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Research Article

Effect of Field Pea Replacement for Oats on Palatability, Feeding Safety, and Growth Performance in Yearling American Quarter Horses [1]

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Abstract

The objective of this study was to determine the palatability, feeding safety, growth performance, and replacement value of field pea (FP) for oats in yearling American Quarter Horses. Forty-eight yearling horses averaging 338.2±0.67 kg were used in a two-year replicated (84-d) study. The horses were randomly assigned based on sex and body weight (BW) to three pelleted experimental growing supplements: 1) 100% Oats and 0% FP (C), 2) 66.7% Oats and 33.3% FP (33.3PEA), and 3) 33.3% Oats and 66.7% FP (66.7PEA). The horses were fed a predetermined amount of alfalfa-bromegrass cubed (pelleted) hay. The supplement fed daily was divided into two meals and fed at 08.30 and 14.00 hours. Horse's BW, body length (BL), wither height (WH), hip height (HH), heart girth circumference (HG), cannon bone circumference (CB), forearm circumference (FA) and gaskin muscle circumference (GM) were taken at 28, 56, and 84 d. There was no statistical difference between supplement treatments for horse average daily gain (ADG) or final BW (P>0.10). There was a linear effect identified for 28, 56, and 84 d periods (P<0.01) for all treatment measurements. There was no statistical difference between supplement treatments for BL, WH, HH, HG, CB, FA, and GM (P>0.10). There was no evidence of discomfort, colic or hoof laminitis identified. When fed as two meals separated by 6 hours, FP was a suitable replacement for oats in yearling horse growing supplements up to a maximum of 66.7%.

Keywords: *Field pea, Feeding safety, Growing supplement, Laminitis, Oats, Yearling American Quarter Horse*

Yulafa İkame edilen Yemlik Bezelyenin Bir Yaşındaki American Quarter Atlarına Yedirilebilirliği, Beslenme Güvenliği ve Büyüme Performansı Üzerine Etkisi

Özet

Bu çalışmanın amacı yulaf yerine ikame edilen yemlik bezelye (FP)'nin bir yaşındaki Amerikan Quarter atlarına yedirilebilirliği, beslenme güvenliği, ikame oranı ve büyüme performansı üzerine etkisinin saptanmasıdır. İki yıl tekrarlanan (84-d) bu çalışmada, ortalama ağırlığı 338.2±0.67 kg olan bir yaşında, kırk sekiz adet at kullanılmıştır. Atlar cinsiyet ve vücut ağırlığı (BW) 'na göre rastgele tahsis edilmiştir. Peletlenmiş üç takviye yem grupları: 1) %100 Yulaf ve %0 FP (C), 2) %66.7 yulaf ve %33.3 FP (33.3PEA), ve 3) %33.3 yulaf ve %66.7 FP (67PEA). Atlar kaba yem olarak önceden belirlenmiş miktarlarda yonca-bromegrass küpleri (peletlenmiş) ile beslenmiştir. Günlük takviye yem ise iki öğüne bölünerek 08.30 ve 14.00 saatlerinde yedirilmiştir. Araştırmanın 28., 56., ve 84. gününde, atların BW, vücut uzunluğu (BL), yüksekliği (WH), kalça yüksekliği (HH), kalp çevresi (HG), incik çevresi (CB), önkol çevresi (FA) ve bacak kas çevresi (GM) ölçülmüştür. Takviye yem grupları arasında ortalama canlı ağırlık artışı (ADG) ve bitiş BW bakımından istatistiksel olarak bir fark saptanmamıştır (P>0.10). Tüm grupların 28., 56., ve 84. gün periyotlarındaki ölçümlerde doğrusal bir etki tespit edilmiştir (P<0.01). Takviye yem grupları arasında BL, WH, HH, HG, CB, FA, ve GM bakımından istatistiksel fark bulunmamıştır (P>0.10). Toynaklarda laminitis ile ilgili herhangi bir veri belirlenmemiştir. Bir yaşındaki Amerikan Quarter atlarının büyüme takviyesi yemlerinde FP 6 saat ara ile iki öğün olarak yediriliğinde yulaf yerine maksimum %66.7 oranında kullanılabilecek uygun bir alternatif yemdir.

