Norwegian University of Life Sciences

Date: 31-05-2021

Final report

Carbohydrates in grass and forages for horses
- The good, the bad and the ugly

Project number: H-17-47-287

Project period: 2018-01-01 to 2020-12-31

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Part 1: Detailed summary

Bakgrunn for prosjektet:
Gress til beite eller grovfôrproduksjon inneholder varierende mengder av karbohydrater, som ofte beskrives som de gode (fiber), de onde (sukker) og de grusomme (fruktaner) i forhold til forebyggelse og utvikling av sykdommer som insulinresistens og forfangenhet. Karbohydratinnholdet i gress varierer mye og spesielt er innholdet og fordøyelsen av sukker og fruktaner i gress mye diskutert blant hesteeiere. I tillegg har innholdet og fordøyeligheten til fiberen stor effekt på energiinnholdet i gress og grovfôr til hester, og er derfor av stor betydning for både høyt- og lavtytende hester.

Formålet med prosjektet:
Formålet med dette prosjektet var å undersøke innholdet av forskjellige karbohydratfraksjoner i forskjellige gressarter og undersøke fordøyelsen i forskjellige dele av hestens fordøyelseskanal. Dette prosjektet bidra med viktig kunnskap om valg av gressarter og høstings- eller beiteregimer for ulike hestetyper.

Forsøkene og resultater i prosjektet:
Prosjektet var inndelt i 3 arbeidspakker: 1) etableringa av forsøksfelter med 6 forskjellige gressarter, 2) målinger av fordøyelighet av gressprøver fra arbeidspakke 1 i laboratoriet (in-vitro målinger), og 3) målinger av fordøyelsen av utvalgte gressprøver i levende hester (in-vivo målinger).

De seks forskjellige gressartene brukt i arbeidspakke 1 var timotei, raigress, hundegress, bladfaks, engsvingel, og strandsvingel. Der ble etablerert 36 forsøksfelter med de forskjellige gressarter, så der kunne innsamles gressprøver på forskjellige høstetider, som etterlignede grovfôrproduksjon eller hester på beite. Der ble høstet et tidlig, middel og seint første slått høy fra forsøksfeltene. Der ble innsamlet gress prøver av gjenveksten gjennom sommeren og høsten. Næringsstoffinnholdet ble analysert i alle prøvene. Det var stor variasjon i sukker,

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fruktan og fiberinnholdet i prøvene. Hundegress var generelt et lavt innhold av sukker og fruktan og raigress et høyt sukkerinnhold. Proteininnholdet i gresset ble lavere når gresset ble eldre.

Det er dyrt og krever mye ressurser å undersøke fordøyelighet av alle prøvene, derfor ble den mulige fordøyelighet av prøvene bestemt i laboratoriet (in-vitro målinger) i arbeidspakke 2. Gressart og høstetid hadde en effekt på fordøyeligheten, raigrass hadde en høy og hundegress en lav fordøyelighet, og når gresset ble mer utviklet falt fordøyeligheten. På bakgrunn av målingene i arbeidspakke 2 blev raigress og hundegress utvalgt til å bli undersøkt i arbeidspakke 3.

I arbeidspakke 3 blev der anvendt levende forsøksheste til å bestemme fordøyeligheten av utvalgte gressprøver. Fordøyeligheten av sukker og fruktaner viste seg å være meget høy i hestenes tynntarm, og gressart og høstetid hadde liten effekt. Fiberfordøyligheten skjer i baktarmen (blind- og tykktarmen) på hesten, og raigress hadde generelt en høyere fordøyelighet enn hundegress. Høstetid påvirkede både fiber og protein fordøyeligheten negativt.

Perspektiver fra prosjektet:
På bakgrunn av resultatene i dette prosjekt kan det konkluderes at sukker og fruktan innholdet i gress varierer mye, og det er vanskelig å vurdere når der er mye i gresset. Fordøyeligheten er generelt høyere jo tidligere gresset høstes, og informasjoner om gressartene kan brukes til å sammensette de rette gressblandinger avhengig av hvilke hester, der skal spise gresset enten som beite eller grovfor. Prosjektet undersøkte ikke de metabolske responser når hestene spiser beite eller grovfôr av de spesifikke gressarter, det bør undersøkes i fremtidige studier.

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Part 2: Main report (max. 10 pages)

Introduction

Carbohydrates are an important part of the ration to horses. However, feedstuffs contain different carbohydrate fractions and these fractions are digested in different parts of the gastrointestinal tract. Grass for grazing or forage production contains variable amounts of fiber, sugar and fructans and these carbohydrates are often described as the good (fiber), the bad (sugar) and the ugly (fructans) in relation to prevention and development of conditions like insulin resistance and laminitis. There is a large variation in carbohydrate content in grasses, and especially the content and digestion of sugar and fructans is debated among horse owners. Furthermore, the fiber content and digestibility largely determines the energy content for the horse and is therefore of interest for both high- and low-performing horses.

