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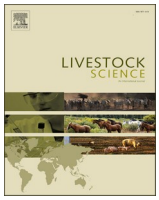

Hay preferences in horses versus selection by their owners

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HIGHLIGHTS

- 69% of the horses preferred hay type B, 31% hay type C, 0% hay type a in a choice experiment.
- 42% of the owners preferred hay type A, while approximately 30% chose hay types b or c.
- No significant association was found between horse and owner's hay preferences ($P > 0.05$).
- Higher protein contents and leaf fractions in hays were factors positively associated with the hay preference of the horses.

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ABSTRACT

The objective of the present study was to evaluate the differences in the selection behaviour by horses and by their owners given a choice of three hay types differing in chemical and nutritional composition. Horse groups included 12 French mountain (FM) stallions, 12 Icelandic (IS) and 12 warmblood horses (WB), with the latter groups consisting of mares and geldings. Hays were offered in a free choice experiment over a period of six consecutive days (baseline choice on day 1, adaption period from day 2–5 and a final preference test on day 6). Additionally, the owners of the horses selected among the three hay types, the one which they assumed would best meet their horse's assumed nutritional requirements. Hay types (A, B and C) showed distinct characteristics based on colour, texture morphology and odour and nutrient contents. The latter were analysed with near-infrared spectroscopy. Most horses (69%) preferred hay type B and 31% preferred hay type C, while horses completely avoided hay type A. The group of FM horses exclusively preferred hay B on both test days, the groups of IS and WB horses also showed a preference for hay B, but less pronounced than FM horses choosing both between hay B and C, respectively. Horses did not choose randomly among the hays offered ($P < 0.05$). In addition, the horses hay preference was influenced by their group assignment ($P < 0.05$) which, however, cannot be generalized to breed or gender (mares, stallions or geldings). The content of crude protein ($r = 0.68$), and leaves ($r = 0.48$) of the hay was positively correlated with the preference of the horses for that particular hay type, although correlations were moderate. Among the owners, 42% chose hay type A, which was completely avoided by the horses, while approximately 30% of the owners chose either hay type B or C, which were richer in energy and protein as the best hay quality for their horses assumed nutritional requirements. Therefore, no significant correlation could be observed between the choice preference of the horses and the selection by the owners. The distinct preference for energy- and protein-rich hay of horses underlines the importance for owners to carefully adjust the hay quality to the horse's activity level and requirements. For horses with lower energy requirements, omission of concentrate feeds, while providing roughage only diets by mixing different hays qualities, appears suitable.

1. Introduction

Selection by horses between forages of different morphological, chemical and nutritional characteristics is limited with horses imposed to living conditions managed indoors compared to horses kept outdoors grazing on grasslands (Bachmann and Stauffacher, 2002; Ruet et al.,

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2019). Horse owners commonly base forage selection offered to their horses on organoleptic or sensory characteristics. Horse owners' individual perception of "good quality hays" were shown to be associated with "high energy hays" (Julliand et al., 2019). However, those forages are not necessarily the most suitable for horses, when regarding their nutritional requirements and their activity level in living conditions managed indoors. Excess energy intake may increase the prevalence of obesity and insulin response if feeds are used that promote higher insulin response (Hoffman et al., 2003).

When horses are given the choice to select between forages previously versus not previously offered to them, horses show a conservative behaviour to select for forages which are common to them (van den Berg et al., 2016). Horses were shown to select for forages higher in non-structural carbohydrates (NSC) and crude protein (CP) concentrations over forages rich in structural carbohydrates (Allen et al., 2013; DeBoer et al., 2017; Grev et al., 2017). The selection behaviour can be modulated by previous intake of known feeds, which suggests that horses could select the forages that best suit their nutritional requirements (LaCasha et al., 1999). Also breed (Bamford et al., 2014) and sward hight (Naujeck et al., 2005) were shown to affect forage selection in horses.

However, few horse owners or stable managers have their hay analysed for protein, energy, or fibre contents. According to Julliand et al. (2019), the suitability of forage quality for horses are primarily based on individual organoleptic or sensory perceptions. In that study, stable owners and managers were able to precisely assess the concentrations of digestible energy (DE) and those of acid detergent fibre (ADF), *i.e.* cellulose, hemicellulose and lignin of various hay types. However, that was not the case for the concentrations of CP or non-fibre-carbohydrates (NFC), with the latter one including sugars, starch, pectins and other soluble organic residues. The ability of the owner to select the type of hay best matching the current nutritional requirements of the horse is therefore potentially limited. However, horse owner do often neither know the nutritional requirements of their horses nor the nutrient concentrations of the diet offered (Murray et al., 2015). When horses are given the choice between forages with contrasting nutritional characteristics, it remains therefore unanswered whether horses, their owners or both select for the forage quality best matching the effective nutritional requirements of the horses.

