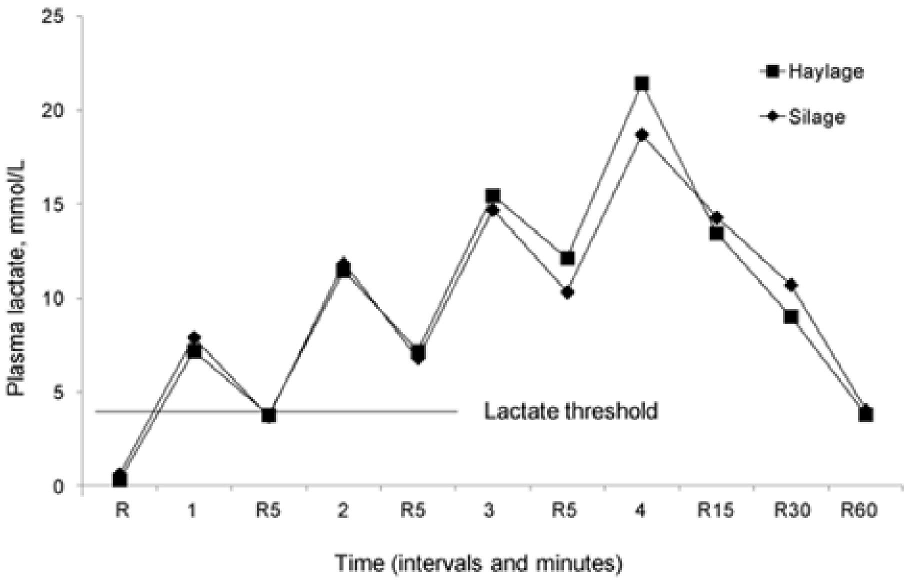
In this study 6 trotters in training were fed with haylage (68 % DM, 0.2 % lactic acid, pH 5.8) and silage (41 % DM, 3 % lactic acid, pH 4.8). The forages were harvested on the same day, from the same ley and had high energy content (11.3-11.4 MJ/kg DM). The diets were mainly comprised of the forages but supplemented with molassed sugar beet pulp (20 % of the energy intake), minerals and salt. Three horses started on the silage diet and three on the haylage diet and then they switched so all horses were tested on both diets. The horses were fed the diets for 17 days before exercise tests were performed. The test was an interval exercise on an oval racetrack with four 1000 meters intervals (average speeds: 9, 11, 11.6 and 12 m/s for the 4 intervals respectively) with 5 minutes walking in between. Sampling was done before, during and after the exercise test. In addition, the same driver drove the same horse in both tests and did not know which diet the horse had. After the exercise tests the drivers ranked the exercise temperament, excitability, of the horses.

The results could not show any significant differences between the diets before, during and after the exercise tests in rectal temperature, heart rate, breathing frequency and blood pH. The horses' plasma lactate concentrations were also analysed and there were no difference between which diets the horses had. The drivers' ranking of the horses' temperament during the exercise tests did not differ between the diets.

Mean values of rectal temperature, heart rate, breathing frequency and blood pH before and after interval exercise (4 intervals of 1000 m, speeds 9, 11, 11.6 and 12 m/s) when the horses had a diet of either haylage or silage.

	Before exercise	After 15 min recovery	After 30 min recovery	After 60 min recovery
Rectal temperature (°C)				
Haylage	37,7	39,3	–	–
Silage	37,8	39,4	–	–
Heart rate (beats/min)				
Haylage	33	81	63	50
Silage	34	80	62	48
Breathing frequency (breaths/min)				
Haylage	12	62	30	21
Silage	14	67	28	20
Blood pH				
Haylage	7.42	7.33	7.37	7.44
Silage	7.44	7.33	7.39	7.42

Mean values of plasma lactate before, during and after interval exercise when the horses had a diet of either haylage or silage. R: before exercise, 1, 2, 3 and 4: directly after the interval, R5: after 5 minutes of walking after the interval.



Differences in Horses' Water Intake and Fluid Balance when they Consume Hay and Silage

In this study the effects on water intake and fluid balance in trotters in training was examined when feeding a diet of hay (82 % DM) and a diet of silage (45 % DM). The forages were harvested on the same day from the same ley, it was an early harvest with high energy content (11.6 MJ/kg DM). The horses ate only the forages, which covered the maintenance requirements × 2, supplemented with minerals and salt.

The horses drank more when they were fed the drier feed (the hay diet) but the total water intake, e.g. what the horses drank + the water via the feed, was higher on the wetter feed (the silage diet). There was no significant difference in how much water was excreted via faeces, a little more water was excreted via urine but the total water excretion (water via faeces + via urine) did not differ between the diets. If we take the total water intake minus the total water excretion via faeces and urine we get an estimation of how much water the horses have evaporated, e.g. lost via the skin. On the silage diet the horses evaporated about 2.8 kg more water per day than on the hay diet.

This indicates that the horses had a higher heat production on the silage diet which is in accordance with the higher digestibility that has been measured for the silage diet. When the horses ate the silage diet with the higher digestibility the heat production increased which caused the higher evaporation of water via the skin and the horses to increase their water intake. Even for maintenance fed horses it has been shown that they drink more on drier forages (hay, haylage) but the total water intake is a little bit higher on wetter forages (silage).

Mean values of water intake and water excretion in kg/day when horses had a diet of either hay or silage.

	Hay (82 % DM)	Silage (45 % DM)
Drinking	24.3	15.5
Water via the forage	1.7	13.8
Total water intake (via drinking + via forage)	26.1	29.2
Water in faeces	13.1	12.1
Water in urine	8.5	9.8
Total water excretion (via faeces + via urine)	21.6	21.9
Total water in – total water out	4.5	7.3

Does Forage Crude Protein Intake Affect the Horse's Performance?

Early harvested forage has a high energy content but often also a high crude protein content, which can result in an excessive crude protein intake. In this study 6 trotters in training were fed two diets that consisted of early harvested grass silage with high energy content (>11 MJ/kg DM). One silage had a high crude protein content (16.6 %) that gave an excess protein intake and the other silage (12.5 %) provided a recommended intake of crude protein. The horses were fed only the forages supplemented with minerals and salt. Three horses started on the high protein diet and three on the recommended protein diet and then they switched so all horses were tested on both diets. The horses were fed the diets for 3 weeks before two race-like exercise tests were performed. One test was performed on a treadmill and the other as a simulated race on an oval racetrack.

The results could not show any significant differences between the diets before, during and after the exercise tests in heart rate, breathing frequency, plasma lactate and blood pH. The table below shows values from directly after exercise and after 15 minutes of recovery.

The high protein diet implied an excess in forage crude protein; >160 % of recommended intake. The results show that the horses could handle the excess during and after the shorter intensive exercise tests resembling trotting races.

Mean values of heart rate, breathing frequency, plasma lactate and blood pH after exercise test on treadmill and simulated trotting race on an oval racetrack when horses had either a recommended or a high crude protein intake.