The aim of this research project is to thoroughly examine carbohydrate content in different grass species harvested at different times/developmental stages in vitro and in vivo. The scientific objectives of this research project are:

- *Examine the carbohydrate content in grass forage species grown under warm continental climate in Scandinavia (Norway) and harvested at different growth stages.*
- *Compare in vitro fermentation of grass samples with in vivo fermentation*
- *Quantify the digestibility of carbohydrate fractions from different grass species in different segments of the gastrointestinal tract.*

Material and methods

This project consisted of three work packages (WP) as described below:

Work package 1: Establishment of experimental fields and chemical analysis of grass
The aim of WP1 is to characterize carbohydrate content and composition in different grass species at different times of harvesting or grazing and produce grass samples to be used in the experiments in WP2 and WP3.

The grass species used for the experiments were grown at the Norwegian University of Life Sciences, Ås, Norway (59°39'42.5"N 10°44'56.0"E, 82 m.a.s.l.). The species sown were Pp: Timothy (Phleum pratense), Sp: meadow fescue (Schedonorus pratensis, syn. Festuca pratensis), Lp: ryegrass (Lolium perenne), Dg: orchard grass (Dactylis glomerate), Sa: tall fescue (Schedonorus arundinaceus, syn. Festuca arundinacea, Minto), Bi: Brome grass (Bromus inermis). A total of 36 plots were divided into three blocks, each containing two replicates (named A and B+C) of each grass species (see Figure 1). The grasses were sown at the end of May 2018 with barley (Hordeum volgare, Salome) as a cover crop (180 kg/ha) and irrigated during the summer 2018. The plots were fertilized with 30 kg N/ha in 2018 after harvest of barley and with 100 kg N/ha in spring 2019.

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TI	TF	PR	SB	MF	OG	Block 1
MF	PR	OG	TI	TF	SB	
TF	OG	TI	MF	SB	PR	Block 2
PR	SB	MF	TF	OG	TI	
OG	MF	SB	PR	TI	TF	Block 3
SB	TI	TF	OG	PR	MF	

***Figure 1** A schematic illustration and photo of the experimental field in June 2019 before the early 1st cut. Pp: Timothy, Sp: meadow fescue, Lp: ryegrass, Dg: orchard grass, Sa: tall fescue, Bi: Brome grass.*

The grasses were cut with a Haldrup plot harvester at 7 cm height in autumn 2018, and in 2019 the grasses were cut between 12:00 and 14:00 at 4th of June (early), 17th of June (medium) and 1st of July (late), and 1st to 4th regrowth were cut in the summer and autumn as illustrated in figure 2.

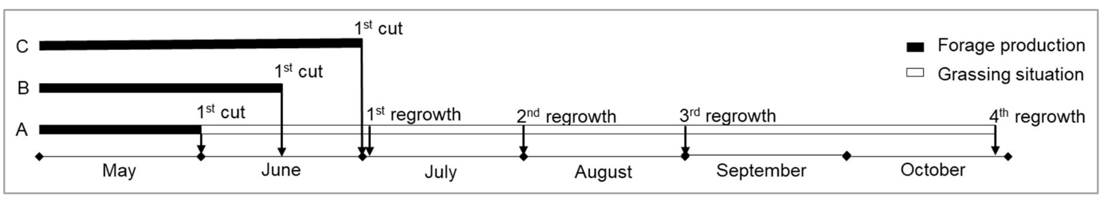

Figure 2 Illustration of the harvesting regime of plots A, B and C, where the 1st to 4th regrowth of plot A was harvested during the summer and autumn.

The plots were cut using a Haldrup plot harvester or manually using electrical clipping machines (see Figure 3). The biomass from each plot cut in 2019 was mixed, and 1 kg of the sample was oven-dried at 50ºC for 3 days after which the dry matter percentage was calculated. Samples were milled on a 1 mm screen and subjected to analysis and further studies in work-package 2 and 3.

Figure 3 Haldrup plot harvester and simulation of horses grazing the experimental fields using electrical clipping machines.

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Work package 2: In vitro digestibility of carbohydrates from grass

The aim of WP2 is to screen the samples collected in WP1 in vitro and select the samples to be investigated in vivo in WP3.