Therefore, in the current experiment, the preferences of hay types each distinct with respect to morphological, organoleptic and nutritional characteristics offered in a free choice experiment to horses was investigated. Horses were categorized in three distinct experimental groups according to breed and gender as those characteristics were used to create differences in nutritional requirements across groups. It was hypothesised that horses select the hay type best correlated with their actual nutritional requirements and that the selection is dependant of horse breed and gender. Hay types without indications of nutrient analysis were also presented to horse owners, who had to select the hay type best meeting their horse's assumed nutritional requirements. It was hypothesized that most horse owners choose for the hay type most concentrated in energy rather than the hay type best meeting the effective nutritional requirements of the horse.

2. Material and methods

2.1. Horses and husbandry

A total of 36 horses from three different breeds were used in the present study that was conducted in April and May 2020 to create the following three experimental groups (FM, IS and WB as specified below): Twelve horses of each breed were housed in different stables (stable 1, 2 and 3), all of them located in the Swiss Midplain region at an approximate 480 m a.s.l. and an average annual mean temperature of 7.80 °C. French mountain horses (FM), a native Swiss breed, were housed in stable 1 at the Swiss National Stud, Icelandic horses (IS) were kept in stable 2 at a private leisure and sport stable of IS disciplines, and warmblood horses (WB) were housed in stable 3, at a private leisure and sport stable. The group of FM horses consisted of stallions only, with a mean age of 10.6 (range: 4–16) years, with an average weight of 543 (range: 50–584) kg and a mean body condition score (BCS) of 6 (Henecke, 1985). The FM horses were kept in individual boxes. The group of IS horses consisted of two mares and ten geldings with a mean age of 12.8 (range: 8–0) years, with an average body weight (BW) of 343 (range: 315–417) kg and a mean BCS of 5. They were kept individually or pairwise in boxes with permanently accessible paddocks. The group of WB horses consisted of three mares and nine geldings with a mean age of 16.0 (range: 11–25) years, with an average weight of 561 (range: 403–660) kg and a mean BCS of 5. The WB horses were kept in individual boxes with permanently accessible paddocks. The activity level of all horses in the trial varied from low to moderate.

2.2. Diets

Across the experimental period, the basic feeding regime of all horses consisted of a hay-based diet (FM: 2.0 kg/100 kg BW, IS: 1.8 kg/100 kg BW, WB: 1.3 kg/100 kg BW), concentrates and minerals excluding the experimental hay types offered as specified in Sections 2.3 and 2.4, respectively). Analytical values of the hay, which was fed in the stables, when the horses were not in the experiment were not available and therefore average values from the National Research Council (2007) for horse hay, first cut, were applied for the calculation of intake of energy and nutrients (Table 1).

The concentrates fed were Muesli-mixtures with an average concentration of digestible energy (DE) of 11.2 MJ/kg dry matter (DM) and slightly differing CP concentrations (mean 107 g/kg DM, range: 95−131, g/kg DM). Per 100 kg BW, French mountain horses received on average 0.23 kg (range: 0.09−0.40 kg/100 kg BW/day), IS horses 0.21 kg (range: 0.10−0.36 kg/100 kg BW/day) and WB horses 0.21 kg (range: 0.09−0.38 kg/100 kg B /day) concentrates in two equal portions daily. All horses were provided a salt lick (NaCl). The IS horses and five of the WB horses received differently branded mineral feeds containing Ca (48.0–108 g/kg DM), P (14.0–25.0 g/kg DM), Mg (12.0–25.0 g/kg DM) and Se (3.00−18.0 mg/kg DM) in addition. Individual daily requirements and intake of energy and nutrients were calculated based on BW and activity level (National Research Council, 2007) (Table 1).

2.3. Sensory, botanical, and chemical characteristics of the experimental hays

Three hay types (A, B and C) were selected for the free choice experiment based on distinct characteristics with respect to colour, texture and odour. Those qualitative characteristics were classified based on the methodology applied in Julliand et al. (2019). Phenological stages of the swards to produce hays A, B and C, respectively, were described according to the definitions given by Huguenin et al. (2020). Hays were obtained from three different farms and were produced from forage harvested in spring 2019. Hay type A was derived from a sward based on the seed mixture UFA 330 (UFA AG, Herzogenbuchsee, Switzerland). This seed mixture was composed of 82% grass (36% *Festuca pratensis* L., 21% *Lolium perenne* L., 17% *Dactylis glomerata* L. and 8% *Phleum pratense* L.) and 18% legumes (12% of *Trifolium repens* and 6% of *Trifolium pratense*). The sward was in the 2nd year of utilisation after sowing. At harvest, the phenological stage of the sward was at 'full heading' to 'flowering'. The colour of hay A was yellowish and the texture rather rough. Hay type B was obtained from a sward based on the seed mixture UFA 430 (UFA AG, Herzogenbuchsee, Switzerland). This mixture contained 86% grasses (28% of *Poa pratensis* L., 28% L. *perenne* 14% of *D. glomerata*, 8% of *P. pratense* and of *Festuca rubra* L., respectively) and 14% legumes (11% of *T. repens* and 3% of *T. pratense*). The sward was in its 3rd year of utilisation. At the time of harvest, the phenological stage of the sward was at 'beginning of heading'. Hay type

Table 1
Mean daily estimated requirements (R) and intake (I) and difference between requirement and intake (Δ) of energy, crude protein, calcium and phosphorous by horse breed.

