Developing a herbivore diet for Emmen Zoo

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University of Zurich[UZH]

Clinic of Zoo Animals, Exotic Pets and Wildlife

EAZA ACADEMY

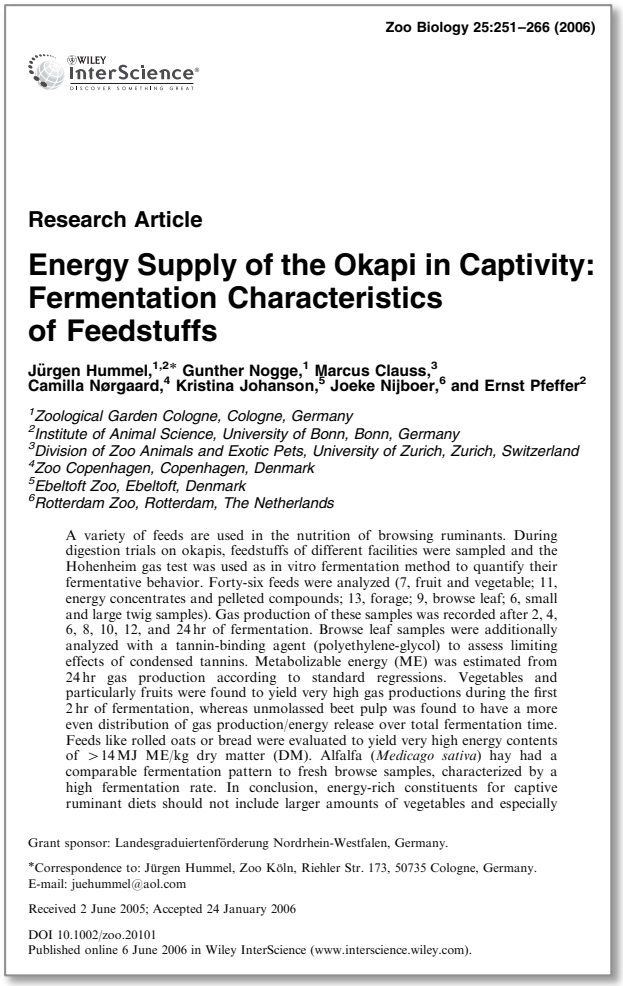
Request ... *and Counter-Request*

- Design a pelleted diet suitable for captive moose and other wild ruminants
- To be produced at a local feed mill
- At the same time, deliver a higher level of energy than forages, and prevent the occurrence of rumen acidosis

- *Zoo pays for travel/accommodation*
- *Recipe to be made publicly available*

Approach

- Starch not a major source of energy but pectins (from beet pulp) – low acidotic potential



Zoo Biology 25:251–266 (2006)

Research Article

Energy Supply of the Okapi in Captivity: Fermentation Characteristics of Feedstuffs

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A variety of feeds are used in the nutrition of browsing ruminants. During digestion trials on okapis, feedstuffs of different facilities were sampled and the Hohenheim gas test was used as in vitro fermentation method to quantify their fermentative behavior. Forty-six feeds were analyzed (7, fruit and vegetable; 11, energy concentrates and pelleted compounds; 13, forage; 9, browse leaf; 6, small and large twig samples). Gas production of these samples was recorded after 2, 4, 6, 8, 10, 12, and 24 hr of fermentation. Browse leaf samples were additionally analyzed with a tannin-binding agent (polyethylene-glycol) to assess limiting effects of condensed tannins. Metabolizable energy (ME) was estimated from 24 hr gas production according to standard regressions. Vegetables and particularly fruits were found to yield very high gas productions during the first 2 hr of fermentation, whereas unmolassed beet pulp was found to have a more even distribution of gas production/energy release over total fermentation time. Feeds like rolled oats or bread were evaluated to yield very high energy contents of >14 MJ ME/kg dry matter (DM). Alfalfa (*Medicago sativa*) hay had a comparable fermentation pattern to fresh browse samples, characterized by a high fermentation rate. In conclusion, energy-rich constituents for captive ruminant diets should not include larger amounts of vegetables and especially

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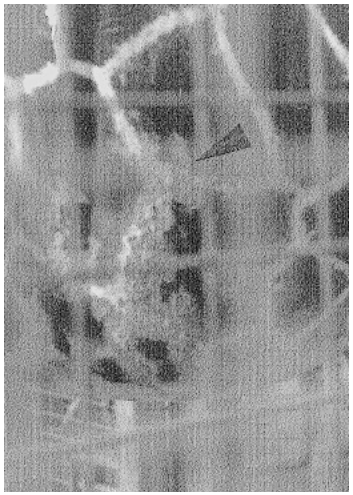
Approach