In-vitro gas production SLU

Grass samples from the three different times of harvest were fermented using inoculum consisting of freshly voided horse faeces and the Gas Endeavour® system. All grass samples were incubated in duplicate. The aim was to evaluate whether gas production differed between grass species and time of harvest. Incubation lasted for 48 hours.

In-vitro gas production NMBU:

A similar experiment to the one at SLU was conducted at NMBU using The ANKOM RF wireless Gas Production System (ANKOM Technology, Macedon, New York, USA). Feed samples (1.1 g) were weighed into each 250 mL bottle. In addition, a macromineral and a buffer-solution were mixed the day before incubation. Each bottle with feed sample was filled with 66 mL of the final buffer solution and placed in a heating oven at 38°C while cecal fluid inoculum was prepared. Inoculum was collected from three horses through their cecal cannula approximately five hours after the morning meal. The ANKOMRF Wireless Gas Production System was set to record every 10 minutes. After 48h the incubation was terminated. The gas produced in mL was then corrected for DM and fitted to the monophasic model by Groot et al. (1996) using the NLIN procedure in SAS (version 9.4, SAS Institute Inc., Cary, North Carolina, USA)

Work package 3: In vivo digestibility of carbohydrates from grass

The aim of WP3 is to use selected samples that are thoroughly described in WP1 and WP2, and study where in the gastro-intestinal tract and to what extent they are degraded.

The MBT experiment was conducted as a randomized 4x4 Latin square design over a four-week period including four horses and four feed samples. The feed samples included were Perennial ryegrass and Orchard grass, each at early and late harvest. These two grasses were selected based on the results from work-package 1 and 2. In total, 320 mobile bags were used, with 40 replicates of each grass x harvest x pore size combination. The mobile bags were made from a precision woven synthetic monofilament fabric with a pore size of either 15 µm (Nitex 03-15/10, SEFAR, Heiden, Switzerland) or 36 µm (Nitex 03-36/28, SEFAR, Heiden, Switzerland). A steel washer with a diameter of 10 mm was heat sealed into one end of each bag. Each mobile bag was filled with 0.5 g of feed sample, ensuring a weight to surface area of 0.21 mg/mm^2 (see figure 4). The mobile bags were intubated at four different test days between 07:00 and 07:45 on Mondays in week 1 and 3, and at Tuesdays in week 2 and 4. The intubation was performed before the morning meal and 20 bags were intubated in each horse using approximately 2 L of water.

Figure 4 Handmade mobile bag with grass sample ready for intubation. A steel washer was heat sealed into one end of each bag.

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To capture the mobile bags, a 50 cm long nylon tube containing a double-sided magnet with a diameter of 2 cm was introduced into the caecum through the cecal cannula. The magnet was withdrawn every hour until 10h post intubation, and bags not recovered at this time were searched for in faeces two to four times per day until the next test day, or until all bags had been recovered. Collected bags were quickly rinsed with tab water and stored at -20°C for further analysis of digestibility of the different carbohydrate fractions.

Results and discussion

Work package 1: Establishment of experimental fields and chemical analysis of grass

The experimental fields were established well in 2018 and ready for harvesting in 2019. Results shown in this report are from the early, middle, and late cut forages, as the largest differences between time of harvest were observed here. The results from the regrowth (Figure 2) is not shown here but will be included in scientific papers.

In general, the fibre content increased and the crude protein content decreased as the plants were growing (Figure 5) in concordance with the theory.