Horse breed	French Moutain (FM)				Icelandic (IS)				Warmblood (WB)			
	R	I	Δ[1]	SEM[2]	R	I	Δ	SEM	R	I	Δ	SEM
Digestible Energy (MJ)	106	116	+10.2	2.10	57.4	61.8	+4.40	1.80	93.8	99.0	+5.20	2.80
Crude protein (g)	833	1480	+647	42.8	480	799	+319	18.2	784	1069	+285	33.1
Calcium (g)	38.0	85.3	+47.3	1.20	20.6	45.1	+24.5	1.40	33.7	56.5	+22.8	1.50
Phosphorus (g)	22.8	34.7	+11.9	1.30	12.4	19.9	+7.50	0.70	20.2	21.7	+1.5	0.5

Mean daily estimated requirements (R) and intake (I) and difference between requirement and intake (Δ) of energy, crude protein, calcium and phosphorous by horse breed.
[1] Note: A positive value indicates that the intake is higher than the requirement of the horse.
[2] SEM = standard error of the mean.

Table 2
Chemical composition (g per kg dry matter, DM) and characteristics of hay types A, B and C offered during the free-choice experiment.

Item	Hay A	Hay B	Hay C
Dry matter (%)	89.1	89.3	88.8
Crude protein	76.3	127	97.0
Crude fibre	372	300	299
Total sugar	53.3	73.0	92.3
Fructan	37.0	38.0	58.3
Crude fat	14.7	24.3	17.0
Ash	53.7	80.3	64.3
Metabolizable energy (MJ)	6.30	7.20	7.50
Digestible energy (MJ)	7.67	8.80	8.93
Non-fibre carbohydrate	157	185	223
Morphological characterization (%)			
Stem	46	19	26
Leaf	44	79	68
Inflorescences	10	2	6
Botanical composition from analysis (% DM)			
Grasses	100	96	97
Legumes	0	4	1
Other plants	0	1	2
Sensorial description			
Colour	yellowish	green - brown	light green – brown to yellowish
Odour	odourless	aromatic	aromatic
Texture	stem-like structure, stiff	no stems, leafy structure, soft	intermediate in structure and softness / stiffness

B appeared green, the texture was soft with a greater proportion of leaves and indicated characteristics associated with a high-quality hay among the different hay types. Hay type C was obtained from a grass-dominated semi-natural sward, utilised for more than six years. At harvest, the phenological stage was 'beginning of full heading'. The colour of hay type C was light greenish and the texture rather of fine stems.

All hays were field-dried and baled into small rectangular bales before being stored in a shed without the use of conserving additives. The botanical composition of the hays fed during the experimental period was assessed by sorting three subsamples of 300 g DM of every hay type into grasses, legumes, and other plants (Huguenin et al., 2020), respectively. These three subsamples were obtained by sampling several individual hay bales during each period of the choice feeding experiment, respectively. Hays were further morphologically separated into proportions of stems, leaves, and inflorescences on a DM basis (Gustavsson, 2011). One subsample of each hay was ground to 1 mm sieve-size to determine the chemical and nutrient composition. Samples were analysed with near-infrared spectroscopy (NIRS) at the laboratory of the institute of food quality LUFA-Northwest (Oldenburg, Germany), with regressions adjusted for grass-based forages. Chemical parameters were analysed based on standardized procedures and definitions given by the VDLUFA ("Verband Deutscher Landwirtschaftlicher Untersuchungs- und Forschungsanstalten"). Analytical parameters included DM, CP, crude fibre (CFb), total sugar (TS), fructan, crude fat (CFa), ash, metabolizable energy (ME), DE, and NFC. Finally, sensorial characterisation of the hays (sight, touch, smell) was performed following the procedure by Julliand et al. (2019). Visual appearance and odour were assessed by the laboratory LUFA-Northwest as typical/within norms for all three hay types respectively.