- Starch not a major source of energy but pectins (from beet pulp) – low acidotic potential
- Forage-based (lucerne meal) – fibre fermentation and fatty acid profile

Approach

- Starch not a major source of energy but pectins (from beet pulp) – low acidotic potential
- Forage-based (lucerne meal) – fibre fermentation and fatty acid profile
- Linseed – fatty acid profile

Linseed



M. Clauss, E.J. Flach, K. Ghebremeskel, C. Tack, J.-M. Hatt

Supplementing the diet of captive giraffe (*Giraffa camelopardalis*) with linseed extraction chips

Abstract

Captive giraffe (Giraffa camelopardalis) are reported to have low linolenic acid concentrations in body tissues in comparison with free-ranging individuals. However, it is not known whether this merely reflects a different diet, or whether it impairs body functions. As linseed contains significant amounts of linolenic acid, the feeding of linseed extraction chips might be a practical way of supplementation. Captive giraffe with low linolenic acid status in their blood lipids (compared to domestic ruminants) were introduced to a diet that included linseed extraction chips. Blood lipids of animals from which samples were available after the change in dietary regime (n = 2) showed an increase in linolenic acid content. One of the animals had a history of skin lesions resistant to treatment. The skin lesions improved markedly during the course of linseed supplementation. While long-term effects of either linolenic acid deficiency or linolenic acid supplementation in giraffe remain to be demonstrated, these results suggest that giraffe might benefit from the addition of linseed extraction chips to their diet.

Keywords

polyunsaturated fatty acids, linolenic acid, skin lesion, peracute mortality syndrome

1. Introduction

It has been reported that captive giraffe (*Giraffa camelopardalis*) have a much lower content of polyunsaturated fatty acids (PUFA) in body tissues than

Approach

- Starch not a major source of energy but pectins (from beet pulp) – low acidotic potential
- Forage-based (lucerne meal) – fibre fermentation and fatty acid profile
- Linseed – fatty acid profile
- High levels of copper for cervids, also acceptable for giraffids and many bovids but not sheep

Approach

- Starch not a major source of energy but pectins (from beet pulp) – low acidotic potential
- Forage-based (lucerne meal) – fibre fermentation and fatty acid profile
- Linseed – fatty acid profile
- High levels of copper for cervids, also acceptable for giraffids and many bovids but not sheep
- Sodium bicarbonate as a buffer against rumen acidosis

Buffer substance

SHORT COMMUNICATION

Effect of subacute ruminal acidosis on the preference of cows for pellets containing sodium bicarbonate

J. L. Cumby[1], J. C. Plaizier[1], I. Kyriazakis[2], and B. W.

[1]*Department of Animal and Poultry Science, University of Guelph, Ontario,*
[2]*Animal Biology Division, Scottish Agricultural College, Edinburgh, UK. Rec*
accepted 14 December 2000.

Cumby, J. L., Plaizier, J. C., Kyriazakis, I. and McBride, B. W. 2001. **Effect of subacute rumina**
cows for pellets containing sodium bicarbonate. Can. J. Anim. Sci. **81**: 149–152. Lactating cow
a choice between two test pellets during a 3-wk experiment. Intake of test pellets containing 4% so
time, but intake of control test pellets with an equal sodium content through inclusion of sodiu
Cows could have preferred bicarbonate pellets in order to attenuate ruminal acidosis, but increa
cannot be excluded.

Key words: Acidosis, diet choice, dairy cattle, sodium bicarbona

THE INFLUENCE OF SODIUM BICARBONATE AND DEHYDRATED ALFALFA AS BUFFERS ON STEER PERFORMANCE AND RUMINAL CHARACTERISTICS[1]

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University of Missouri—Columbia[2] 65211