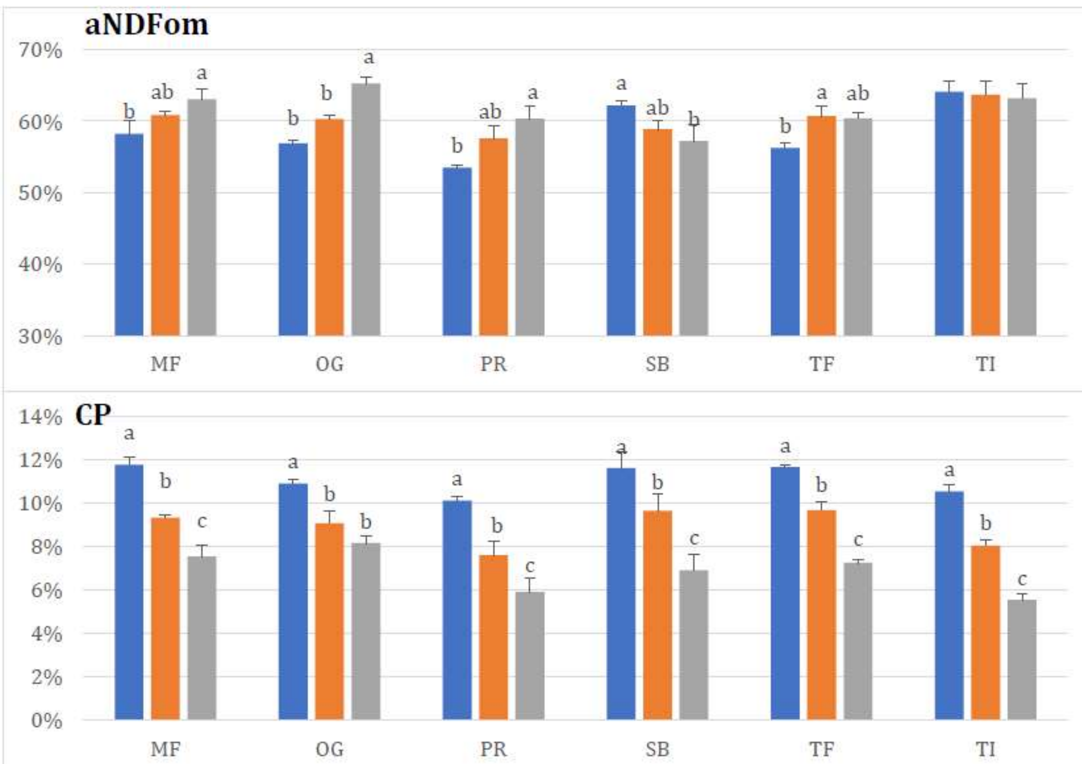

Figure 5 Analysis of fibre (α-amylase treated neutral detergent fibre on organic matter basis:aNDFom) and crude protein (CP) as % of dry matter for different grass species at different harvest times. MF=meadow fescue, OG=orchardgrass, PR=perennial ryegrass, SB=smooth brome, TF=tall fescue, TI=timothy. Blue columns=early harvest at 4th of June, orange columns=medium harvest at 17th of June, grey columns=late harvest at 1st of July. Values are presented as mean±SD. Different letters within grass species indicate significant (p<0.05) differences.

The sugar content of the grass samples was analyzed as water soluble carbohydrates (WSC) including glucose, fructose, sucrose and fructans (see Figure 6). There was no clear indication of a decreasing WSC content as the plants matured, but ryegrass had the highest

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and orchard grass the lowest content of WSC. The fructan content were in general low, but highest at the late harvest at 1st of July. It was unclear why this was found, but meadow fescue and orchard grass remained low in fructans. Broom grass was included as a potential low WSC grass species, but this cannot be recommended based on the results from this study.