	Directly after excercise		**15 min after excercise**	
	Recommended	High	Recommended	High
Exercise test on treadmill				
Heart rate[1] (beats/min)	213	216	70	72
Breathing frequency (breaths/min)	99	100	82	93
Plasma lactate (mmol/L)	17.6	18.3	11.7	11.1
Blood pH	7.32	7.29	7.38	7.38
Exercise test on racetrack				
Heart rate[1] (beats/min)	222	215	80	78
Breathing frequency (breaths/min)	–	–	100	86
Plasma lactate (mmol/L)	20.2	22.9	18.7	20.5
Blood pH	7.28	7.26	7.32	7.30

[1] *Highest heart rate noted.*

Abrupt Feed Changes from Hay to Haylage and Silage – Effects on the Hindgut Ecosystem

This study examined the impact of an abrupt feed change from hay (81 % DM) to haylage (55 % DM) and to silage (36 % DM) on the colon and faecal ecosystem in maintenance fed horses. The forages were an early first harvest from the same lay, and they were harvested on the same day and dried to different dry matter (DM) concentrations. The only thing separating the forages was the conservation method. The abrupt feed changes and the adaptation over time to the haylage and silage were studied both short-term (28 h) and long-term (3 weeks).

The first 28 hours after the abrupt feed change no changes were detected in the colon and faecal ecosystem. The abrupt feed changes resulted in no differences in pH, DM, short-chain fatty acids or osmolality and the lactic acid concentration was almost exclusively under the detection limit in colon and faeces. There were also no differences in the concentration of total anaerobic bacteria, cellulolytic and lactate-utilizing bacteria, lactobacilli and streptococci in colon and faeces. The results indicate that an abrupt feed change between forages conserved differently but with similar nutritional and botanical composition is not associated with the same risks for intestinal disorders as a change from forage to concentrate. An abrupt change to large concentrate meals rich in starch can result in a high increase in colon lactic acid concentration and decrease in pH.

After 3 weeks minor changes in the bacterial flora were detected, a small increase in lactobacilli on the silage diet and a small decrease in streptococci on the haylage diet. But overall there were large individual variations and these differences in bacterial concentrations did not result in any changes in short-chain fatty acids which are the rest products of the bacterial flora. There were also no significant differences in colon and faecal pH on days 8, 15 and 21 after the feed change. Over the 3 weeks a small but significant decrease (1-3 %) in the colon content and faecal DM concentration was observed after the change to both haylage and silage. In a study with trotters in training a tendency to increased faecal DM (<1 % difference) was observed the first two days after a change from silage to hay, but after 3 weeks on both the hay diet and the silage diet the DM concentration had decreased by 0.6-1.2 %. In none of the studies was loose faeces or diarrhoea observed.

Mean values of pH and dry matter (DM) in colon and faeces before and after abrupt feed changes from hay to haylage and silage, the forages were harvested on the same day from the same ley.

	Day before feed change: Hay	Change to	Days efter feed change		
			8	15	21
pH					
Colon	6.7	Haylage	6.8	6.6	6.6
	6.8	Silage	6.8	6.6	6.8
Faeces	6.0	Haylage	6.4	6.3	6.4
	6.2	Silage	6.2	6.1	6.2
DM (%)					
Colon	5	Haylage	4	3	3
	5	Silage	4	4	5
DM (%)	24	Haylage	20	21	21
	22	Silage	22	23	21

Forage Crude Protein Content – Effects on the Hindgut Ecosystem

Early harvested forage has a high energy content but often also a high crude protein content, which can result in an excessive crude protein intake. This study examined the impact on the colon and faecal ecosystem in maintenance fed horses when feeding two silage diets; one silage high in crude protein content (17 %) that gave an excess protein intake and another silage (13 %) that provided a recommended intake of crude protein.

There was no difference in the colon bacterial flora or the colon content and faecal dry matter (DM) concentration after 3 weeks of adaptation to the high crude protein silage and the silage providing the recommended crude protein intake. The concentration of short-chain fatty acids in the colon, the rest products from the bacterial flora, was higher when the horses were fed the high protein silage compared to the recommended. The pH value of the colon content was also slightly lower on the high protein diet which can be due to the higher concentration of short-chain fatty acids. In comparison to other studies when starch rich feeds have been introduced the pH value was still high on both silage diets.

The two diets did not result in any difference in the amounts of nitrogen, ammonia or urea in the colon fluid, which indicates that the absorption of the higher crude protein intake took place earlier in the gastrointestinal tract. The horses' water intake and the plasma urea concentration tended to be higher when the horses were fed the high protein silage compared to the recommended. This also indicates that there was an increased absorption of nitrogen and a higher nitrogen metabolism on the high protein diet.

Abrupt feed changes between the silages were also performed and resulted in no or small changes in the colon ecosystem the first 24 hours. The concentration of total anaerobic bacteria and lactobacilli was a little higher 24 h after an abrupt change to the high protein silage. But there was no difference in colon and faecal pH or DM concentrations between the diets the first 24 h after the abrupt feed changes. Also the concentration of short-chain fatty acids and lactic acid in the colon did not differ between the diets the first 24 h.

The results suggest that an excess crude protein intake from forage, in horses fed at the maintenance level of energy intake, does not imply any major changes in the colon bacterial flora and its activity. In addition, an abrupt feed change between two forages with different crude protein content does not seem to be associated with the same risk of intestinal disorders as a change from forage to starch rich concentrate.

Mean values of short-chain fatty acid concentration (mmol/L) in the colon and pH in colon and faeces after 3 weeks of adaptation to forage diets providing a recommended or a high crude.

	Crude protein intake from forage	
	Recommended	**High**
Acetic acid	30.5	33.3
Propionic acid	9.1	10.8
Butyric acid	3.0	4.1
Total short-chain fatty acids	45.1	51.8
Colon pH	7.2	6.9
Faecal pH	6.6	6.4

Forage Crude Protein Content – Effects on Nitrogen Metabolism and Water Intake

Early harvested forage has a high energy content but often also a high crude protein content, which can result in an excessive crude protein intake. This study examined the impact on nitrogen metabolism and water intake in trotters in training when feeding two diets that consisted of early harvested grass silage with high energy content (>11 MJ/kg DM). One silage had a high crude protein content (16.6 %) that gave an excess protein intake and the other silage (12.5 %) provided a recommended intake of crude protein.

Proteins are composed of amino acids which contain nitrogen (N), an excess intake of N cannot be stored in the body and has to be excreted. The high protein diet corresponded to an excess crude protein intake of 160 % of the requirement and resulted in higher excretion of N via urine and faeces. In addition, the plasma urea concentration was higher when the horses were fed the high protein silage which indicates an increased absorption of N and an increased N metabolism. On the high protein diet the horses had a higher water intake and urine excretion which indicates an impact on the fluid balance due to a higher heat production. E.g. when the body disposes of excess N heat is also produced, and to get rid of excess heat the body's evaporation increases and therefore the water intake also has to be increased.

The increased N excretion and lower faecal pH when the horses consumed the high protein diet indicates that there was an increased fermentation in the large intestine, e.g. a higher activity of the bacterial flora. The faecal DM concentration was lower on the high protein diet, which might be due to several factors like an increased amount of N in the large intestine can affect flows of water into and out of the intestine or differences in the forages' fibre fractions can affect the water-holding capacity of the intestinal content.

In this study abrupt feed changes between the high protein silage and the recommended were also performed. Already after 15-18 hours after the abrupt change to the high protein diet urine pH was significantly lower and after 36-48 hours the N excretion via faeces was higher. This indicates that the horse quickly begins to excrete the excess N. After the abrupt change from the high protein silage to the silage that gave a recommended crude protein intake it was not until day 3 that the water intake decreased which indicates a 2 day period was needed for the excess N to be 'washed out'.