Summary

A 95-d feedlot trial utilizing 53 Angus and Angus × Hereford steers (340 kg) was conducted to determine the effects of adding dehydrated alfalfa pellets (Dehy) or a combination of Dehy alfalfa pellets and 1% sodium bicarbonate (Dehy + $NaHCO_3$) to a 76.4% cracked corn (CC) -- 12% cottonseed hull (CSH) control diet on average daily gain (ADG), feed efficiency and nutrient digestion. The Dehy treatment resulted in greater (P<.05) ADG during the 77- to 95-d period compared with the control diet. The Dehy + $NaHCO_3$ treatment increased (P<.05) ADG and feed efficiency for the 77- to 95-d period. The Dehy and Dehy + $NaHCO_3$ treatments improved (P<.05) mean dry matter (DM) and neutral detergent fiber (NDF) digestibilities compared with the control diet. A metabolism trial utilizing three rumen-fistulated Hereford steers (450 kg) in a 3 × 3 Latin square design evaluated the effects of diets on ruminal pH, buffering capacity, volatile fatty acid concentration and nutrient digestibility. The Dehy + $NaHCO_3$ treatment increased (P<.05) rumen pH on d 5, 10 and 15 and the Dehy treatment increased rumen pH on d 10. The Dehy and Dehy + $NaHCO_3$ treatments improved (P<.05) DM, NDF and N digestibilities compared with the control. Although Dehy and Dehy + $NaHCO_3$ increased ADG and nutrient digestibility, Dehy + $NaHCO_3$ was associated with a further improvement in rumen and blood variables of acid-basis status.
(Key Words: Dehydrated Alfalfa Pellets, Sodium Bicarbonate, Finishing Diet, Digestibility.)

Introduction

With the increased feeding of concentrates, renewed interest has been generated in the use of buffers as aids in the prevention of acidotic conditions. Dietary buffers are used to attenuate ruminal pH and prevent acidosis (Huntington et al., 1977). In many instances, buffers have improved animal performance (Nicholson and Cunningham, 1961). Buffer supplementation results in a fairly consistent improvement in cellulose digestion (Emmanuel et al., 1970; Terry et al., 1970). Cheng et al. (1955), among others, have suggested that maintenance of a rumen pH of 6.8 to 7.0 through the use of buffers may be responsible for the increased nutrient digestion often associated with the feeding of buffers.

Legumes, especially alfalfa, have been shown to increase ruminal pH and buffering capacity compared with grasses (Mertens, 1979; Van Soest, 1982). Ha et al. (1983) demonstrated that the addition of 10% alfalfa and 2% $NaHCO_3$ to a high concentrate diet resulted in similar increases in rumen pH and decreases in blood lactate concentration in lambs. Stroud (1983) demonstrated that 10% dehydrated alfalfa improved rumen buffering capacity below pH 5 in steers fed a 75% concentrate diet.

The objective of these studies was to evaluate the effects of dehydrated alfalfa pellets and dehydrated alfalfa pellets plus $NaHCO_3$ on performance, feed intake and nutrient digestibility, as well as blood and ruminal physiological variables in feedlot cattle.

Experimental Procedures

Steer Performance Trial. A 95-d feedlot trial with 53 Angus and Angus × Hereford steers (340 kg) was conducted to determine the effect of supplementing a cracked corn basal diet with dehydrated alfalfa pellets (Dehy) and $NaHCO_3$ on rate and efficiency of gain, feed intake and

[1]Journal Article 9535 of the Missouri Agr. Exp. Sta.
[2]Dept. of Anim. Sci.
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EFFECTS OF LIMESTONE AND SODIUM BICARBONATE BUFFERS ON RUMEN MEASUREMENTS AND RATE OF PASSAGE IN CATTLE

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Introduction

Responses to buffers have been variable and unpredictable. Buffers can be beneficial when diets produce an unfavorably low pH of digestive tract contents (Emerick, 1976; Mertens, 1979), which can occur with rapidly degradable grain diets and fermented feeds. Diets that do not produce unfavorable digestive tract conditions would not be expected to be improved by buffers. Even with this explanation, responses to buffers are variable and seem to indicate a mode of action other than or in addition to a change in pH of the digestive tract contents. The inclusion of buffers in diets may increase the rate of disappearance of liquid material from the rumen due to passage as a result of osmotic action (Harrison et al., 1975). Kellaway et al. (1978) reported that rate of liquid disappearance was increased when sodium bicarbonate ($NaHCO_3$) was included in the diet, but they did not account for effects of intake on rate.

The purpose of this experiment was to compare the effects of limestone and $NaHCO_3$ in corn-corn silage diets fed at two levels of intake on rumen fluid pH, ammonia N (NH_3-N), volatile fatty aeid (VFA) concentration, buffering capacity, rate of disappearance of solid and liquid material from the rumen and fecal pH.