Anahtar sözcükler: *Yemlik bezelye, Besleme güvenliği, Büyütme takviyesi, Laminitis, Yulaf, Bir yaşında Amerikan Quarter atı*

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INTRODUCTION

Horses are a simple stomach herbivore that can thrive well consuming a balance of grass and legume forage or pasture. However, when growing, or involved in light to heavy work, forages alone will not supply sufficient energy to meet the energy requirement for work, but heavy oats *(Avena sativa,* 14.5-17.2 kg/bushel), a common staple for horses, can supply the necessary energy for most working conditions.

Digestive integrity is vitally important for the horse. Oats are the grain concentrate of choice among horse owners, because after ingestion the grain forms a bulky loose mass in the stomach and supplies energy for maintenance and work. As a fiber, protein, and energy source, oats contain: crude protein (CP; 11-14%CP), lysine (LY; 0.40-0.55%), fiber (FIB; 12.0-15.9%), digestible energy (DE; 3.23-3.33 Mcal/kg), fat (4.9-5.2%), calcium (Ca^{++}0.05%) and phosphorus (P; 0.35%) [1].

Peas are considered to have originated from the region of southwest Asia encompassing present day north-western India, Pakistan, Afghanistan and Central Asia c. 7000 - c. 6000 BC. Cultivation of the crop spread east into present day China and north and west into Russia, the Mediterranean Basin, and Europe [2].

Field pea (FP) is grown in the northern Great Plains of the United States and the central provinces of Canada in crop rotations. The primary objective of farmers is to market the grain as human food or for export. In North Dakota, 2013 FP production was reported to be 43,338 MT [3]. When specifications for human food or export are not met, the grain becomes feed for all classes of livestock, with the exception of horses. FP is not commonly fed to horses in the USA.

FP is a protein and energy dense concentrate containing: CP (22-26% CP), LY (1.50-1.70%), FIB (6.0-7.0%), DE (3.40 Mcal/kg), starch (48-52%), fat (1.6%), Ca^{++} (0.05%) and P (0.48%), and is also a rich source of microminerals, water soluble and fat soluble vitamins [1,4,5]. The nutrient value of raw FP compared to soybean meal (SBM) has been evaluated in non-ruminant swine growing and finishing diets and shown to be a suitable substitute for SBM [6], and in ruminants, pea starch degradation rate has been reported to be slower than wheat, barley, and oats, but similar to the degradation rate of corn [7].

Colic is the expression of visceral abdominal pain in the horse, which can occur frequently, since the horse has a low threshold for pain and is most often associated with diet and dietary changes [8]. Improper feeding management, when feeding high starch non fibrous carbohydrate grains, can lead to grain overload associated with rapid fermentation of carbohydrates resulting in reduced pH (acidosis), intestinal mucosa damage and death of gram-negative bacteria, and the onset of endotoxemia (prodromal stage) and a cascade of events leading to laminitis of the hoof wall [9,10]. Feeding safety is of utmost importance when horses are fed non-fibrous carbohydrates, since overwhelming the digestive system leads to episodes of colic [11]. Because the young growing horse attains 80-90% of its mature size within the first two years of life [12], the young growing horse is an ideal growth model to evaluate the suitability of field peas as an ingredient in growing horse supplements.

Despite oat grain being the most common grain concentrate fed to horses worldwide, the objective of this study was to evaluate the value of FP as a non-fibrous carbohydrate replacement concentrate in yearling growing horse supplements using a reciprocal substitution protocol in which 33.3 and 66.7% of the oats in supplements was replaced with FP and compared to a control supplement without FP. Although, a paralleling digestibility study was not conducted, we hypothesized that due to the slower reported degradation rate of FP in ruminant diets [7] that FP would not be fully digested in the small intestine of the horse, but hindgut illness would not develop, because the supplements are fed in two meals separated by 6 hours. It was further hypothesized that there would be no difference identified for body linear and circumference measurements among horses fed the experimental FP supplements.

MATERIAL and METHODS

This research project was conducted at the Dickinson Research Extension Center, Ranch Headquarters, Manning, North Dakota, USA (47°11'34" N 102°50'17" W) in accordance with guidelines approved by The North Dakota State University Institutional Animal Care and use Committee (Protocol Approval Number: A0426).