In conclusion, an excessive intake of crude protein corresponding to 160 % of the requirements the horses handled by within the first 24 h start to excrete the excess N via urine and faeces. This implicated a higher water intake and urine excretion. But does this have any effects on the horses' performance? In this study exercise tests were performed on a treadmill and racetrack. Any effects on the horses' exercise response or recovery during and after the exercise tests could not be detected.

Mean values of water intake, urine and nitrogen (N) excretion, urine and faecal pH and faecal DM after 3 weeks of adaptation to forage diets providing a recommended or a high crude protein intake.

	Crude protein intake from forage	
	Recommended	**High**
Water intake (kg/day)	16.4	20.8
Urine excretion (kg/day)	10.6	11.6
N excretion via urine (g/day)	117	171
N excretion via faeces (g/day)	52	63
Urine pH	7.46	7.03
Faecal pH	6.27	6.11
Faecal DM (%)	20.9	19.5

Forage Intake – Effects on Body Weight and Fluid Balance

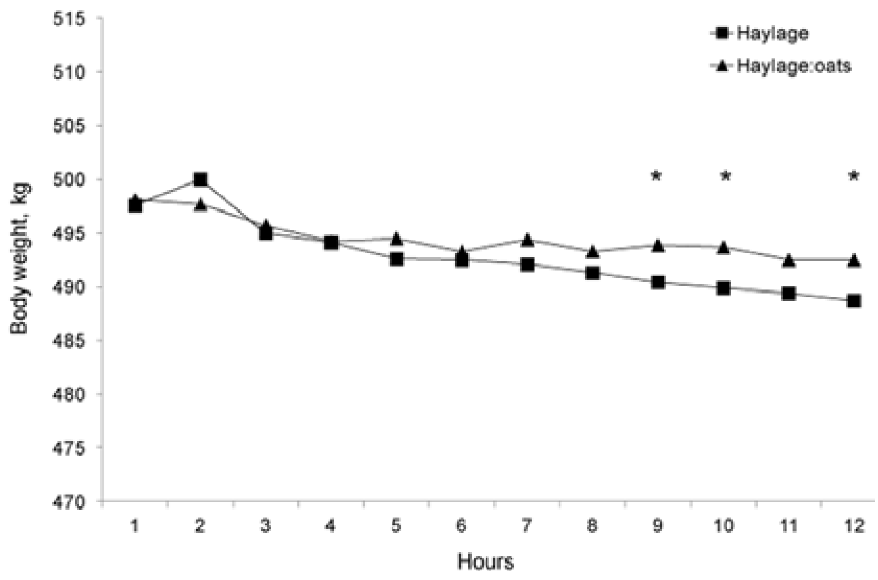
This study examined the impact on body weight and plasma volume during a 12 hour fast in trotters in training when fed either a diet of energy rich haylage or a diet of 50:50 haylage:oats. The same haylage was used for the two diets and bots diets covered the maintenance requirements × 2 and were supplemented with minerals and salt.

The horses were about 3 kg heavier and drank about 3 L more water when they ate the forage diet than the 50:50 forage:oats diet and the faecal dry matter (DM) concentration was lower when they were fed only forage (20.9 vs. 25.2 %), e.g. the faeces contained more water. During the fast, the horses lost more weight when they were on the forage diet than the forage:oats diet and after 9 hours there was a significant difference in body weight between the diets. On average the horses lost 2.4 kg more during the fast on the forage diet, almost as much as they were heavier before the fast. That they lost more weight during the fast on the forage diet could be due to that they lost a larger amount of water via the faeces, since the faecal DM concentration was lower (e.g. the faeces was wetter) when they ate only forage. In this study the horses were standing in their boxes during the fast, but it is likely that a more rapid weight loss would have been observed if the horses for example were transported to a competition which implies nervousness and defecation.

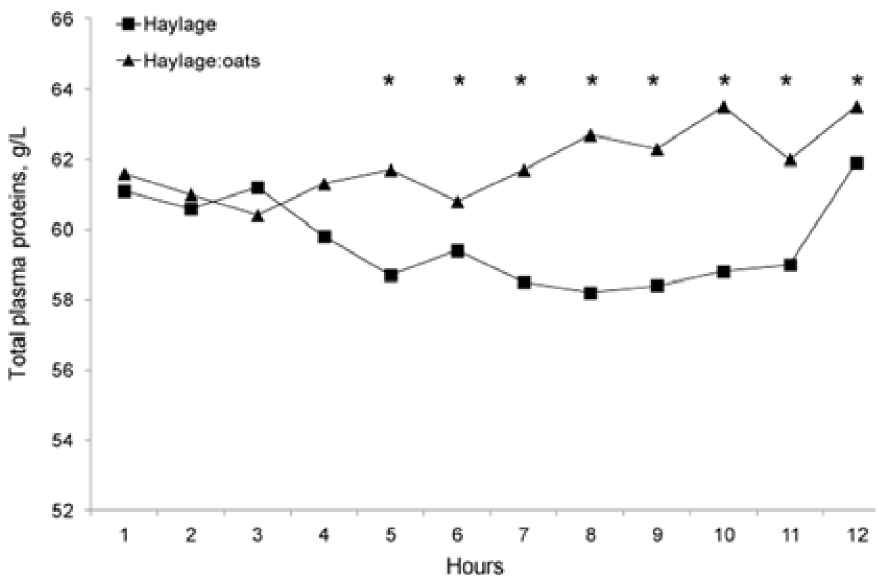
Measuring the concentration of proteins in plasma (total plasma proteins TPP) is an indirect measurement of changes in the horse's total plasma volume. The higher the concentration of TPP the smaller plasma volume. After 8 hours of fasting on the haylage:oats diet a significant increase in TPP was observed, which is a sign of beginning of dehydration. On the haylage only diet it was not until the last hour of fasting (hour 11-12) that an increase in TPP could be observed. This indicates that when horses eat only forage, or a lot of forage, they can better maintain their fluid balance. Probably because on a high forage diet they have a larger fluid reservoir in the large intestine since the forage fibres bind water.

In conclusion, a high forage diet might be an advantage for the horse's fluid balance and facilitate for the performing horse to maintain its fluid balance when going to competitions.

Mean values of body weights during a 12 hour fast in trotters in training when fed either a diet of energy rich haylage or a diet of 50:50 haylage:oats. * means significant difference between the diets.



Mean values of total plasma proteins during a 12 hour fast in trotters in training when fed either a diet of energy rich haylage or a diet of 50:50 haylage:oats. * means significant difference between the diets.



Forage Intake – Effects on Body Weight and Excercise

This study examined the impacts on body weight and exercise response in trotters in training when fed a high energy forage-only diet (haylage, early harvest) compared to a 50:50 forage (late harvest): concentrate diet. The early and the late harvested haylage were from the same ley, the concentrate consisted of mainly oats and soybean meal and both diets were supplemented with minerals and salt. The two diets, forage-only and forage: concentrate, provided the same daily energy and protein intake.

Three horses started on the forage-only diet and three on the forage: concentrate diet and then they switched so all horses were tested on both diets. The horses were fed the diets for 17 days before exercise tests were performed. The test was an interval exercise with four 600 meters intervals (average speeds: 10.5-13 m/s) on a track with 0.6 % incline. The horses were tested in pairs and sampling was done before and after the exercise tests. The same driver drove the same horse in both tests and did not know which diet the horse had. After the exercise tests the drivers ranked the exercise temperament, excitability, of the horses.