Materials and Methods

Eight rumen-fistulated cattle (four Angus steers, mean weight 500 kg, and four nonlactating Holstein cows, mean weight 600 kg) were fed four diets (table 1) at approximately maintenance (1 × M, .110 Mcal metabolizable energy/body weight$^{.75}$) or two times the estimated maintenance level of intake (2 × M) in an 8 × 8 Latin square design. Metabolizable energy (ME) of the diet was calculated from NRC (1976). Diet dry matter (DM) consisted of 55% cracked corn, 35% corn silage and 10%

Buffer substance

Suitable species

Reindeer and similar species

GRAZERS AND BROWSERS DATASHEET

54

REINDEER

Benefits

- Small pellet size for greater acceptability.
- Adequate levels of Vitamin E and Selenium.
- Contains 2.5% Sodium Bicarbonate which helps prevent acidosis and supplies bicarbonate ions which are essential for cellulytic bacteria.

Ingredients

Barley, Wheat, Wheat Feed, Grass Meal, Oat Hulls and Bran, Sodium Bicarbonate, Soya Bean Oil, Vitamins and Minerals.

(Ingredients may be subject to change due to seasonal availability)

Feeding recommendations

Designed for Ad-Lib feeding throughout the year. Adequate good quality hay and browse should also be provided. The animals will adjust food intake from virtually nothing during winter to about 5Kg, or more, per animal per day during summer and prior to the rut. During rut, food consumption reduces considerably and animals may lose some of their body condition but this should be regained by increased food consumption for the short period after the rut.

During winter and early spring the animals will eat very little and will dramatically lose body condition. This is natural and, provided the animals are healthy, with good deposits of back-fat at the onset of winter, there will be no deleterious effects.

Additional information

Modified from a formula provided by Mr Richard Knock at the Zoological Society of London, Whipsnade Park.

Calculated analysis

(Unless otherwise stated nutrients are expressed as total calculated levels)

Moisture	%	10.00
Crude Fat	%	5.69
Crude Protein	%	12.19
Crude Fibre	%	10.07
Ash	%	11.01
NFE	%	50.28
Acid Detergent Fibre (ADF)	%	11.93
Neutral Detergent Fibre (NDF)	%	28.19
Starch	%	27.44
Metabolisable Energy (ME)	MJ/Kg	9.64
Lysine	%	0.53
Methionine	%	0.22
Calcium	%	0.69
Phosphorus	%	0.68
Sodium	%	1.23
Magnesium	%	0.37
Copper	mg/Kg	16.81
Vit. A (added as Retinyl Acetate)	IU/g	6.09
Vit. D3 (added as Cholecaliferol)	IU/g	1.22
Vit. E (added as dl-alpha-tocopherol acetate)	IU/Kg	63.82

Code	Diet	Pack weight	Form
853806	Reindeer Diet (P)	25Kg	4mm Pellet

Revision 4

Reindeer Pellets

Description

Reindeer Pellets are designed as a complete feed fortified with vitamins and minerals – This diet provides the nutritional balance needed to meet production needs. It can be fed as sole source of concentrate during breeding, or fed with a small amount of hay or moss.

Features and Benefits

- **Pellet form** - Easy to feed; minimizes waste.
- **Small pellet size** - For greater acceptability.
- **Suitable for trough feeding** - Added convenience.

Product Form

- Pellet size: 5/32" diameter x 1/2" length.

Catalog # 0001440

50 lb. net weight paper sack.

Guaranteed Analysis

Crude protein not less than 12.0%
Crude fat not less than 5.0%
Crude fiber not more than 16.0%
Calcium (Ca) not less than 0.90%
Calcium (Ca) not more than 1.25%
Phosphorus (P) not less than 0.70%
Salt (NaCl) not less than 0.40%
Salt (NaCl) not more than 1.0%
Sodium (Na) not more than 1.5%

Ingredients

Ground oats, dehydrated alfalfa meal, wheat middlings, sodium bicarbonate, soybean oil, dicalcium phosphate, dehulled soybean meal, salt, calcium carbonate, magnesium oxide, choline chloride, menadione dimethylpyrimidinol bisulfite (vitamin K), ascorbic acid (vitamin C), pyridoxine hydrochloride, ethoxyquin (a preservative), cholecalciferol (vitamin D_3), dl-alpha tocopheryl acetate (vitamin E), biotin, vitamin A acetate, calcium pantothenate, vitamin B_{12} supplement, thiamin mononitrate, riboflavin, nicotinic acid, folic acid, manganous oxide, zinc oxide, ferrous carbonate, copper sulfate, zinc sulfate, calcium iodate, cobalt carbonate, sodium selenite.