2.4. Study design: hay preference test for the horses and their owners

The experimental period consisted of an adaption period with a baseline preference test on day 1, a further adaption period from day 2–5 and a final preference test on day 6 (Fig. 1). To determine whether the hay preferences of the horses were repeatable and whether the adaptation period had an influence on the preference of the horses, a baseline preference test was conducted on day 1 with 1 kg of each hay type (A, B and C) offered simultaneously during 30 min in plastic boxes (65 L in volume). From day 2 to 5, a mixture of 1 kg of each hay was offered in a unique plastic box. At day six, the preference test was carried out with 3 kg of each hay offered simultaneously in separate plastic boxes. During the whole experimental period, the hay containing boxes were placed in the horse's stall in the morning between 6 and 7 am, before the horses were supplied with their daily diet (as described in detail in Chapter 2.2). The three hay boxes were prepared in advance in front of the horse stalls, so that all twelve horses were simultaneously offered all hay types. The order of the plastic boxes was randomized in each horse stall. The duration of the preference test on day 6 was limited to 30 min only, to ensure that horses could consistently choose from all three hay types during the trial since ingestion of one kg hay was assumed to last between 30 and 45 min (Ellis, 2010). After removing the hay boxes, the remaining hay in each plastic box was weighted and DM ingestion of each hay type was recorded. The experiment started with the FM horse group (20th–25th of April 2020), continued with IS horse group (1st–6th of May 2020) and ended with WB horse group (11th–16th of May 2020). For each horse, the type of hay with the highest DM ingestion (kg) was defined as the preferred hay type.

In parallel to the hay preference test of the horses, horse owners (N = 36) had to fill in a questionnaire lasting for 10–15 min including general information with respect to their horse (name, breed, use and activity of the horse), as well as concerning the three hay types offered to the horses in the hay preference test. For this purpose, 3 boxes containing 1 kg of either hay type A, B or C were presented to the participants. Owners were then asked to perform a sensory analysis of hay types A, B and C (sight, touch, smell) using a questionnaire according to Julliand et al. (2019). Based on their individual perceptions at the end of the sensory analysis, owners were then asked to choose which hay type they think would best correspond to their assumed nutritional requirements of their horses.

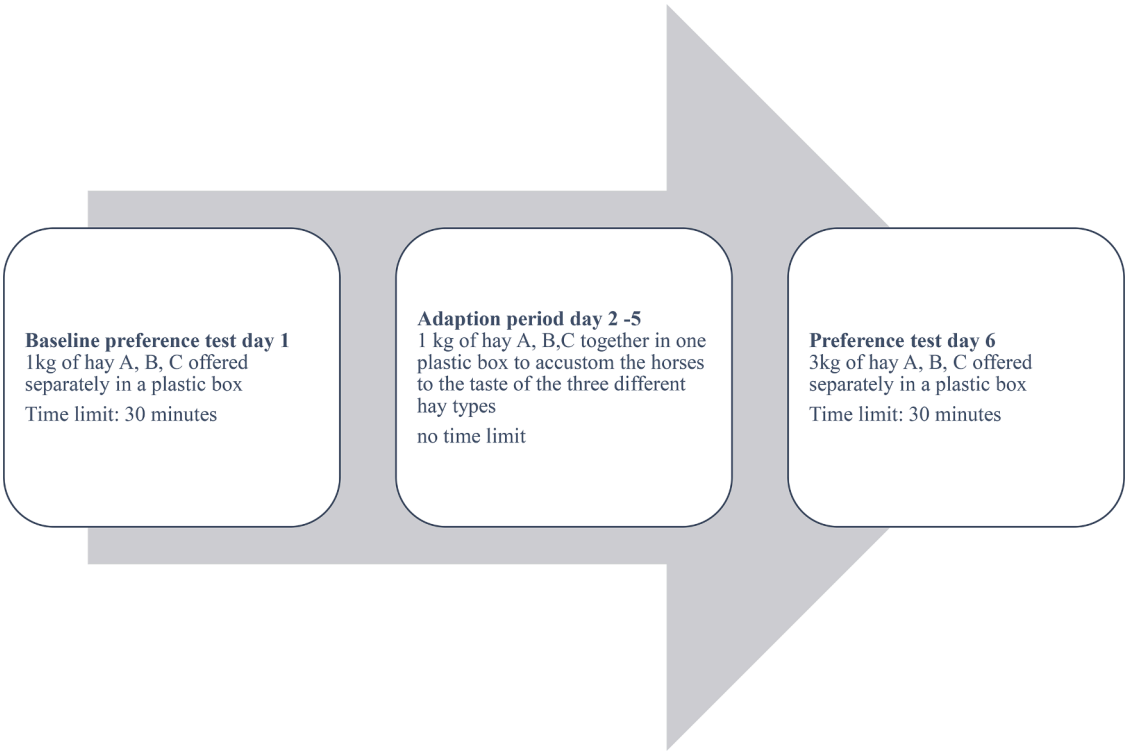

Fig. 1. Timeline of the hay preference test in each stable.