Before the interval exercise tests the horses tended to be heavier when fed the forage-only diet (mean values: 522 kg vs. 519 kg). Fifteen minutes after the interval exercise tests the horses were weighed again and there were no significant difference in weight loss: mean values were 8.5 kg on the forage-only diet and 7.0 kg on the forage:concentrate diet. But 24 hours after the exercise tests the horses were heavier on the forage-only diet than on the forage:concentrate diet (mean values: 517 kg vs. 512 kg), which indicates a faster recovery on the forage-only diet.

The plasma lactic acid concentration after the exercise tests did not differ between the diets. But the average heart rate was slightly higher after exercise, and 15 and 30 minutes after exercise the breathing frequency was higher when the horses were fed the forage:concentrate diet. There was no statistically significant difference in the drivers' ranking of the horses' exercise temperament between the forage-only diet and the forage:concentrate diet. But 4 of the 6 horses had a higher grading for exercise temperament on the forage: concentrate diet. This indicates a psychological response, that the higher exercise temperament on the forage:concentrate diet resulted in higher heart rates and breathing frequencies. It is known that concentrate can have the effect of increasing "excitability" in some individuals but the reasons for this are unknown.

Individual and mean values (± SE) for drivers' ranking of horses' temperament on a scale from 0 – 11.5 (0 is 'lazy' and 11.5 is 'very hard pulling') during interval exercise when horses were fed either a high energy forage-only diet or a forage:concentrate diet.

Horse	Forage-only	Forage: Concentrate
1	7.6	7.7
2	4.7	5.9
3	7.9	5.7
4	7.5	10.1
5	5.8	8.3
6	5.5	6.5
Mean value	6.5±0.5	7.4±0.7

Forage Fibre Composition Affects the Hindgut Ecosystem

This study examined the impact on the hindgut ecosystem when horses were fed early harvested grass haylage, lucerne haylage and the more conventional diet of late harvested grass haylage supplemented with concentrate. The grass haylages were from the same ley but harvested 6 weeks apart, the concentrate was oats and soybean meal.

There were no differences in the concentrations of total anaerobic and cellulolytic bacteria in the hindgut flora. The concentrations of pectinolytic and xylanolytic bacteria were lower when the horses ate the early harvested grass haylage. This might be due to that pectins and xylans are easily fermentable fibres (included in hemicellulose) that might have been fermented earlier in the gastrointestinal tract and therefore were no longer available when the feed reached the hindgut. There were no difference in starch degrading bacteria but the concentration of lactate-utilizing bacteria was higher when the horses were fed the diet of late harvested grass haylage and concentrate. This can be explained by the concentrate containing more starch and when starch is fermented by the hindgut bacteria lactate is produced.

Irrespective of which of the three diets the horses were fed the concentration of short-chain fatty acids in the hindgut did not differ. But the ratio (acetic acid + butyric acid) / propionic acid was lower when the horses were fed the diet of late harvested grass haylage and concentrate than the two other diets that consisted of only forage. This is because the relationship between how much of these acids that are produced is affected by the diet – a lot of forage gives a larger part acetic acid + butyric acid and concentrate implies a larger part of propionic acid. In this study the horses did not receive any large concentrate meals and therefore no decrease in the hindgut pH was observed, which can occur when large meals of starch rich concentrate are fed.

In conclusion, the different forage based diets implied minor changes in the hindgut bacterial flora, but an evident effect of the concentrate could be observed by the increase in lactate-utilizing bacteria in spite of small concentrate meals.

Mean values of concentration of lactate-utilizing bacteria in caecum, colon and faeces when horses were fed late harvested grass haylage supplemented with concentrate, early harvested grass haylage and lucerne haylage.

	Lactate-utilizing bacteria (log cfu/ml)		
	Grass haylage: Concentrate	Grass haylage	Lucerne haylage
Caecum	7.7	6.6	6.6
Colon	6.9	5.7	6.4
Faeces	7.8	6.8	6.9

Feeding Forage Before Concentrate

The feeding practices can have impact on the ecosystem in the hindgut of the horse. This study examined the effect on the hindgut environment in riding horses in training when the forage (hay) was fed before the concentrate (oats) and vice versa.

When the horses were fed the forage before the concentrate instead of the opposite, the faecal pH and the buffering capacity of the faeces were higher. To feed the forage before the concentrate also implied positive differences in the short-chain fatty acids in the faeces: the concentration of acetic acid was higher, the propionic acid lower and the ratio acetic /propionic acid was higher.

The results from this study show that the feeding practices, forage or concentrate first, affects the activity of the hindgut flora (the short-chain fatty acids) and the environment in the hindgut of the horse. The results also indicate that feeding forage before concentrate gives a higher buffering capacity in the hindgut which might protect against "acidification" of the colon content e.g. a decrease in pH.

Mean values of pH, short-chain fatty acids and buffering capacity in faeces when horses were fed either forage or concentrate first.

	Forage first	Concentrate first
pH	6.6	6.4
Acetic acid (mol %)	77.0	72.9
Propionic acid (mol %)	12.3	16.3
Buffering capacity (mmol/l)	108	84

Behavioural Disturbances – Stereotypies

Captive animals faced with insoluble problems can develop behavioural disturbances, stereotypies. Examples of behavioural disturbances are weaving, crib-biting, box-walking and wood-chewing. Many factors influence the development of behavioural disturbances but how much forage the horse is fed is one of the main factors.

Studies have shown that the more forage horses were fed the lesser the risk of behavioural disturbances. The amount of concentrate had the opposite effect; the more concentrate the bigger risk of behavioural disturbances. Straw as bedding also decreased the risk of behavioural disturbances.

That forage decreases the risk of behavioural disturbances can partly be due to that a high forage intake provides enough fibre, but more forage also means occupation e.g. that the horses behavioural need for eating during a longer period of time is fulfilled. It is important to prevent behavioural disturbances because when they are developed they are difficult to get rid of.

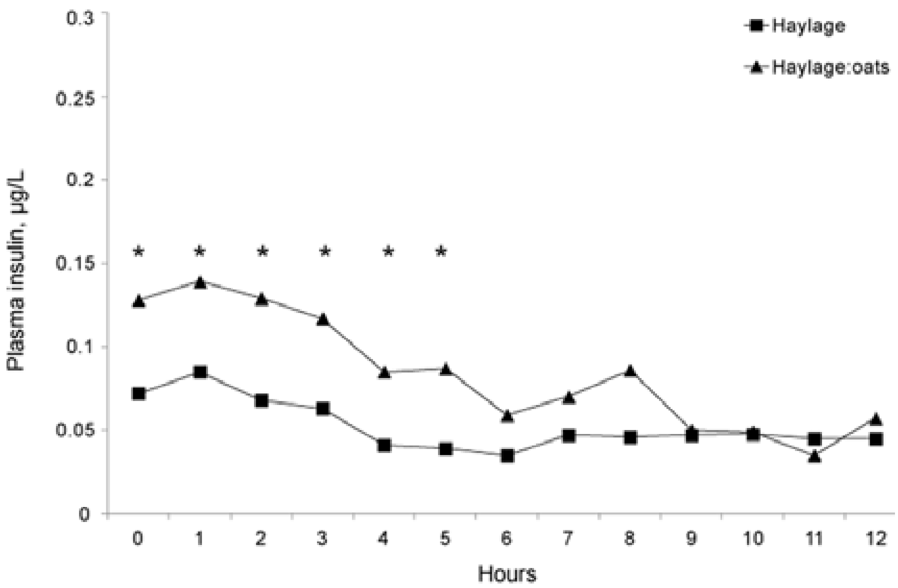
Forage or Concentrate – Effects on Insulin Response

This study examined the impact of the diet on insulin response at feeding and during a 12 fast in trotters in training. A diet consisting of only energy rich forage (haylage) was compared to a 50:50 forage:oats diet. The same haylage was used for the two diets and bots diets covered the maintenance requirements × 2 and were supplemented with minerals and salt.