Feeding Directions

Feed Reindeer Pellets ad libitum with a small amount of hay or moss throughout the year. Feed consumption may be reduced during the rut season. Always keep plenty of fresh, clean water available to animals.

Structure

European Association of Zoo- and Wildlife Veterinarians (EAZWV)
5th scientific meeting, May 19 - 23 - 2004, Ebeltoft, Denmark.

THE FORMULATION OF A BEET PULP-BASED PELLETED FOOD FOR CAPTIVE WILD RUMINANTS AND PRELIMINARY EXPERIENCES

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1. Noorder Dierenpark, Hoofdstraat 18, Postbus 1010, 7801 BA Emmen, The Netherlands
2. Van Cooten Diervoeders b.v., The Netherlands
3. Zoological Garden of Cologne, Germany
4. Institute of Animal Physiology, Physiological Chemistry and Animal Nutrition, Munich, Germany

Poster abstract

A major challenge in captive wild ruminant nutrition is the simultaneous provision of an adequate energy supply and the prevention of rumen acidosis (1). Pectins and other soluble fibre components are a readily available energy source for ruminants, but their fermentation is not, in contrast to starch or sugars, prone to result in an acidotic rumen condition (3). Therefore, the inclusion of feeds with a high pectin content in the diet of captive wild ruminants has been promoted recently (2,4). The acquisition of a new pair of moose (*Alces alces*) at Emmen Zoo, Netherlands, led to the formulation of a new pelleted food with this concept in mind. Objectives of pellet formulation were a high proportion of pectin-rich ingredients, a low proportion of starches and sugars, a mineral composition with a high copper content considered appropriate for cervids and other wild ruminants except sheep, and the inclusion of sodium bicarbonate as a buffering substance to provide additional protection against rumen acidosis.

The formula consists of beet pulp/citrus pulp (22.5%), soy products (22.5%), Lucerne meal (22.5%), sunflower hulls (12.5%), wheat (8.0%), molasses (2.5%), cellulose powder (2.5%), linseed (2.0%), /vitamin-mineral premix (2.2%), sodium bicarbonate (1.0%). The calculated analysis of this product is (on a dry matter basis): crude protein 16.8 %, crude fat 5.7 %, crude fibre 22.3 %, crude ash 8.5 %, starches and sugars 16.4 %; neutral detergent fibre 40.7 %, acid detergent fibre 26.0 %. Subtracting protein, fat, ash, neutral detergent fibre and starch/sugars from 100 % leaves a residual 12.0 %, which will mostly represent the pectin fraction. Copper is added at 22 mg/kg dry matter.

The pellet has been fed to 2 moose, 13 giraffes (*Giraffa camelopardalis*), 44 impalas (*Aepyceros melampus*), 3 Lesser kudus (*Tragelaphus imbebris*), 4 pudus (*Pudu pudu*) and 32 guanacos (*Lama guanicoe*) for nearly a year. The pellets were accepted readily by all individuals. No adverse effects of the pellets were noted so far. Compared to earlier years, the skin condition of the impala group was judged to have improved. While beet pulp may cause problems due to swelling in the oesophagus in horses and therefore should be offered soaked, it is commonly fed un-soaked to domestic ruminants. The pellet was offered un-soaked to all 98 animals; only in one case (a giraffe bull) were problems observed in the form of regurgitation/vomiting approximately 15 minutes after food intake which is believed to be due to an oesophageal stricture. A conclusive evaluation of the new food will be possible after several years of feeding.

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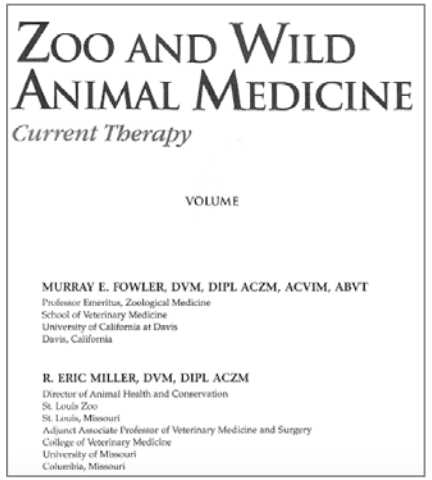
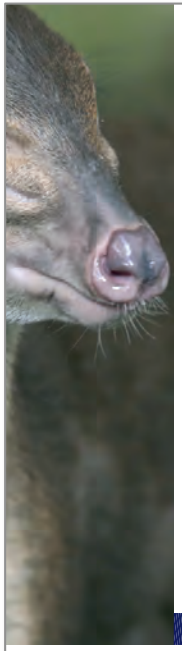
Example Recipes for Pelleted Diets Fed to Browsers*