Over a 2-year period, forty-eight yearling Quarter Horses (filly, n=30; stud colt, n=18) that averaged 338.2±0.67 kg were used in an 84 d feeding study to evaluate three oat growing supplements formulated with increasing levels of FP. Horses were randomly assigned to supplement treatment in the completely randomized design based on sex and yearling weight. Eight horses were assigned to each treatment each year and individual horse served as the experimental unit. Supplements were prepared to meet the nutritional requirements of the yearling growing horse [1]. The three reciprocal horse growing supplement treatments were: 1) 100% Oat and 0% Pea (C), 2) 66.7% Oat and 33.3% Pea (33.3PEA), and 3) 33.3% Oat and 66.7% Pea (66.7PEA).

The forage fed to the horses in the study was a cubed (3.81 x 3.81cm) alfalfa-bromegrass hay that *(Medicago sativa* and *Bromus inermis)* contained approximately one-third brome grass and two-thirds alfalfa. The nutrient composition of the alfalfa-grass hay was CP (15.5%), fat

(2.30%), FIB (33.70%), Acid Detergent Fiber (ADF) (35.2%), Neutral Detergent Fiber (NDF) (44.3%), starch (2.00%), LY (0.75%), Ca^{++} (1.04%), P (0.35%), and ash (7.1%). The nutrient composition of oat grain used to prepare the supplements was CP (13.5%), fat (5.60%), FIB (12.20%), ADF (14.2%), NDF (24.4%), starch (40.0%), LY (0.55%), Ca^{++} (0.01%), P (0.41%), and ash (3.1%), and the nutrient composition of FP used in the supplements was CP (23.5%), fat (1.60%), FIB (6.5%), ADF (8.0%), NDF (17.3%), starch (49.0%), LY (1.67%), Ca^{++} (0.05%), P (0.48%), and ash (2.8%). Soybean meal, which was used to balance protein across the supplement treatments, contained CP (44.5%), fat (1.0%), FIB (7.0%), ADF (10.0%), NDF (14.9%), starch (6.0%), LY (3.13%), Ca^{++} (0.40%), P (0.71%), and ash (4.4%).

The Supplement ingredient composition and nutrient analysis is shown in *Table 1*, and the calculated nutrient content of the daily diet is shown in *Table 2*. The alfalfa-bromegrass hay was sampled weekly, composited, and analyzed by a commercial laboratory for CP, ADF, NDF, fat, starch, LY, Ca^{++}, P, and ash (AgSource Soil and Forage Laboratory, Bonduel, WI, USA). Hay DE (Mcal/kg) for the horse was estimated according to: DE = 2118 +12.18* (%CP) -9.37* (%ADF) -3.83* (%hemicellulose) + 47.18* (%FAT) +20.35* (%NSC) -26.3* (%ASH); where hemicellulose equals ADF-NDF and Non-structural Carbohydrates (NSC) equal (100-%NDF-%FAT-%ASH-%CP) [1].

Before initiation of feeding, the experimental supplements were analyzed for CP, fat, ADF, NDF, Ca^{++}, P, and ash at the North Dakota State University Nutrition Laboratory. Samples were analyzed in duplicate [13] for DM by drying at 135°C (AOAC method 930.15), CP (AOAC method 2001.11), ether extract (AOAC method 920.39), Ca^{++} and P (AOAC methods 968.08 and 965.17), and NDF and ADF [14] and ash (AOAC method 942.05). Hay, supplement, and the total amounts fed to each horse daily, and the ration analysis is shown in *Table 2*.

Based on the daily feed fed and nutrient analysis shown in *Table 2*, starch from hay and supplement would supply 3.57, 3.78, and 3.99 g/kg of horse starting weight for the C, 33.3PEA, and 66.7PEA, respectively. Feeding this amount of starch in a single meal would overload the small intestine digestive capacity leading to acidosis, colic, founder, and laminitis [15]. Therefore, to avoid hindgut digestive disturbance, the amount of supplement fed was divided equally into two meals and after hay was fed one-half of the supplement was fed at 08.30 a.m. each morning and the remaining one-half was fed at 14.00 p.m. each afternoon.