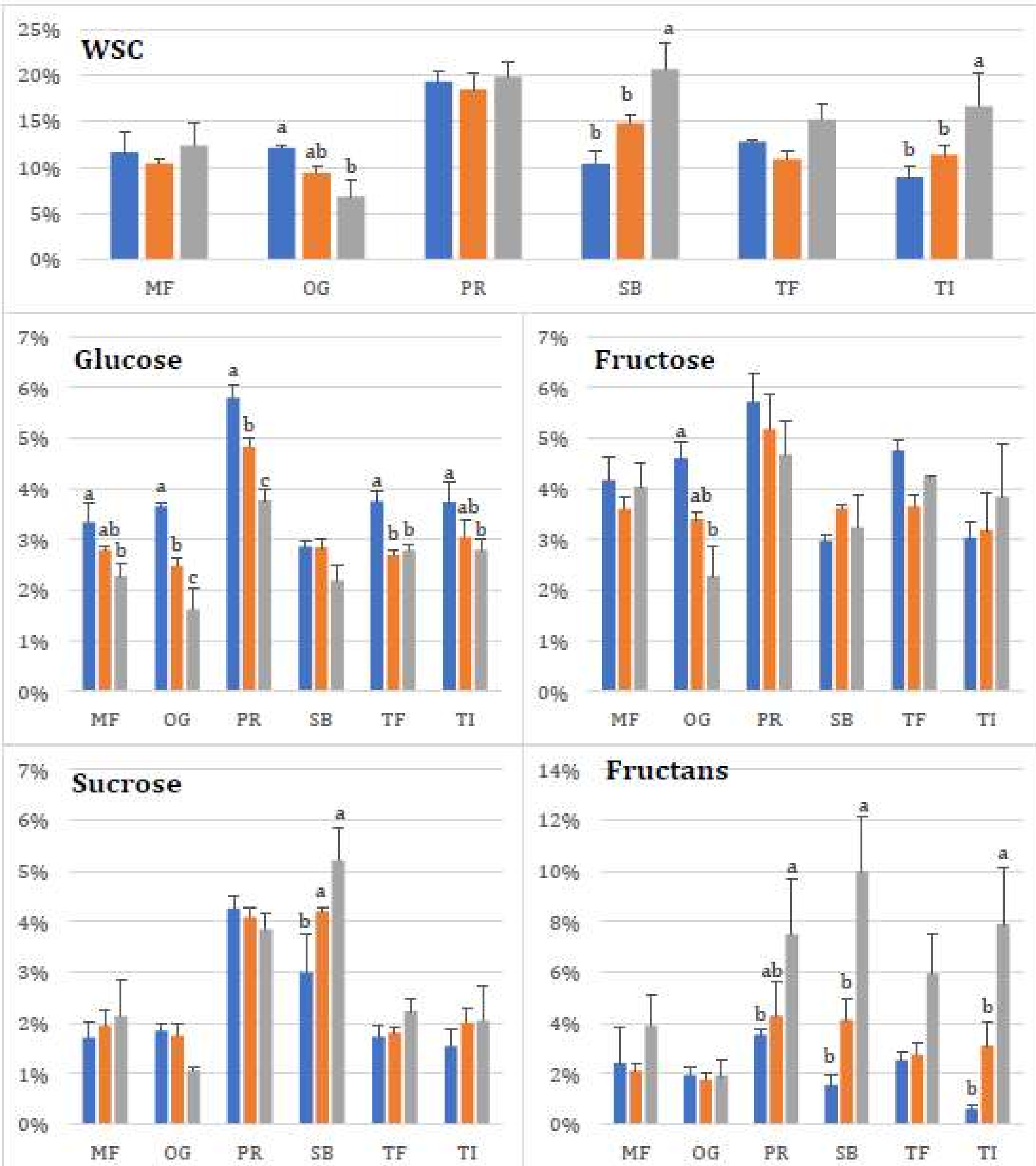
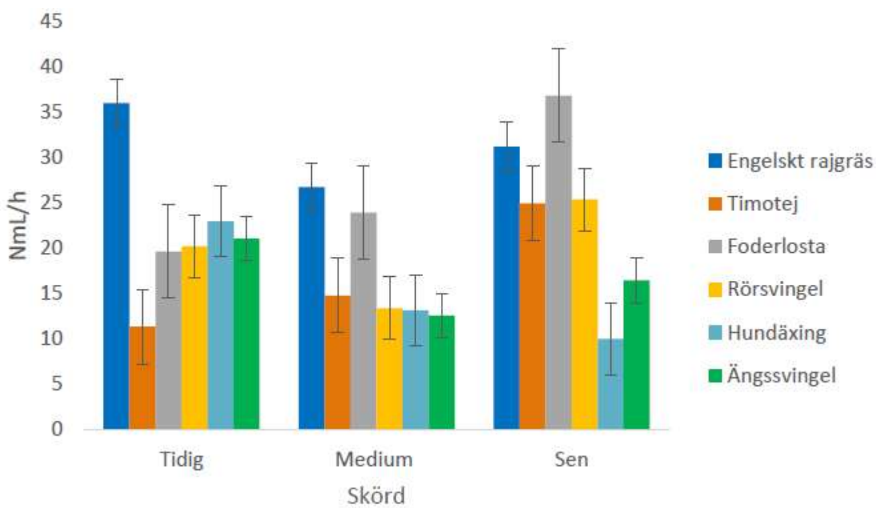


Figure 6 Analysis of water soluble carbohydrates (WSC), glucose, fructose, sucrose, fructans as % of dry matter for different grass species at different harvest times. Note different y-axes. MF=meadow fescue, OG=orchardgrass, PR=perennial ryegrass, SB=smooth brome, TF=tall fescue, TI=timothy. Blue columns=early harvest at 4th of June, orange columns = medium harvest at 17th of June, grey columns=late harvest at 1st of July. Values are presented as mean±SD. Different letters within grass species indicate significant (p<0.05) differences.

Conclusion work package 1:
The aim was to examine the carbohydrate content in grass forage species grown under warm continental climate in Scandinavia (Norway) and harvested at different growth stages. We found that grass species affect the chemical composition, and this should be considered when establishing fields for grazing and forage production depending on the expected use of the product. Rye grass had the highest content of WSC and orchard grass the lowest.

Work package 2: In vitro digestibility of carbohydrates from grass
Experiments with large animals are expensive, laborious and time consuming. Therefore, it is important to select the right samples to test in-vivo in WP3. Many samples can be screened using in vitro gas production techniques simulating the degradation of the feed in the animal. In vitro measurements were performed in Sweden at SLU and in Norway at NMBU.