2.5. Statistical analysis

A goodness-of-fit test was conducted to assess the hay preferences of horses against the null hypothesis that horses chose randomly across the three hay types offered during the preference test rather than on a specific pattern. The same test was performed with the first choice of the owners for the hay they assumed best corresponding to the nutritional requirements of their horses. In addition, a two-sided Fisher's exact test was conducted on the contingency table obtained by cross-tabulating horse first choice and horse group to assess whether there was statistical evidence against the null hypothesis of independency of rows and columns. The same test was conducted on the contingency table obtained by cross-tabulating owner's first choice and horse group. For better reading, the naming of the horse groups will be simplified to FM, IS and WB horses in the following sections. A generalised linear model (GLM) with binomial error distribution and logit link function with explanatory variables describing the owner's choice, the estimated requirements of the horses, and the characteristics of the hay was fitted to the data collected in the experiment. This modelling approach was intended to highlight the main variables that influenced the first choice of owners and horses, respectively. As the generalised linear model with binomial error distribution did not converge, a more exploratory Spearman correlation analysis of the horses first choice with all potentially explanatory variables collected during the animal experiment was resorted. Due to the exploratory nature of this hay preference experiment, no adjustment for multiple testing was applied. All analyses were performed with the R language and environment for statistical computing, version 4.0.3 (R Core Team, 2020).

3. Results

3.1. Hay preferences of according to horse group

The average hay intake of the FM horses during the 30 min at the preference test on day 6 was 0.26 kg/100 kg BW (range: 0.19–0.37 kg/ 100 kg BW kg), of the IS horses 0.23 kg (range: 0.17–1.30 kg/ 100 kg BW) and of the WB horses 0.24 kg (range: 0.18–0.32 kg/100 kg BW). All FM horses exclusively preferred hay B on both test days (Table 3). The average hay intake per 100 kg BW of FM horses on test day 6 was for hay $A = 0$ kg; hay $B = 0.25$ kg; hay C = 0 kg. The average hay intake per 100 kg BW of IS horses on test day 6 was for hay $A = 0$ kg, hay $B = 0.11$ kg and hay C = 0.12 kg and of WB horses hay $A = 0$ kg, hay $B = 0.12$ kg and hay C = 0.12 kg. The groups of IS and WB horses also showed a preference for hay B, but less pronounced than FM horses, with choosing both between hay B and C, respectively (Table 3). On day 1, hay B was the first choice from 7 out of 12 (58%) and hay C from 5 out of 12 IS horses (42%), whereas on day 6 the preferences between hay B and C equalled (6 out of 12 IS in the case of hay type B and C, respectively). Nine of the 12 WB horses chose hay B on day 1 (67%), but only 7 out of 12 WB horses still showed preference for hay B on day 6 (58%). Accordingly, preference for hay type B on trial days 1 and 6 remained at 100% for FM horses, decreased 8% for Icelandic horses in favour of hay type C, and decreased 9% for WB horses in favour of hay C. Nevertheless, hay type B remained the most popular hay for FM and WB horses, respectively, while for IS horses the preference between hay B and C was balanced on day 6. Horses did not choose randomly among the hays offered ($P < 0.05$). In addition, the horses hay preference was influenced by their group assignment ($P < 0.05$).

Chemical and botanical characteristics that had an impact on the preferred hay type of the horses are shown in Fig. 2. The content of CP ($r = 0.68$) and leaves ($r = 0.48$) of the hay, was positively correlated with the preference of the horses for that particular hay type, although correlations were moderate. On the other hand, the higher the proportion of stems of the hay, the more unlikely horses selected for this hay type ($r=-0.48$). Consequently, crude protein content of the selected hay and the proportion of the stems were strongly negative correlated ($r=-0.81$). Contents of hay TS ($r = 0.28$), fructan ($r = 0.09$), ME ($r = 0.43$), DE ($r = 0.40$) and NFC ($r = 0.41$) had a lower impact on the hay choice of the horses.

Table 3
Hay preferences of horses in total numbers and % when given a choice of three different hay types (A, B or C) at day 1 and at day 6, before and after the adaptation period, respectively as well as the average (range) hay consumption.

Breed[1]	Hay A			Hay B			Hay C		
	n[2]	%[3]	kg[4]	n	%	kg	n	%	kg
Baseline preference test day 1 (1 kg of each hay)									
FM	0	0	0.03 (0.00–0.20)	12	100	0.79 (0.57–0.92)	0	0	0.25 (0.11–0.40)
IS	0	0	0.01 (0.00–0.02)	7	58	0.33 (0.00–0.48)	5	42	0.31 (0.10–0.61)
WB	0	0	0.01(0.00–0.08)	9	67	0.60 (0.00–0.75)	3	33	0.31 (0.10–0.61)
Total	0	0		28	75		8	25	
Preference test on day 6 (3 kg of each hay)									
FM	0	0	0.06 (0.00–0.05)	12	100	1.33 (1.00–1.83)	0	0	0.03 (0.00–0.19)
IS	0	0	0.01 (0.00–0.02)	6	50	0.37 (0.01–0.69)	6	50	0.43 (0.00–0.97)
WB	0	0	0.01 (0.00–0.08)	7	58	0.66 (0.00–1–52)	5	42	0.65 (0.27–1.46)
Total	0	0		25	69		11	31	

[1] FM = French mountain ($n = 12$), IS = Icelandic ($n = 12$), WB = Warmblood ($n = 12$), total ($n = 36$).
[2] Number of horses who preferred this hay type.
[3] Percentage of 12 horses in stable 1,2,3 respectively of all 36 horses who preferred hay A, B or C.
[4] kg = mean (and range) of ingested hay during 30 min.