The concentration of insulin in plasma was lower before and after feeding when the horses were on the haylage diet compared to the haylage:oats diet. Also during the first 5 hours of fasting the plasma insulin was significantly lower on the forage only diet. The insulin concentration remained almost unchanged before and after feeding and during the fast on the haylage diet whilst it was higher before and increased after feeding on the haylage:oats diet.

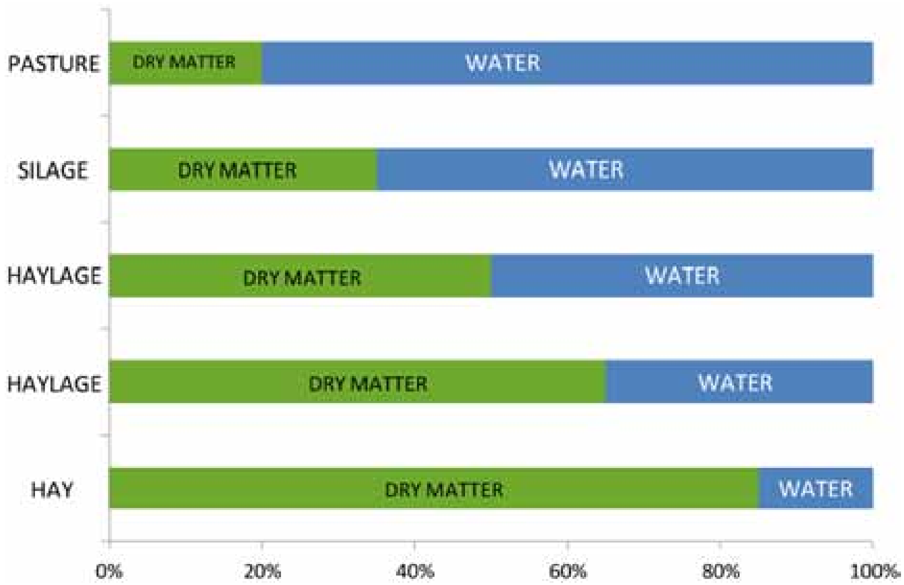
A diet consisting of only forage does not imply the same increase in the plasma insulin concentration as a diet where starch rich concentrate is included.

Mean values of plasma insulin during a 12 hour fast in trotters in training when fed either a diet of energy rich haylage or a diet of 50:50 haylage:oats. * means significant difference between the diets.



Kg Feed and Kg Dry Matter (DM)

The dry matter (DM) content of forage is the dry material that is left when the water content of the forage has been deducted. Since water does not contain any nutrients it is very important to know the forage's DM concentration to be able to value the forage and to be able to calculate feed rations. How much water forage contains varies greatly between pasture, silage, haylage and hay which clearly show in the figure below. When sending a feed sample for analysis the DM concentration is included in the analysis response. Sometimes it is necessary to calculate the forage's nutritional content from kg DM to kg feed and vice versa. For example if you have calculated the horse's requirements in kg DM you have to recalculate them into kg feed to know how much feed to weigh up when it is time to feed the horse. Below two examples for calculations are shown, how to calculate energy and protein values from kg DM to kg feed and from kg feed to kg DM for the hay and silage.



Metabolizable energy and digestible crude protein (dCP) per kg feed and per kg DM for hay and silage with DM concentrations of 82% and 45%.

	Hay (82 % DM)	Silage (45 % DM)
Energy in MJ/kg feed	9.5	5.2
Energy in MJ/kg DM	11.6	11.6
dCP in g/kg feed	93	57
dCP in g/kg DM	113	127

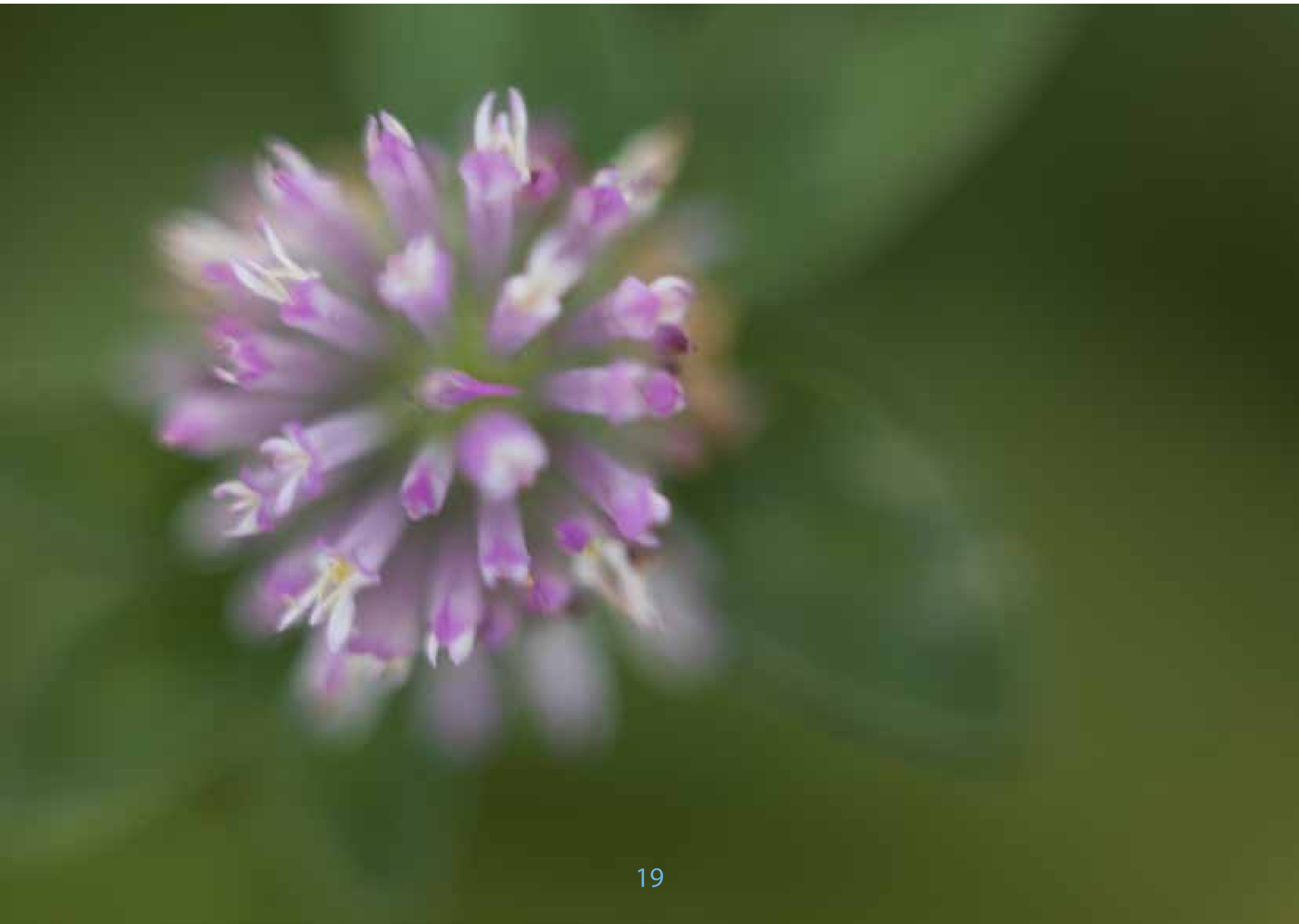
Arithmetic examples:

From kg DM to kg feed:

Hay	*82%*	*DM (82/100 = 0.82)*
11.6 MJ/kg DM	»	11.6 × 0.82 = 9.5 MJ/kg feed
113 g dCP/kg DM	»	113 × 0.82 = 93 g dCP/kg feed
Silage	*45%*	*DM (45/100 = 0.45)*
11.6 MJ/kg DM	»	11.6 × 0.45 = 5.2 MJ/kg feed
127 g dCP/kg DM	»	127 × 0.45 = 57 g dCP/kg feed

From kg feed to kg DM:

Hay	*82%*	*DM (82/100 = 0.82)*
9.5 MJ/kg feed	»	9.5 / 0.82 = 11.6 MJ/kg DM
93 g dCP/kg feed	»	93 / 0.82 = 113 g dCP/kg DM
Silage	*45%*	*DM (45/100 = 0.45)*
5.2 MJ/kg feed	»	5.2 / 0.45 = 11.6 MJ/kg DM
57 g dCP/kg feed	»	57 / 0.45 = 127 g dCP/kg DM



Hay, Haylage, Silage – What's the Difference?

Hay should of course be as dry as possible and not wrapped in plastic, but there is no clear definition separating haylage and silage. Today the most common definition is that haylage is drier than silage, and some haylage is so dry it is hay wrapped in plastic. In the feeding experiments presented on this website forage with dry matter (DM) concentrations between 50-70% are called haylage and between 35-50% are called silage. The table shows some analyses results of 3 grass leys, which were used in feeding experiments with horses, conserved as hay, haylage and silage. Within each ley the feeds were harvested on the same day; to be able to see the effects of the conservation method only the forages compared must be from the same ley and be harvested simultaneously.

The conservation method has an impact on the chemical composition of the forage. In drier forage, like hay and haylage, there is less or no lactic acid fermentation and the pH value then becomes higher. During silage/haylage making the rate of fermentation depends on the amount of moisture present in the ensiled crop. Wilting delays the bacterial multiplication and leads to higher pH and sugar content. One can say that the lactic acid producing bacteria in the silage "eats" the sugar.

Lower concentrations of nitrogen and higher concentrations of the fibre fraction NDF in hay compared to silage harvested simultaneously have also been reported. This can be due to larger leaf losses during handling in the field; during haymaking the crop is wilted longer and the finer more nutritious leafs become more brittle, falls of easier and gets left on the ground.

The conservation method has some impact on the horse; effects have been measured for digestibility and for the horse's water intake and fluid balance.

Analyses results of 3 grass leys conserved as hay, haylage or silage and which have been used in feeding experiments with horses (in g/kg DM if not otherwise stated).

	Ley 1 (first harvest)			Ley 2 (first harvest)		Ley 3 (second harvest)	
	Hay	Haylage	Silage	Hay	Silage	Haylage	Silage
DM (%)	81	55	36	82	45	68	41
Energy (MJ/kg DM)	11.7	11.5	11.5	11.6	11.6	11.2	11.3
Crude protein	170	152	174	155	167	145	131
NDF	483	469	429	479	430	477	456
ADF	273	280	277	263	273	281	283
Sugar[1]	117	122	80	157	140	132	106
Lactic acid	0.5	2.0	34.7	-	6.7	1.7	29.9
Acetic acid	0.1	0.8	4.0	-	1.3	0.3	2.9
pH	6.0	5.6	4.5	-	5.3	5.8	4.8
Lactic acid bacteria[2]	0	4.3	6.6	0.4	5.1	-	-
Mould[2]	2.6	0.8	1.7	1.1	0	2.2	< 2.0

[1] *Glucose, fructose, sucrose and fructans.*
[2] *log_{10} cfu/g feed.*

Store Round Bales Standing

The plastic film for silage/haylage bales is a stretch film which becomes a bit sticky when it is stretched, this makes the plastic layers glue together and the bale becomes more air tight. When the bale is standing upright the plastic layers lie vertical and the pressure from the bale content stretches the plastic so the plastic layers continue to be sticky and the bale remains air tight.

If the bale is lying down on the side the plastic layers lie horizontal and the pressure from the bale content cannot stretch the plastic as good as when the bale is standing. This can result in reduced air tightness of the bale and air will more easily leak into the bale. When really unlucky, and in combination with low bale density, rainwater can get in between the plastic layers on bales stored lying down.

So to ensure air tight bales and prevent bad hygienic quality – store the round bales standing!

Horsewrap vs. Standardfilm

Horsewrap is a stronger stretch film developed for bale wrapping of haylage for horses and should be able to handle the sharper and stiffer fresh matter which high DM concentrations imply. In this study Horsewrap was compared to the normal standard film, standard bale wrap, and 32 bales each were wrapped with the two stretch films. The crop was 2 cocksfoot leys from the second cut. The two stretch films were 25 µm thick, 750 mm wide and pre stretched about 70%, and the overlap on the bale was 50% of the film width.

There was a big difference in surface damage between the two stretch films but there was a great variation between individual bales. Nutrient losses were greater in the bales with the standard film and this was due to larger surface damages (bird attacks) and therefore discarded forage. Besides birds there are quite a lot of problems with cats, but it can also be dogs and other animals, that scratches and makes holes in the bales. The stretch film Horsewrap managed the surface damage attacks better and also had tighter joints. Wrapping the bales with Horsewrap resulted in bales with higher gas tightness compared to the standard bale wrap. Gas tightness is measured by inserting a one way valve (Ekolag) through the plastic, creating a small negative pressure and the time in seconds that it takes for the negative pressure to rise from -20 mm to -15 mm water column is measured.

In conclusion, bales should be protected against bird attacks, otherwise there is a risk for mould growth that can result in large nutrient losses. The quality of the plastic film can decrease these problems; the stretch film Horsewrap gave gas tighter bales, less surface damage and lower nutrient losses from mould growth.

Mean values for DM, density, gas tightness, surface damages, total nutrient losses and losses caused by surface mould growth when using standard bale wrap and horsewrap.

	Standard Balewrap	Horsewrap
DM Content (g/kg fresh matter)	552	578
Density (kg DM/m^3)	219	207
Gas tightness (seconds)	71	84
Surface damage (% of bale surface)	4.9	2.1
Nutrient losses (g/kg DM)	110	78
» where of surface damages (mould growth) (g/kg DM)	50	9
Estimated conservation losses (g/kg DM) with "tight" bales (eg. minus surface damages)	60	69

Layers of Plastic

Number of layers of plastic film on the bale has an impact on the bale's gas tightness. In this study the bale gas tightness, density, surface damages, total nutrient losses and losses caused by surface mould growth was investigated when wrapping bales with 6 or 8 layers of Horsewrap and regular standard bale wrap. 16 bales with each 6 and 8 layers of stretch film were wrapped with Horsewrap and standard bale wrap, in total 64 bales. The crop was 2 cocksfoot leys from the second cut. The two stretch films were 25 µm thick, 750 mm wide and pre stretched about 70%, and the overlap on the bale was 50% of the film width.