Table 1. *Supplement composition and analysis (DM)*
Tablo 1.*Takviye yemin bileşimi ve analizi (Kuru Madde)*

Supplement Ingredients	**C***		**33.3PEA***		**66.7PEA***	
	kg	**%**	**kg**	**%**	**kg**	**%**
Oats	2.72	80.24	1.81	57.10	0.91	30.95
Peas	0.00	0.00	0.91	28.71	1.81	61.57
Soya Bean Meal	0.45	13.27	0.23	7.25	0.00	0.00
Equine Vitamin/Mineral[1]	0.05	1.48	0.05	1.58	0.05	1.70
Molasses	0.17	5.01	0.17	5.36	0.17	5.78
Total	3.39	100.00	3.17	100.00	2.94	100.00
Analysis						
Crude Protein, %		17.61		17.97		19.00
Crude Fat, %		4.54		3.73		2.71
Crude Fiber, %		10.62		9.33		7.75
ADF, %		12.64		11.11		9.29
NDF, %		21.38		19.95		18.15
Starch, %		32.27		37.29		42.46
Lysine, %		0.91		1.02		1.20
Calcium, %		0.08		0.06		0.04
Phosphorus, %		0.43		0.42		0.42
Ash, %		3.09		1.31		1.21
Digestible Energy, Mcal/kg		3.34		3.46		3.60

****C-*** *100% oats and 0% pea;* ***33.3PEA-*** *67% oats and 33.3% pea;* ***66.7PEA-*** *33.3% oats and 66.7% pea; [1]* ***Equine Vitamin/Mineral;*** *Vit A 300.000 UI, Vit D 30.000 UI, Vit E 700 UI, Vit B_{12} 0.46 mg, Riboflavin 100 mg, Niacin 500 mg, d-Pantothenic Acid 300 mg, Choline 1.250 mg/Calcium 17.1-20.5%, Phosphorus 15.0%, Salt, 0.5-1.5% Sulfur 0.95%, Magnesium 0.75%, Potassium 0.45%, Iron 7.000 ppm, Zinc 3.000 ppm, Manganese 2.000 ppm, Copper 1.250 ppm, Iodine 147 ppm, Cobalt 50 ppm, Selenuim 30 ppm*

Table 2. *Daily feed intake and total ration analysis (DM)*
Tablo 2. *Günlük yem tüketimi ve toplam rasyon analizi (Kuru Madde)*

Parameter	C*	33.3PEA*	66.7PEA*
Daily Feed Intake, kg/Horse			
Alfalfa-Brome Hay	4.48	4.71	4.93
Supplement Pellet	3.47	3.18	2.95
Total Fed/Day	7.95	7.88	7.88
Total Ration Analysis			
Crude Protein, %	16.42	16.49	16.81
Crude Fat, %	3.28	2.88	2.45
Crude Fiber, %	23.63	23.88	23.99
Starch, %	15.21	16.21	17.14
ADF, %	25.36	25.50	25.51
NDF, %	34.30	34.49	34.52
Lysine, %	0.82	0.86	0.92
Calcium, %	0.62	0.65	0.67
Phosphorus, %	0.39	0.38	0.38
Ash, %	5.35	2.45	2.47
Digestible Energy, Mcal/kg	2.70	2.71	2.72

C- 100% oats and 0% pea; **33.3PEA- 66.7% oats and 33.3% pea; **66.7PEA**- 33.3% oats and 66.7% pea*

The supplements were not isocaloric (DE, Mcal/kg; *Table 1*); however, based on diet calculated DE, which has been previously described, the amount of supplement fed daily to each horse was adjusted so that all horses received the same amount of daily energy across treatments. Initially, 0.91 kg of supplement was offered at each morning and afternoon feeding. The amount of supplement fed each day was increased gradually during the first three weeks of the study until the desired amount of supplement was met. The caloric balance across treatments was met with 3.4, 3.12, and 2.95 kg/horse/d for the C, 33.3PEA, and 66.7 PEA treatments, respectively.

