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RESEARCH ARTICLE

Effect of Dried Sugar Beet Pulp on Some Blood Parameters and Heart Rate in Exercised Horses [1] [2]

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[2] *This research summarised from PhD thesis which name is "Replacement of oats with dried sugar beet pulp in exercised horses"*

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Summary

This research has been carried out in order to study the effects of using dried sugar beet pulp (DSBP) instead of oats on the blood parameters and heart rate of horses during exercise. The research has been performed using the 4x4 Latin Square design. The trial was carried out over 100 days. Each of the 4 periods of 25 days consisted of 21 adaptation days and 4 sampling days. In the trial, 4 different kinds of concentrated feed, balanced for energy and protein, were given to the control group, a 12.5% DSBP added group, a 25% DSBP added group and a 37.5% DSBP added group. No difference was found in the heart rate and blood samples of the horses to which the exercise test was applied, with regard to levels of plasma lactic acid, glucose, cholesterol and triglyceride (P>0.05).

Keywords: *Horse, Dried sugar beet pulp, Lactic acid, Glucose, Heart rate*

Egzersiz Yaptırılan Atlarda Kurutulmuş Şeker Pancarı Posası Kullanılmasının Bazı Kan Parametreleri ve Nabız Sayısı Üzerine Etkisi

Özet

Bu araştırma, at rasyonlarında yulaf yerine kurutulmuş şeker pancarı posası (KŞPP) kullanılmasının egzersiz sırasındaki bazı kan parametreleri ve nabız sayıları üzerine etkisini incelemek amacıyla yapılmıştır. Araştırma 4x4 latin kare metoduna göre yürütülmüştür. Denemenin her bir dönemi 21 günü adaptasyon ve 4 günü kan alma olmak üzere 25 gün, toplam 100 gün sürdürülmüştür. Denemede, enerji ve protein yönünden dengelenmiş olan 4 farklı konsantre yem; kontrol grubu, %12.5 KŞPP, %25 KŞPP ve %37.5 KŞPP ilave edilmiş grup olmak üzere atlara verildi. Egzersiz testi uygulanan atlardan alınan kan numunelerinde plazma laktik asit, glikoz, kolesterol ve trigliserid düzeyleri ile nabız sayıları bakımından farklılık önemli çıkmamıştır (P>0.05).

Anahtar sözcükler: *At, Kurutulmuş şeker pancarı posası, Laktik asit, Glikoz, Nabız sayısı*

INTRODUCTION

In horse nutrition, while energy, protein, vitamin and mineral needs are supplied by grains, the forages supply the need for fiber. For this reason, when levels of grains are increased to achive a well balanced ration, the risk of behavioural problems, and illnesses such as such as colic, gastric ulcer and laminitis increases [1]. In such situations, dried sugar beet pulp (one of the alternative energy sources), can be replaced by the high inclusion rates of grains to achieving suitable blood glucose and muscle glycogen stores for the exercise. The glycemic index that shows the effects of the feeds on the plasma glucose levels is lower then the all other grains and higher then the all the other forages. The grains that have a high glycemic index, such as corn, are utilised by the enzymatic pathway and cause a rapid increase of blood glucose, which may result in cecal acidosis, enterotoxemia, colic and laminitis. Some metabolic and digestive system disorders can be avoided by the use of sugar beet pulp [2,3].

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Sugar beet pulp differs from the other forages such as hay with respect to high availability of easy digestible fiber [4]. The majority of the easy digestible fiber is converted to volatile fatty acids and used as an energy source by the microbial fermentation in cecum and colon. The high digestibility of the fiber in sugar beet pulp and the hay results in a high energy level [5].

The objective of this study was thus to determine the effect of using dried sugar beet pulp (DSBP) instead of oats on the blood parameters and heart rate of horses during exercise.

MATERIAL and METHODS

Experimental Design and Animals

This research has been performed by using the 4x4 Latin Square design. Four clinically healthy thoroughbred males (6-12 years) with a mean±s.d. body weight (BW) of 458.5±2.31 kg were used. The horses were housed individually in stands with a layer of wooden shavings as bedding. The trial was carried out over 100 days. Each period of 25 days consisted of 21 adaptation days and 4 sampling days.