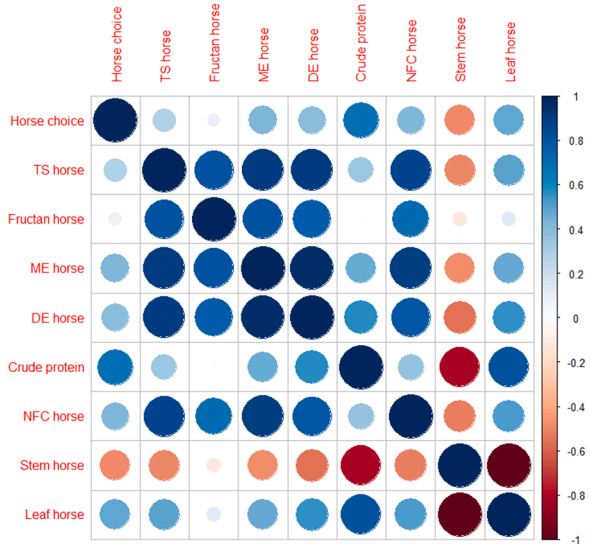

Fig. 2. Correlations between selected chemical and botanical hay characteristics and the preference of the horses.
TS = total sugar, ME = metabolizable energy, DE = digestible energy, NFC = non-fibre carbohydrate, all as per kg dry matter in the preferred hay type of the horse.

3.2. Hay selection by the owners

Hay preference by the owners resulted in 30% hay type A, 28% hay type B, and 42% hay type C regarding the assumed requirements of their horses (Table 4). Based on the goodness-of-fit test, horse owners were unlikely to choose hay types randomly ($P < 0.05$), but their choice was associated to the factor horse group ($P < 0.05$).

The hay choices of the owners varied widely in relation to what they considered to be their estimated needs of the horses. Consequently, the calculated correlations between the hay choice of the owners and the chemical as well as botanical characteristics of the hay types were negligible ($P < 0.05$) (Contents of hay TS ($r = 0.01$), fructan ($r = 0.13$), DE ($r = 0.15$), DP ($r = 0.03$) and the proportions (%) of stems ($r = 0.08$) and leaves ($r = -0.08$)).

Table 4
Owners' preference (%)[1] for one of the hay types (A, B or C) they believed best suited their horses' needs by stable.

Selection	Hay A	Hay B	Hay C
Owners stable 1 (FM)[2]	50	25	25
Owners stable 2 (IS)	0	50	50
Owners stable 3 (WB)	42	8	50
Total (mean)[3]	30	28	42

[1] Percent values indicate, how many of the 12 horse owners in each of the stable 1,2,3 selected hay A, B or C for their horses.
[2] FM = French mountain horses, IS = Icelandic horses, WB = warmblood horses.
[3] Mean indicate the percentage of horse owners who selected hay type A, B or C across stables.

3.3. Hay selection of horses versus owners

Regarding the first choices of horses in relation to those of the owners, no significant association between these two preferences was found (Fisher's Exact test, $P = 0.54$).

4. Discussion

Feeding horses in living conditions managed indoors with limited physical activity are challenging to feed without the risk of gaining BW. Information of the nutritional requirements of energy and protein of the horses and/or on the concentrations of energy and protein of the forages are often not analysed or insufficiently estimated. In the current study, the main question was therefore to investigate whether horses or their owners choose for the same hay quality when offered a choice and whether this choice corresponds to the nutritional requirements of the horses or not. Regarding the balance between nutrient requirements and intake, all horses in the study had a positive balance in terms of energy and total protein, most evident in the FM horses. The preference test conducted in the present study resulted in a distinct hay preference for the hay type richest in digestible protein and with the highest proportion of leaves. Although protein intake in all horses of this study was over supplied, horses still selected for the hay type richest in protein. This finding is in alignment with several other studies, which have reported a positive relationship between preference and protein content of forages (Allen et al., 2013; Clark et al., 2016; DeBoer et al., 2017; Grev et al.,

2017).