Ingredient	% Original Weight
Beet pulp	22.5
Soy extraction meal	22.5
Alfalfa meal	22.5
Sunflower hulls	12.5
Wheat	8.0
Molasses	2.5
Cellulose powder	2.5
Linseed	2.0
Sodium bicarbonate	1.0
Mineral/vitamin supplements	4.0
NDF† (% dry matter)	40.7



Commercial product



HERBIVORES

Browser

Suitable for: Browsing zoo herbivores, as for example giraffe, okapi, roe deer, moose, duiker, and intermediate feeders as deer, goats etc.

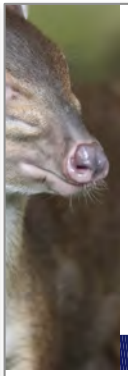
YOUR BENEFITS

- Balanced fiber composition, highly suitable for browsers with high contents of fermentable fiber from apple pomace, soybean hulls and beet pulp
- Protein content adapted to the needs of browsers with regard to the lower protein content of European alfalfa
- Calculated corresponding to the latest information on herbivore feeding
- Little cereals and thus lower in sugar and starch
- High levels of vitamin E and organic selenium
- Copper supplemented for the higher needs of cervids
- Biotin supplemented for horn and fur
- No mineral iron is substituted
- Linseed products for a naturally high content of omega-3-fatty acids
- Bicarbonate for the prevention of ruminal acidosis
- With an appropriate ration composition there is no need of additional supplements thanks to adequate vitamin- and mineral supplementation

We are happy to work with you to create an individual feeding recommendation

TYPE OF FEED, FORM, DELIVERY QUANTITY

- supplementary feed
- Form: pellet 8 mm round
- Delivery quantity: 25 kg paper bag
  pallets of 750kg



HERBIVORES

Browser

FEED SPECIFICATIONS

Major nutrients (%)

Dry matter	89
Crude protein	20.2
Crude fat	3.1
Crude fiber	20.4
Crude ash	9.9
NFE	35.4
NDF	34.7
ADF	24.7
Starch	3.6
Sugar	3.9

Energy (MJ/kg)

Gross energy	16.4
Metabolisable energy	6.4
Digestible energy	10.5
Net energy for lactation	4.2

Macrominerals (%)

Calcium	1.3
Phosphorus	0.7
Magnesium	0.3
Sodium	0.6
Potassium	1.3
Chlorine	0.3

Trace elements (mg/kg)

Iron	500
Zinc	280
Copper	33
Iodine	2
Manganese	122
Selenium	0.7
Cobalt	1.1

Vitamins (added, mg/kg)

Vitamin A (IU/KG)	10500
Vitamin D3 (IU/KG)	1500
Vitamin E	1860
Vitamin K3	0.8
Vitamin B1	11
Vitamin B2	10
Vitamin B6	7
Vitamin B12	0.04
Nicotinic acid	80
Pantothenic acid	32
Folic acid	1.4
Biotin	7
Choline	1000
Vitamin C	15

Amino acids (%)

Arginine	1.2
Lysine	1.14
Methionine	0.32
Methionine + Cystine	0.63
Tryptophan	0.28
Threonine	0.81

Ingredients

Soybean hulls (NGMO), alfalfa, soybean meal (NGMO), linseed products, beet pulp, apple pomace, potato protein, wheat, cellulose, mineral and vitamin premix, molasses.

Remarks

- Given values are calculated averages in air-dry feed.
- Gross and metabolisable energy calculated according to Kamphues et al. 2009; digestible energy calculated acc. to NRC Horses 2007.
- Digestible energy calculated according to NRC Horses 2007.
- Net energy for lactation calculated according to FMBV Art. 14 Anhang 8.6.
- Nutrients are subject to natural variation of the raw materials and their production process.

OUR FEED RECOMMENDATION

- The feed is suitable for supplementing a diet based on roughage (depending on the species grass hay, alfalfa, browse, etc.)
- Always provide free access to fresh drinking water.
- Benchmark: 0.5-1.5% of body weight per day in addition to hay ad libitum throughout the day.
- Not suitable for sheep and other copper sensitive herbivores due to the addition of copper (~ 33ppm in total).
- Unless soaked, this feed is less suitable for equids and animals with a tendency to esophageal obstruction because of expanding fibers (especially beet pulp).

We are happy to work with you to create individual feeding recommendations for the respective species