Surface damages (bird attacks) on the 6 layer standard bale wrap were markedly different from the three other treatments (p. 24). Besides birds there are quite a lot of problems with cats, but it can also be dogs and other animals, that scratches and makes holes in the bales. 6 layers of standard bale wrap resulted in large surface damages and losses, but adding 2 layers substantially decreased the problems. 6 layers of Horsewrap was comparable to 8 layers of standard bale wrap. There was no big difference between 6 and 8 layers of Horsewrap and 8 layers of standard bale wrap. However, for both stretch films the gas tightness was about twice as good with 8 layers than with 6, which indicates that both joint tightness and the leaking of air through the plastic was improved. Gas tightness is measured by inserting a one way valve (Ekolag) through the plastic, creating a small negative pressure and the time in seconds that it takes for the negative pressure to rise from -20 mm to -15 mm water column is measured.

In conclusion, bales should be protected against bird attacks; otherwise there is a risk for mould growth that can result in large nutrient losses. Number of layers of plastic film had an impact on surface damages and losses. In this study the difference in nutrient losses between 6 and 8 layers of plastic film was calculated to 56 g/kg DM, and with 330 kg DM per bale the economical loss was calculated to 2.5 Euros per bale.

Trioplast recommendations:

- » Silage with DM between 35-50% stand for normal silage.
- » Haylage with DM between 50-65% stand for normal haylage.

It is not recommended to wrap forage harvested with a dry matter above 70%, especially if the crop is in a late growth stage. Under such conditions may the amount of air in a bale cause unwanted mould and yeast growth during the conservation process.

Under such circumstances can the amount of air which is trapped in the bale cause growth of mold and yeast in the beginning of the storage period. Besides that the crop in the bales become much more stalky which can puncture the film layers during wrapping, causing low air tightness of the bale. This can except of previous explained damages cause water intrusion and bad smell of the crop in the bales. There is also a high risk of stubble damage underneath the bales when unloading them from the wrapper in the field.

When feed with higher DM (60-70%) is wrapped, we recommend to increase the amount of layers per bale than what normally is used to give the bale an extra protection against punctures from the stubble in the field, an increased tightness of the bale as a compensation eventually for worse lamination between the film layers caused by dust in the air during the wrapping process and punctures on the film during wrapping of the first layers of film.

Mean values for DM, density, gas tightness, surface damages, total nutrient losses and losses caused by surface mould growth when using 6 or 8 layers of plastic with the standard bale wrap and horsewrap.

	Standard Balewrap		Horsewrap	
Number of layers film:	6	8	6	8
DM (g/kg fresh matter)	539	564	556	600
Density (kg DM/m³)	218	219	197	217
Gas tightness (seconds)	40	102	63	105
Surface damages (% of bale surface)	9.2	0.6	2.9	1.4
Nutrient losses (g/kg DM)	152	67	92	65
» whereof surface damages (mould growth) (g/kg DM)	93	8	29	8
Estimated conservation losses (g/kg DM) with "tight" bales (eg. minus surface damages)	59	59	63	57

"Re-baling" into Small Bales

Silage or haylage in big bales can be problematic for smaller horse farms. The big bales contain too much forage for a few horses to finish in 3-4 days and big bales cannot be moved manually. Therefore small bales are often requested when they are easier to handle. Small bales of silage or haylage are produced in mainly two ways: by using small round balers or conventional high-density square balers used for haymaking at harvest, or by harvesting the forage in large round bales which are later opened during winter and "re-baled" into small square bales. To get high enough bale density with the conventional high-density square baler the original knotters can be replaced with knotters intended for large square balers. Then stronger twines can be used to reach higher densities without breaking the twines.

A pilot study has been performed where big round bales of silage (45-55% DM) of good hygienic quality were opened at the end of March and immediately baled and wrapped into small square bales, using a stationary set high-density baler. After 30 days of storage samplings began, new bales were opened and sampled once a week during 6 weeks. Analyses done were nutritional content and prevalence of yeast, mould, lactic acid bacteria and clostridia.

The re-baling into small bales resulted in no differences in nutritional content. The hygienic quality of the small bales was not altered except from a small increase in yeast, which is difficult to determine if it was due to the re-baling or if this increase would have happened anyway. The small bales reached a high density, comparable to densities of big bales of about 200 kg DM/m3, after re-baling which can be due to that the crop was already ensiled, soft and compacted. Otherwise it is usually difficult to exceed 160 kg DM/m3 during conventional production of small silage bales.

Hygienic Quality of Forage

Forage of good hygienic quality is important for the horse to stay healthy. Hay should be dry and dust free and silage requires a successful ensiling process with good tight baling and air tight storage conditions. Here is a presentation of some chemical hygiene analyses which are used to evaluate how well the ensiling succeeded and whether the forage is of acceptable hygienic quality for the animals. The tableon the next page shows some limit values used in the evaluation of forage hygienic quality.

The pH value is a measurement of acidity and shows if acid has been produced. Different acids are more or less strong and the pH is the sum of all acids' strength. In wetter forage the goal is to have enough acid to inhibit all microbial growth. In wilted forage bacteria is also inhibited by the lower supply of water and the pH does not have to decrease as much as in wetter forage. Therefore an acceptable pH varies depending on the DM concentration of the forage and in very dry forages the pH value is no longer a valid measure of quality.

Lactic acid is the acid produced during a successful ensiling process. Lactic acid is produced by lactic acid producing bacteria (LAB), during degradation of carbohydrates. Lactic acid is the strongest acid formed during the ensiling process and therefore also the acid most contributing to the decrease in pH. LAB are the most tolerant bacteria and can continue to grow the longest when the pH decreases. So when LAB stops growing the pH has decreased low enough to inhibit all microbial activity and the silage is now stable for storage as long as it is air tight.

Some LAB can also produce acetic acid, but acetic acid is not as strong as lactic acid and therefore does not lower the pH as much. Also unwanted bacteria, like enterobacteria, produce acetic acid. Too high concentrations of acetic acid are therefore an indication that the ensiling process has not been successful and unwanted bacteria has grown in the forage, especially if at the same time the forage lactic acid content is low.

Butyric acid is not wanted in silage, it is formed mainly by butyric acid producing bacteria, clostridia. High concentrations of butyric acid in combination with high ammonia nitrogen (N)/total N shows that the silage has been damaged by clostridia, which enters the crop when it is contaminated by soil and manure. A good hygiene to prevent contamination of the crop and wilting to at least 30% is a good way to avoid clostridia.

The amount of ammonia-N (NH_3-N) reflects how much of the crop's protein that has been degraded by unwanted microbial activity. The unwanted protein degradation in silage is mainly done by proteolytic clostridia but also enterobacteria can degrade protein. A high concentration of NH_3-N is therefore an indication of unwanted microorganisms in the forage. To visualise how big part of the crop's protein has been degraded it is common to calculate NH_3-N in % of total N (NH_3-N/total N).