4.1. Preference of the horses as a function of hay characteristics

Previous studies, which offered hay types of different chemical and botanical compositions showed that horses also selected for the hay type with a higher fibre concentration (in this case ADF), which usually have higher NSC and protein concentrations, as well as hays with a softer (*i.e.* leafier) structure (Ordakowski-Burk et al., 2006; Rodiek and Jones 2012; Clark et al., 2016). In the study of Clark et al. (2016), horses preferred bermudagrass hay over teff hay, with bermudagrass being the hay with the higher protein concentration and softer physical structure. Most horses (69%) in our study preferred hay type B, the hay richest in energy and protein, while 31% of the horses preferred hay type C, but in contrast no horse preferred hay type A. Furthermore, hay preferences were not manifested in the same way among horse groups. All FM stallions had an exclusive preference for hay type B only, whereas 50% of the IS horses showed a preference for either hay type B or C, respectively. Warm blood horses expressed a similar preference as IS horses with 58% showing a preference for hay type B and 42% for hay type C. It was not possible to determine whether these variations in preference were due to breed, since there was not an even distribution of mares, stallions and geldings represented within each horse group, respectively. However, it has been shown that horse taste preferences may by influenced by breed on the one hand but also on by gender on the other hand (LaCasha et al., 1999; Janczarek et al., 2018). In the study by LaCasha et al. (1999) horse taste preferences depended not only on the breed but also on the sex and in the study of Janczarek et al. (2018), stallions expressed a different behaviour and timing when consuming dried sugar beet molasses compared to mares. The FM stallions in our study was the only group who preferred exclusively hay type B during the baseline test on day 1 and in the preference test on day 6, which may, however, be associated to the breed itself or the gender, as all FM horses were stallions only. Similar hay preference results were obtained for both IS and WB mares and geldings (with selection mainly but not exclusively for hay type B) compared to the FM stallions which might also support the gender differences. However, interactions between gender or breed could not be assessed with the current experimental set-up and the selection behaviour of the horses may therefore not be generalized for breed or gender effects.

4.2. Procedure of the preference test

Characteristics such as smell or taste have been reported to have an impact on the feed selection of the horse (van der Berg et al., 2016). A duration of 5 days was chosen for the adaptation period, so that horses were accustomed to the three different hay types prior to the experimental period, which is with a common duration when compared to other studies with adaption periods between three and 15 days (Clark et al., 2016; Heuschele et al., 2018; Owens et al., 2019). During the first preference test on day 1, some horses rejected to feed from the plastic boxes, however, after 2 days, horses were familiarized with feeding hay offered in plastic boxes. According to Leiner and Fendt (2011), a horse requires between two to six days to get used to a new object or place. This process was facilitated by performing the trial in the horse's usual stalls to avoid additional stress or interactions with the choice preference test. Additionally, the habituation to the three different hay types was essential, as horses are likely to select for familiar feeds (van der Berg et al., 2016).

In most preference tests performed with horses, only two choices are given (Cairns et al., 2002; van der Berg et al., 2016; Owens et al., 2019) while in our study the choice of three different hay types was investigated to offer a broader variety of forages with contrasting nutritional characteristics. However, Duncan (2005) suggests that it would be more appropriate to conduct preference tests with more than two choices only to assess the true preferences of horses. Other authors have therefore proposed to offer up to five options to choose from (Müller and Udèn, 2007; Janzareck et al., 2018). The influence of a previous forage experience on the selection behaviour with fresh grass has been investigated by LaCasha et al. (1999), where horses consumed less of the forage species to which they had been previously exposed compared with unadapted horses. The preference test in this study was performed early in the morning prior to feeding indoors, to avoid confounding with ingestion of other feeds or lack of appetite. It was shown that horses preferred to graze from a sward height of 7 cm and it was therefore assumed that sward height as well as the quality of the young re-grown grass had an influence on diet selection of horses (Naujeck et al., 2005). In contrast, Heuschele et al. (2018) have investigated the preference of horses for oat but did not find differences between horses fed prior to pasture allowance or after. In our experiment, given a free choice of three different hay types differing in structural and nutritional composition, approximately two thirds of the horses chose the hay with the highest protein and leaf content (hay B). Horse owners in the study of Julliand et al. (2019) were able to accurately assess the hay quality in terms of energy and fibre, but not in terms of protein and sugar content. According to van der Berg et al. (2016) and Cairns et al. (2002), there was evidence that horses can differentiate between energy contents of feeds and may direct their selection towards feeds being more concentrated in energy. Horses were also shown to select for specific flavours. In the study by Cairns et al. (2002), horses also preferred certain flavours over others (mint versus garlic). However, the preference for mint changed when feeds with this flavour contained less energy. Hay B and C were the hays preferred by the horses in our study, which contained more energy and protein than hay type A which was completely avoided. This finding agrees with the beforementioned studies reporting the preference of horses for high rather than low energy and protein-feeds (van der Berg et al., 2016).