Each horse was housed and fed individually in rectangular 32' x 128' pens constructed with continuous steel fencing that provided face to face contact and social interaction. Initially, and at 28 d intervals, the horses were weighed using an alley way platform scale (Avery Weigh Tronic, 1000 Armstrong Drive, Fairmont, MN 58031-1439 USA, (http://www.averyweigh-tronix.com/products/indicators/). Also at 28 d intervals, horse body measurements to include body length (BL), wither height (WH), hip height (HH), heart girth circumference (HG), cannon bone circumference (CB), forearm circumference (FA) and gaskin muscle circumference (GM) were also taken at 28 d intervals using a padded stock for handler and technician safety (Montana Westwood Inc., 50 Westwood Land, Trout Creek, Montana 59874, USA). With the exception of body weight, dual measurements were taken by two research technicians and the mean value of the two measurements was recorded.

At the end of the 84 d study, the hooves of each horse were inspected and given a laminitis score ranging from 1 to 5 with 1 being noticeable classic signs of laminitis and 5 no outward signs of laminitis. As each horse was led by a handler, a two-member panel scored each horse for painful gait or reluctance to move and the feet of each horse were held to feel for abnormal warmth and digital pulses [16,17].

Data was analyzed using the PROC GLM procedure of SAS [18]. Orthogonal contrasts were conducted for linear (L), quadratic (Q), and cubic (C) effects. Effects for L, Q, and C were only discussed when a significant *F*-test was detected. Individual horse served as the experimental unit. Differences between the supplement treatment groups were considered significant at P≤0.05.

RESULTS

The objectives of this study were to determine the acceptability and replacement value of FP, when FP replaced up to 66.7% of the oats in yearling growing horse supplements, to measure linear and circumference body measurements, and score horses in the feeding study for early process indicators of laminitis (prodromal stage).

The horses readily consumed the experimental supplements with no visible evidence of feed refusal or abdominal discomfort. The horses were weighed and measured individually initially and at 28 d intervals. Growth performance for the horses has been summarized in *Table 3*. There was no difference between treatments for horse ending BW (P>0.10); although there was a periodic 28 d linear effect for BW identified (P<0.10). ADG increased steadily from the start of the study to the end of the study for the 0PEA and 33.3PEA treatments. For the 66.7PEA treatment, there was a quadratic effect identified during the last 28 d period (P<0.01), indicating that ADG increased during the first 56 d and then declined during the last 28 d period. Despite the observed quadratic effect for ADG, horses fed the 66.7PEA supplement gained numerically more than horses fed the 0 and 33.3PEA supplements. Although speculative at best, the authors suggest that, perhaps, the horses receiving the 66.7PEA supplement may have been experiencing a very mild decline in hindgut pH during the last 28 d feeding period, although there was no indication based on the horses behavior that would indicate such a problem.

Length and height measurements for BL, HH, and WH are shown in *Table 4*. Experimental supplement treatment differences for BL (P=0.93), HH (P=0.22) and WH (P=0.21) did not differ statistically. Growth among horses within treatments and across treatments was similar resulting in a significant linear effect for BL, HH, and WH (P<0.01), when Orthogonal Contrast were analyzed [18]. The percent change between the starting and ending value for BL, HH, and WH was consistent across experimental treatments and when

Table 3. *Growth performance of yearling American Quarter horses*[1] *(2 Year)*
Tablo 3. *Bir yaşındaki Amerikan Quarter atlarının büyüme performansı (2 Yıl)*

Growth Performance	C*	33.3PEA*	66.77PEA*	P-Value
Body Weight, kg				
Initial	338.49	337.47	338.72	0.99
Day 28	345.32	341.56	346.23	0.89
Day 56	364.01	357.32	370.53	0.47
Final	385.44	383.17	390.09	0.77
ADG, kg				
Day 28	0.24	0.15	0.27	0.71
Day 56	0.67	0.56	0.87	0.29
Day 84	0.77	0.92	0.70	0.55
Total ADG	0.56	0.54	0.61	0.57
Orthogonal contrast**				
Linear	< 0.01	< 0.01	-	-
Quadratic	-	-	< 0.01	-

****C***\- *100% oats and 0% pea;* ***33.3PEA***\- *66.7% oats and 33.3% pea;* ***66.7PEA***\- *33.3% oats and 66.7% pea; ** Cubic orthogonal contrast was NS;*[1] *(n=48)*

Table 4. *Length and height measurements for yearling American Quarter horses*[1] *(2 Year)*
Tablo 4. *Bir yaşındaki Amerikan Quarter atlarının uzunluk ve boy ölçümleri (2 Yıl)*