If there has been heating in the silage there has probably been a chemical process going on where protein binds to fibre. Heating in silage/haylage can happen when air enters the bale and unwanted aerobic microorganisms grows, and then the formation of toxins can also be suspected. But heating can also develop early through cell breathing without growth of microorganisms. This can consume a lot of sugar and result in a bad ensiling process due to shortage of sugar. The heating causes a decreased nutritional value when valuable protein binds to fibre which means that either the protein or the fibre is no longer digestible. Analysing ADF-N gives an answer to how much of the forage's protein content has been bound to fibre, if the ADF-N is 20% it implies that 20% of the protein can no longer be utilised.

Nitrate is a toxic N compound that exists in mainly fresh matter. During certain circumstances the nitrate concentration can be extra high in fresh matter: for example with highly N fertilised leys harvested early, especially in combination with drought after the fertilisation or harvest close after the fertilisation. During the ensiling process nitrate is degraded completely to ammonium or partly to sub compounds like nitrite and other N oxides. Nitrate is less degraded in fresh matter with high sugar contents, that has been wilted or when acid has been added.

Some limit values used during evaluation of the forage's hygienic quality		
pH	< (0.0257*DM %) + 3.71 Direct cut silage Wilted (<35 % DM) Wilted (>50 % DM)	Applies between DM 15-50 % < 4.2 = good < 4.5 = good Not useful measure
Lactic acid	Silage direct cut with formic acid: 6-10 % of DM Silage direct cut no formic acid: 8-12 % of DM Silage, wilted (30-60 % DM) 3-7 % of DM	 = normal = normal = normal
Acetic acid	All silage 1-3 % of DM	= normal
Butyric acid	< 0.10 % of sample 0.10-0.30 % of sample > 0.30 % of sample	= good = less good = bad
NH_3-N	< 8 % of total nitrogen 8-12 % of total nitrogen > 12 % of total nitrogen	= good = less good = bad
ADF-nitrogen	2-5 % of total nitrogen > 15 % of total nitrogen	= normal = very bad
Nitrate (NO_3)	< 1.85 % of feed	Possibly safe

Microbiological Analysis of Forage

When a microbiological analysis of forage is performed different microorganisms (bacteria, yeast, mould) that may exist in forage are cultured. In addition a qualitative evaluation can be made where different mould species are identified and if plenty of a toxin producing mould is found an analysis of mycotoxins can be performed. For wet forages the pH value is also determined. For dry forages, like hay, the water activity (aw) is determined and it reflects the water that is available for the microorganisms and is also a measurement of the forage's storage stability. Water activity and DM concentration is not the same thing. The water activity is set as a number between 0 and 1 and for dry forage to be considered stable for storage the water activity cannot exceed 0.7.

A microbiological hygiene analysis is often considered after a visual and oral examination has established that the forage is bad. The ambition of the microbiological hygiene analysis is often to try to determine if the forage can be fed or not. The best things to do is to first call the laboratory and describe the problem and how the damaged forage looks/smells, and then one can get instructions on how/where to take samples and how they should be sent. Commonly a microbiological sample should be kept cold, not frozen, and sent to the laboratory as soon as possible. After the analyses are performed an overall evaluation of the forage's hygienic quality is done and the result from the laboratory can be 'without objection' or a longer comment about differing values.

Grass Harvest Date and the Haylage Hygienic Quality

Wrapped forages for horses are commonly harvested in a relatively late botanical growth stage. Plant maturity influences not only the nutritional content but also the composition of the microflora living on the crop which can influence the conservation of the feed. This study that was performed in Sweden has examined how a late harvest date affects the hygienic quality of the forage. The microbial and chemical composition in haylage during conservation and storage was compared between three first harvests from the same lay (mainly timothy and meadow fescue). The three harvests were taken in May (ear emergence of approximately 50% of the timothy), June (timothy seeds present in the ears and firmly attached) and August (timothy stems dry and wilted, no seeds left in the ears).

The harvest date was shown to have an impact on the hygienic quality of haylage, but to a limited extent. A later the harvest resulted in higher number of yeast, but lower number of enterobacteria in the haylage. The harvest date had no effect on number of clostridial spores. At the latest harvest the highest number of mould species was found before the grass was conserved, but after conservation there was no difference.

The harvest date had only a small impact on the haylage conservation. The wanted lactic acid bacteria were in highest numbers in the latest harvest, but the lactic acid concentration was generally low. The latest harvest in August had the lowest pH and the lowest concentration of ethanol. Since haylage has a high DM concentration and is not ensiled to a larger extent the differences were small and these variables are difficult to use as quality measurements.

In conclusion it is recommended to harvest within reasonable time, under Swedish conditions not later than beginning of July, to prevent negative effects on the hygienic quality of the forage.

The microbial composition in haylage at three different harvest dates of primary growth (log10 cfu/g).

Harvest time	Yeast	Mould	Clostridial spores	Enterobacteria	Lactic acid bacteria	No. of mould species
May	**3.46**	1.37	1.60	1.74	4.33	0.1
June	**4.38**	<1.20	<1.40	<1.40	4.78	-
August	**5.23**	1.50	1.63	<1.40	6.63	0.1

Bacteria, Fungus and Mould in Forage

Silage with a DM concentration below 35% is conserved by lactic acid producing bacteria that produces lactic acid with a subsequent decrease in pH. The lactic acid producing bacteria exist naturally on the plant and are good bacteria that we want to have a lot of. The lactic acid and the lower pH value inhibit the growth of unwanted bacteria. The presence of water is required for microbial growth, the higher the DM concentration the more limited is the ensiling and lactic acid production. The lactic acid production starts to decline already at DM concentrations of 35-40%.

Long-stemmed forage in bales with DM concentrations below 40-45% can have limitations in the lactic acid production which can imply a higher risk for bad fermentation and growth of for example enterobacteria and clostridia. Therefore the use of silage additives is recommended for long-stemmed material below 45% DM to support the ensiling process. Presence of enterobacteria and clostridia in the forage can also be considered as an indication that there has been a contamination with soil, manure, cadaver or old litter. A high prevalence of these types of bacteria in the forage can result in reduced consumption, intestinal disorders and serious health hazard for horses.

At DM concentrations of 65-70% the lactic acid production stops and in wrapped forages with such high DM concentrations the risk of mould growth increases, partly due to a larger portion of air pits and a higher risk for puncturing the plastic. Mould requires air to be able to grow. Moulds can form toxins, mycotoxins, which have a negative impact on horses. Effects of mould damaged forage can appear as anything from reduced performance to neurological disorders. Mouldy and dusty hay and straw are common causes of respiratory problems in horses.

Yeasts grow fast when there is oxygen and slow during anaerobic conditions. Yeast does not form toxins, but its activity can result in large nutrient losses, heating and can open up for subsequent mould growth. According to Swedish feeding recommendations a DM interval of 45-65% is recommended for wrapped forages for horses.

Limit values indicating the forage's hygienic quality (cfu/g).

Lactic acid producing bacteria	**> 10^6 per gram sample**	**= Recommended for silage**
Coliform bacteria (37°)	10^2 per gram sample	= maximum
Anaerobic bacteria	10^3 per gram sample	= maximum
Clostridia	10^3 per gram sample	= maximum
Bacillus	10^3 per gram sample	= maximum
Yeast	10^5 per gram sample	= maximum
Mould	10^5 per gram sample	= maximum

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