Horses are sensitive to taste and indeed are very selective with respect to most other herbivores, especially when offered feeds with different flavours (Goodwin et al., 2005). A non-nutritive sweet taste or sweet odour like banana and coconut appears to encourage horses to consume a particular feed (Randall et al., 1978; Merkies and Bogart, 2013; van den Berg et al., 2016). The horses' preference for hay types B and C in the present study could therefore also be explained by the sugar content with regard to taste and in terms of odour by the higher aromatic scent of hay types B and C compared to hay A. However, also feed structure and texture as well as palatability and digestibility may affect the choice behaviour of horses (Ordakowski-Burk et al., 2006; McCown et al., 2012; Clark et al., 2016; Owens et al., 2019). This would also explain why most of the horses chose hay type B in the preference test, which has the most flexible and soft structure. Hay types B and C contained more sugar than hay type A. Hay type C had the highest fructan content, as well as the highest NFC content. This, however, shows, that horses may have had a higher preference for structural characteristic of the hays investigated than their concentration of rapidly fermentable carbohydrates.

4.3. Hay selection by the owners

The question whether the hay chosen by the horse meets its nutritional requirements was answered differently by most of the owners in this study. While none of the 36 horses preferred hay type A, a third of the owners selected this hay type, on the assumption that this hay quality would best meet the assumed nutritional requirements of their horses.

While a large proportion of the horses selected for hay type B, 50% of the owners of the FM horses and 42% of the owners of the WB horses selected for hay type A, which, in contrast, contained the least amount of energy and protein but a higher proportion of stems and fibre. According to the average rating results of the owners, hay type A was described as yellow and was even compared to straw as well as having a low aromatic odour. The owners of FM and WB horses, however, assumed this hay

type best suited their horse's nutritional requirements, although they were aware that this hay quality had the lowest nutritional content. Regarding the FM horses, this may be surprising, since their work intensity was estimated to be medium. However, FM horses, a Swiss native light draft breed is known as an easy keeper and tends to have overweight (Pfammatter et al., 2017). Therefore, the selection by the owners for hay type A as a hay quality lower in energy might explain the decision to select this hay type for the FM and WB horses. The mean energy requirement for maintenance of a WB horse (of 600 kg BW) is 63 MJ ME per day. If light work is performed, 25%, for medium 25–50% and for high intensity work 50–100%, of the energy maintenance requirements (MJ ME) should be added (Coenen and Vervuert, 2020). In this respect, the considerations of the owners seem reasonable. On the other hand, it could also be argued, that forage more concentrated in energy and protein with a better taste are offered to horses and in turn, concentrated feeds are reduced or omitted. Even with sport horses, the coverage of the energy requirement is possible with pure hay feeding only, if Se and Na are supplemented (and if necessary, Cu, Se and Zn) as these minerals are usually deficient in forages originating from Northern and central Europe (Müller et al., 2012). Being aware of the high incidence of health and welfare issues, such as gastric ulcers and stereotypic or altered behaviour in horses fed with high amounts of concentrates in the equine diet (Sykes et al., 2015), this aspect seems even more important. In contrast, hay type B has been very popular in the stable with the IS horses and has been chosen by 50% of owners. This hay was judged to be green in colour, with a soft and flexible texture and a strong aromatic odour and was the richest in energy and protein content. Hay type C has also been frequently selected among IS horse and WB horse owners (50% and 42%, respectively), but only to 25% among FM owners. Characterized by its fine stems, green colour, botanical richness and superior aromatic odour, this hay seemed to be the most appreciated by owners. Thus, the hypothesis that most owners select the hay type best suited for their horses was not consistent across horse groups.

5. Conclusions

The horse's hay preference test showed that horses selected hay with a leafy structure rich in energy and protein. This selection indicates a preference for ingestion of feeds providing excess of energy and protein when compared to actual nutritional requirements. In contrast, the hay type lowest in energy and protein concentrations, but rich in stems and of a straw-like texture, was completely avoided by all horses. There were also differences in hay preference observed between different horse groups, which, however, could not related to breed or gender (mares, stallions or geldings). Nevertheless, among the owners, 42% preferred to choose the hay type completely avoided by the horses, while approximately 30% of the owners chose one of the two other hay types rich in energy and protein as the best hay quality for their horses assumed nutritional requirements. Therefore, no significant correlation between the choice preference of the horses and the selection by the owners was found. The findings of our study emphasize on the need to obtain information of the nutritional requirements of the horses and the nutrient concentrations of feeds offered to horses. The distinct preference for energy- and protein-rich hay of horses could be addressed for horses with lower activity levels or lower needs by providing or mixing different qualities of hay.

CRediT authorship contribution statement

Sonia Holzer: Investigation, Data curation, Writing – original draft, Project administration. **Conny Herholz:** Investigation, Writing – review & editing, Supervision. **Lorenzo Giuseppe Tanadini:** Formal analysis, Writing – review & editing. **Simon Ineichen:** Investigation, Supervision, Writing – review & editing. **Samy Julliand:** Conceptualization, Methodology, Writing – review & editing, Supervision.

Declaration of Competing Interest

None.

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