The result from SLU showed that time of harvest and grass species affected accumulated gas volume and fermentation rate. Early harvest perennial ryegrass had the highest accumulated gas volume ($P<0.03$) and fermentation rate (NmL/h) ($P<0.005$) after 6 and 5 hours (Figure 7), respectively. After 6 h incubation late harvested orchard grass had the lowest accumulated gas volume of all combinations of grasses and time of harvest ($P<0.04$). Based on the results from SLU, it was concluded that the choice of grass species and time of harvest may have a significant effect on how the grass is fermented in the horse's large intestine.



Figur 7 Rate of fermentation of the 6 different grass species harvested the 4th of June (Tidlig), medium harvest at 17th of June (Medium), late harvest at 1st of July (Sen). Ängssvingel=meadow fescue, Hundäxing=orchardgrass, Engelskt rajgräs=perennial ryegrass, Foderlosta=smooth brome, Rörsvingel=tall fescue, Timotej=timothy.

The in vitro measurements at NMBU only included the early and late cut grass samples (Figure 8). The maximum gas production decreased from early to late harvest for all grass samples. A positive correlation between the in vitro dry matter digestibility and maximum gas production was found ($r = 0.87$), showing that gas production is a good indicator of the potential digestibility of a feed.

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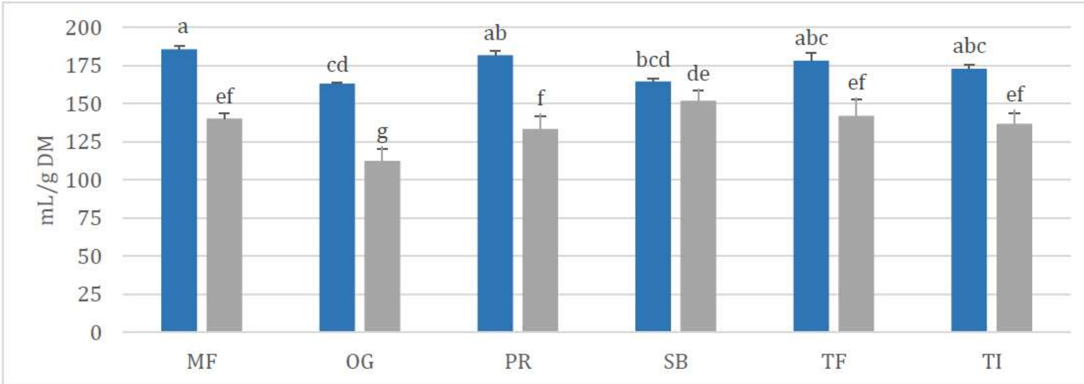

Figure 8 Maximum gas production (ml/g dry matter) for the grass x harvest interaction. MF=meadow fescue, OG=orchardgrass, PR=perennial ryegrass, SB=smooth brome, TF=tall fescue, TI=timothy, DM=dry matter. Blue columns=early harvest at 4th of June, late=harvest at 1st of July. Values are presented as mean±SD. Different letters indicate significant (p<0.05) differences.

Conclusion work package 2:

The aim of this work package was to screen the samples collected in work package 1 in vitro and select the samples to be investigated in vivo in work package 3. We fond that harvest time and grass species affected the in vitro gas production. Similar results were found at SLU and NMBU, and rye grass had a high and orchard grass a low rate of fermentation. Based on the results from Work package 1 and 2, rye grass and orchard grass were selected for work package 3 as two grass species with distinct differences in chemical composition and in vitro fermentation characteristics.

Work package 3: In vivo digestibility of carbohydrates from grass

The mobile bag technique, with administration of small bags containing the four feeds to be studied (early and late cut rye and orchard grass), was used with success. The bags were recovered in the cecum of the horses after they had passed the stomach and small intestine of the horses. This is the first study to demonstrate the prececal digestibility of WSC in horses. Limited research exist in this area as the access to cannulated horses is limited in the world.

The results presented in Table 1 show that the prececal digestibility of fiber is low, as expected, whereas the digestibility of crude protein was higher in rye grass than orchard grass and decreased with harvest time. Protein digestion, absorption and metabolism is still an area of research that needs attention in horses, as many factors are affecting this as indicated here. In general, the digestion of total WSC and individual sugars (glucose, fructose, sucrose and fructans) were high. In work package 1 large differences in chemical composition was found, meaning that the intake of WSC (and other nutrients) probably would be different depending of grass species, and with a high prececal digestibility this would result in different metabolic responses. One limitation with the mobile bag technique is that nutrients disappearing form the bags are assumed to be digested, but this requires supplementary experiments. Investigations on the metabolic responses in horses needs further investigations, for example in grazing experiments or experiments where horses are fed experimental forages of specific grass species.