Parameter	C*	33PEA*	67PEA*	P-Value
Body Length, cm				
Initial	137.62	136.01	138.26	0.78
Day 28	139.38	138.51	140.16	0.69
Day 56	141.17	140.41	142.54	0.38
Final	142.60	142.58	143.17	0.93
Orthogonal contrast**				
Linear	< 0.01	< 0.01	< 0.01	-
Hip Height, cm				
Initial	142.26	143.81	142.97	0.56
Day 28	143.79	145.58	144.66	0.53
Day 56	144.34	147.12	145.20	0.16
Final	145.97	148.23	146.41	0.22
Orthogonal contrast**				
Linear	< 0.01	< 0.01	< 0.01	-
Wither Height, cm				
Initial	137.64	139.29	137.44	0.37
Day 28	138.81	141.23	138.99	0.10
Day 56	139.96	142.40	139.96	0.14
Final	140.95	143.39	141.41	0.21
Orthogonal contrast**				
Linear	< 0.01	< 0.01	< 0.01	-

****C***\- *100% oats and 0% pea;* ***33.3PEA***\- 66.7% oats and 33.3% pea; ***66.7PEA***\- *33.3% oats and 66.7% pea; ** Quadratic and cubic orthogonal contrasts were NS;*[1] *(n=48)*

Table 5. *Circumference body conformation measurement for yearling American Quarter horses[1] (2 Year)*
Tablo 5. *Bir yaşındaki Amerikan Quarter atlarının vücut çevresinin ölçümü (2 Yıl)*

Parameter	C*	33.3PEA*	66.7PEA*	P-Value
Heart Girth Circumference, cm				
Initial	159.27	159.11	158.59	.94
Day 28	161.85	161.45	160.82	.84
Day 56	163.95	163.71	163.08	.84
Final	167.36	167.36	167.01	.97
Orthogonal Contrast**				
Linear	<0.01	<0.01	<0.01	
Cannon Circumference, cm				
Initial	17.56	17.23	17.58	.95
Day 28	17.86	17.90	18.02	.83
Day 56	18.02	18.04	18.08	.97
Final	18.37	18.18	18.37	.76
Orthogonal Contrast**				
Linear	<0.01	<0.01	<0.01	
Forearm Circumference, cm				
Initial	46.43	46.53	47.27	.60
Day 28	46.99	47.63	47.84	.58
Day 56	47.29	47.51	48.14	.64
Final***	47.45^a	49.53^b	47.79^a	.05
Orthogonal Contrast				
Linear Quadratic	<0.01	<0.01	<0.01	
Gaskin Circumference, cm				
Initial	41.02	40.40	41.00	.72
Day 28	41.37	40.96	41.44	.71
Day 56	41.35	41.23	41.55	.84
Final	41.99	41.51	42.15	.44
Orthogonal Contrast**				
Linear	<0.01	<0.01	<0.01	

C- 100% oats and 0% pea; **33.3PEA- 66.7% oats and 33.3% pea; **66.7PEA-** 33.3% oats and 66.7% pea; ** Quadratic and cubic orthogonal contrasts were NS; *** Means with unlike superscripts differ significantly (P<0.01); [1] (n=48)*

averaged across treatments the average percent change was 4.0, 2.7, and 2.75% for BL, HH, and WH, respectively.

Physical circumference body measurements for HG, CB, FA, and GM are shown in *Table 5*. The anatomical circumference change due to supplement treatment was both uniform within and across measurements during the 84 d experimental supplement study. This parallels the consistent and repeating results reported for BL, HH, and WH. There was no statistical difference between circumference measurements for HG, CB, FA, and GM during each 28 d interval (P>0.10) or for the entire experiment (P>0.10). A significant orthogonal linear effect was identified for all of the circumference measurements (HG, CB, FA, and GM).

Safety is very important when feeding horses a supplement containing non-fibrous carbohydrate. Throughout the study, the horses were observed frequently after diets were consumed for signs of abdominal discomfort associated with the prodromal stage of laminitis. At the end of the study, each horse was given a physical evaluation and score for detectable evidence of laminitis or abnormal hoof development. There was no evidence of disease among the horses on test, especially horses that received the 66.7PEA supplement.