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Table 1 Prececal digestibility of nutrients (in %) averaged over grass species, pore size of mobile bags or time interval, where bags were recovered. Fiber (aNDFom),crude protein (CP), water soluble carbohydrates (WSC).

	Grass species		Harvest time		Pore size		Time			p-value			
	OG	PR	Early	Late	15	36	1-3	4-6	7-10	G	H	P	T
aNDFom	7.0 (±3.6)	6.5 (±2.5)	9.0 (±2.5)	4.5 (±1.5)	5.8 (±2.7)	7.7 (±3.2)	5.2^{b} (±2.1)	6.6^{b} (±3.2)	8.5^{a} (±3.2)	NS	***	**	***
CP	71.5 (±4.7)	77.0 (±6.0)	78.1 (±4.6)	70.4 (±4.6)	73.3 (±6.0)	75.2 (±6.0)	70.0^{b} (±5.4)	75.8^{a} (±5.8)	77.0^{a} (±4.6)	***	***	*	***
WSC	98.5 (±1.2)	99.2 (±0.8)	99.1 (±0.9)	98.6 (±1.2)	98.7 (±1.2)	99.1 (±0.8)	97.8^{b} (±1.0)	99.2^{a} (±0.4)	99.7^{a} (±0.4)	*	*	NS	***
Glucose	99.2 (±1.5)	99.2 (±1.1)	98.7 (±1.2)	99.7 (±1.3)	99.0 (±1.1)	99.4 (±1.5)	98.9 (±2.0)	99.0 (±0.4)	99.7 (±1.0)	NS	NS	NS	NS
Fructose	99.1 (±0.8)	99.5 (±0.8)	99.6 (±0.4)	99.0 (±1.0)	99.4 (±0.9)	99.2 (±0.7)	98.7^{b} (±0.6)	99.4^{ab} (±0.4)	99.8^{a} (±0.8)	NS	*	NS	*
Sucrose	93.4 (±6.4)	99.7 (±2.0)	98.5 (±3.0)	94.6 (±7.1)	95.9 (±6.5)	97.2 (±5.0)	93.9 (±7.8)	97.9 (±2.4)	97.8 (±5.3)	*	*	NS	NS
Fructans	102.5 (±3.6)	98.8 (±1.2)	99.4 (±1.8)	100.9 (±3.7)	100.0 (±2.8)	100.3 (±3.2)	99.2 (±3.8)	100.3 (±1.6)	101.0 (±3.1)	*	NS	NS	NS

*OG=orchardgrass, PR=perennial ryegrass, early=harvest at 4th of June, late=harvest at 1st of July, 15=pore size 15µm, 36=pore size 36µm, 1-3=collected 1 to 3h post intubation, 4-6=collected 4 to 6h post intubation, 7-10=collected 7 to 10h post intubation, G=grass, H=harvest, P=pore size, T=time with the first line indicating differences between 1-3 and 4-6, the second 1-3 and 7-10 and the third 4-6 and 7-10. *P<0.05, **P<0.001, ***P<0.0001, NS=not significant. Values are presented as mean±SD. Different letters within time indicate significant (p<0.05) differences between the time intervals.*

Conclusion work package 3:

The aim of work package 3 was to use selected samples that are thoroughly described in work package 1 and 2, and study where in the gastro-intestinal tract and to what extent they are degraded. We showed that the prececal digestion of all WSC fractions were high, and there were differences in the crude protein digestibility.

Conclusions

In conclusion, grass species and harvest time affected the chemical composition (work package 1) and the in vitro fermentation (work package 2). In vivo experiments are expensive and laborious, and the in vitro methods can be used to screen a large number of samples for their potential digestibility. However, in vivo studies are still needed for studying digestion and metabolic responses. We found that the prececal digestibility of all WSC fractions were high including fructans.

Relevance for the practical horse sector incl. recommendations

This project has provided new insight into the carbohydrate content in grass forage species grown under warm continental climate in Scandinavia (Norway) and harvested at different growth stages. In combination with thorough investigations on the nutritive value of the forages, especially the different carbohydrate fractions, recommendations regarding selection of grass species for different purposes can be made.

The simple description of the carbohydrate fractions in grass as the good (fiber), the bad (sugar) and the ugly (fructans) is more complex. Different grass spices harvested at different time points will affect the chemical composition and nutritive value of the feeds. Where rye grass might be good alternative for the high-performance horse with high energy

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requirement, orchard grass might be useful for the obese pony with insulin dysregulation. This is important knowledge for seed companies, forage producers and horse owners when e.g. establishing new fields, producing, selling, or buying forages for horses.