DISCUSSION

Variations in production and stage of horse growth result in nutrient requirements for the horse that exceed what can be supplied by pasture or harvested forages. Oats, barley, corn, and milo are the most common cereal grains fed to horses, and oats are the preferred cereal grain among horsemen, because of the desirable groat to hull ratio.

FP grain is not a common grain fed to horses in the USA; however, this protein and energy dense ingredient may be a very valuable feed for horses. At least based on information in the scientific literature, FP is an excellent source of protein and energy in beef cattle and swine diets [19-22] and, although, FP contains 48-50% starch the starch component degrades more slowly than barley, wheat, or oats in ruminant diets and has a degradation rate similar to corn [7].

Feed grains are a significant source of energy from starch and the small intestine is the site of 55 to 85% of absorption [11]. Starch that is not absorbed in the small intestine passes to the caecum and large colon of the hindgut where anaerobic microbial digestion occurs producing absorbable volatile fatty acids, a process, which is similar to the digestive process in ruminants. The hindgut of the horse is very sensitive to digestive changes. When quantities of starch bypass the small intestine and disrupt hindgut digestive balance, an acidosis condition can develop due to declining pH leading to colic and, when severe, damage to the hoof [11].

Best horse management practice recommendations are to limit the amount of starch per meal to less than 2 g/kg BW [23] and to increase digestion of starch in the small intestine [24] by slowing passage rate or feeding multiple meals per day. Coarse feed texture passes more slowly than fine textured or pelleted feed, which is finely ground during preparation prior to the pelleting process [25]. Multiple meals per day (3 to 5) and mobile bag retention time were evaluated for oats, wheat, corn, horse bean, and barley [26]. Prececal digestibility was nearly 99% for oats and wheat, which are also known to be rapidly fermented in the rumen of cattle. Slower prececal degradation was measured for corn, barley, and horse bean suggesting that a greater portion of these substrates may pass on to the hindgut where alterations of the microbial community are associated with pH decrease and a corresponding increase in lactic acid concentration [27]. Accordingly, corn starch digestibility levels >200 mg/100 kg BW show smaller precedal digestibility [28] presumably due to starch characteristics that limit microbial degradation [29]. In our study, considering the digestibility constraints described for corn [27-29], we hypothesize that FP starch would not be completely digested in the small intestine. Therefore, assuming FP microbial degradation is similar to that of corn, FP could be considered a very useful non-structural carbohydrate energy source for the growing yearling horse provided supplements containing FP are fed using a multiple meal protocol such as the one used in this experiment.

Dietary safety and feeding management protocols are of utmost importance to protect horses of any age from unnecessary grain (starch/sugar) overload [30]. Grain overload is one of several causative events that can lead to laminitis. Laminitis is a very complex disease that begins in the digestive tract and ends with excruciating pain and irreparable damage to the feet and legs of the horse. Very simply, the disease begins with inflammatory gastrointestinal illness resulting in disruption of the intestinal mucosa due to acidosis and subsequent endotoxemia that initiates a cascade of metabolic and endocrine disturbances resulting in detachment of the coffin bone from the hoof basement membrane [10,31,32]. Alimentary gastrointestinal acidosis was avoided in our study by feeding individual supplement meals. Each supplement meal provided 1.79, 1.89, and 2.0 g of starch/kg of horse BW for the C, 33.3PEA, and 66.7PEA supplements, respectively. Dividing the daily amount of FP supplements into two meals daily separated by 6.0 hours resulted in no noticeable deleterious, negative, effects among horses in the study, especially, the 16 horses that received the highest 66.7PEA treatment.

Yearling horse growth and confirmation measurements improved linearly clearly suggesting that FP is a suitable replacement for oats in growing horse diets. Leg and hoof evaluation at the end of our study support feeding multiple meals with FP that provide ≤2 g of starch/kg of horse BW and, when feeding an oat-FP blended supplement, the oats in the mixed substrate may contribute to greater overall diet safety.

Finally, dietary supplements prepared with up to 66.7% FP replacement for oats that were fed in two meals per day were safe to feed and supported excellent yearling horse growth, conformation, and hoof and leg integrity.

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