This study did also raise new questions in relation to forage production and its nutritive value for horses. The metabolic responses in horses were not studied in this project, and only limited research exist on grazing horses, hence this needs further studies. Carbohydrates make up a large part of the diet for horses, but other nutrient fractions are also important, e.g. protein. Focus on protein digestion and metabolism should be in focus in relation to give us a better understanding of the digestion and metabolism of protein. Furthermore, many horses are fed imported protein feeds like soya beans, and focus should be on local produced protein feeds like grasses and legumes. In vitro studies provided useful information on the potential digestion of feeds, but the method needs to be validated further for improving and understanding the strength and limitations.

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Date 31-05-2021

Part 3: Result dissemination

State all result dissemination from the financed project into the appropriate section, including information as indicated. Additional rows can be added to the table.

Scientific publications, *published*	*Author(s), year, title, journal, Vol, No, pp. (doi/link if applicable)*
	Stang FL, R Bjerregaard, CE Müller, Å Ergon, M Halling, NW Thorringer, A Kidane, RB Jensen. 2022. The effect of harvest time of forage on carbohydrate digestion in horses quantified by in vitro and mobile bag techniques. Journal of Animal Science, skac422, doi.org/10.1093/jas/skac422
Scientific publications, *submitted*	*Author(s), title*
Scientific publications, *manuscript*	*Ergon Å, Müller C, Halling M, Jensen RB: The effect of grass species and harvest time on chemical composition*
	Müller C, Ergon Å, Halling M, Jensen RB: The effect of grass species and harvest time on in-vitro fermentation in horses
	Müller C, Ergon Å, Halling M, Jensen RB: Pre-cecal and total tract digestibility of water-soluble carbohydrates from grass in horses
Conference publications/ presentations	*Mari Terese Hoffgård, Cecilia Müller, Åshild Ergon & Rasmus Bovbjerg Jensen. 2022. The effect of harvest time of timothy grass on in-vitro and in-sacco digestibility in horses. European workshop on equine nutrition (EWEN). 22nd-25th of August, Cirencester, UK*
	Müller C, Halling M, Ergon Å, Jensen RB. 2020. Den gode, den onde och den fule" - kolhydrater i gråsarter till håstfode: icke-strukturella kolhydrater. Vallkonferaens, 4-5 February 2020, SLU, Uppsala, Sweden
	Round table discussion on how to handle the insulin dysfunctional horse at EEHNC 25th March 2021 online conference, where our results were used to show the large variation in WSC in different grasses.
Other publications, *media etc.*	*Velg riktig grovfôr til hesten, 27th of October 2020, Felleskjøpet webinar, https://www.youtube.com/watch?v=WlRhSzr7n2E*
	Kolhydrater i hästars grovfoder studeras: "Har betydelse för hur vi bör tänka vid skörd" FORSKNING Publicerad: 2020-05-07 https://www.hippson.se/artikelarkivet/forskning/kolhydrater-i-hastars-grovfoder-studeras-har.htm
Oral communication,	*We have used the experimental fields in the following courses: Spring 2019: Ernæring av hest – Bachelor/master course August 2019: Keeping the hindgut and the horse healthy – International PhD/master course*

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to horse sector, students etc.	*Results have been used in various courses as examples on forage production, growth, and utilization, not only for horses but for different animal species*
	Courses at NMBU: *Animal Science HFX132* *Horse nutrition HFH255* *Grazing Ecology and Management HFX205* *Animal Nutrition VET305*
	Courses at SLU: *Production and quality evaluation of forages BI1327* *Feed Science and forage production HV0166* *The biology of the horse Hv0180* *Horse nutrition HV0177* *Animal Health and Nutrition Hv0129*
Student theses	***Student:*** *Stephanie Widegren (SLU)* ***Supervisor****: Cecilia Müller* ***Year:*** *2020* ***Title:*** *In vitro gas production in different grass species using equine faecal inoculum* ***Type of thesis:*** *Master thesis*
	Students: *Frida Lindskov Stang & Rikke Bjerregaard (NMBU/KU)* ***Supervisor****: Rasmus Bovbjerg Jensen* ***Year:*** *2020* ***Title:*** *Carbohydrates and crude protein in forages for horses* ***Type of thesis:*** *Master thesis*
	Students: *Emma Lindahl (SLU)* ***Supervisor****: Cecilia Müller* ***Year:*** *2020* ***Title:*** *Carbohydrate composition and in vitro-gas production in grass at simulated horse pasture* ***Type of thesis:*** *Master thesis*
Other	

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Link to YouTube webinar: https://www.youtube.com/watch?v=WlRhSzr7n2E

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