Diets and Feeding

In the trial, there were 4 different kinds of concentrated feed which consisted of control, a 12.5% DSBP (Dried sugar beet pulp) added group, a 25% DSBP added group and a 37.5% DSBP added group *(Table 1)*. The chemical composition of the feeds is shown in *Table 2*. Diets were formulated to be as isoenergetic and isonitrogenic as possible. Soybean meal and corn oil was included in the concentrates to keep the ratio between crude protein and energy constant in each diet. Horses were fed concentrates at 1.2% of their BW on a daily basis according to NRC requirements [6,7]. In the same way, grass hay, which is used as forage, was also given as 1.2% of their BW. The horses were fed 3 times a day at 07:00, 12:00 and 19:00. Hay and concentrate were fed at the same time each day. All feedstuffs had a same equal Ca/P (1.41). The horses were watered 6 times in a day.

Table 1. *Components of the concentrated feed*

Tablo 1. *Konsantre yemlerin bileşimi*

Ingredient, % as-fed basis	Control	12.5% DSBP*	25% DSBP	37.5% DSBP
Oat	98.08	82.5	66.95	51.37
DSBP	-	12.5	25.00	37.5
Soybean meal	-	2.04	4.08	6.12
Corn oil	-	1.15	2.29	3.44
Dicalciumphosphate	-	0.20	0.39	0.59
Limestone	1.02	0.71	0.39	0.08
Vitamin-mineral*	0.60	0.60	0.60	0.60
Salt	0.30	0.30	0.30	0.30

DSBP: *Dried sugar beet pulp*
*** Per kg:*** *Vit A 10.000.000 IU, Vit D_3 200.000 IU, Vit E 20.000 mg, Vit K_3 12.000 mg, Vit B_1 6.700 mg, Vit B_2 3.300 mg, nicotin amide 5.200 mg, Vit B_6 5.000 mg, Vit B_{12} 3.300 mg, folic acid 1.400 mg, D-Biotin 40 mg, choline 67.000 mg, Vit C 34.000 mg, $MnSO_4$ 6.700 mg, $FeSO_4$ 8.000 mg, ZnO 12.000 mg, $CuSO_4$ 4.000 mg, Co 67 mg, Se 10 mg, Na 1.140 mg, L-Lysine 70.000 mg, DL-Methionine 35.000 mg*

Exercise and Collection of Samples

During the adaptation period, horses were exercised every day with a rider for 35 min periods. On the last day of the adaptation period, a 16 G intracath was implanted into the left jugular vein of each horse following local anesthesia. In the four days sample collecting period at the beginning of the exercise, after two hours feeding, a heart rate monitor (Polar Horse 810i, Polar horse rate monitors, USA) was implanted into the horse. Horses were exercised with a rider in different periods. In these exercises, the average speed of the horses was measured as 1.8 m/s in walking, 2.8 m/s in trot, 4.4 m/s in canter and 7.5 m/s in gallop. Blood was taken 8 times: before the feeding, after the feeding period, at the beginning

Table 2. *Chemical composition of concentrated feed and feedstuffs*

Tablo 2. *Konsantre yemlerin ve yem hammadelerinin kimyasal kompozisyonu*

Analyzed Composition	Control	12.5% DSBP	25% DSBP	37.5% DSBP	Hay	Oat	DSBP	Soybean Meal
DM (%)	93.28	93.56	93.29	93.97	90.23	92.37	90.25	92.49
Ash (%)	4.40	4.48	4.65	4.77	10.39	3.84	6.30	6.12
DE Mcal/kg*	3.01	3.02	2.98	2.97	1.80	3.02	2.46	3.14
CP (%)	11.10	11.12	11.12	11.10	7.44	11.40	9.20	45.63
EE (%)	4.89	5.44	5.86	6.46	2.00	5.35	1.00	1.84
CF (%)	14.09	15.41	17.40	19.80	32.59	14.80	23.20	5.40
NDF (%)	36.77	37.73	38.69	39.30	67.00	37.99	50.53	15.46
ADF (%)	15.50	15.38	16.18	16.81	43.32	15.69	22.74	5.05

DSBP: *Dried sugar beet pulp, DM: Dry matter,* ***DE:*** *Digestible energy,* ***CP:*** *Crude protein,* ***EE:*** *Ether extract,* ***CF:*** *Crude fiber,* ***NDF:*** *Neutral detergent fiber,* ***ADF:*** *Acid detergent fiber*
*** DE Mcal/kg:*** *2118 + 12.18 (CP) - 9.37 (ADF) - 3.83 (NDF-ADF) + 47.18 (EE) + 20.35 (100 - CP-EE-NDF-ash) - 26.3 (ash) determined according to Harris [7]*

of the exercise, after every 3 steps of exercise including walking, trotting, cantering, galloping and 45 min after the end of the exercise. The blood samples which were taken contained lithium heparin and were centrifuged at 3.000 rpm 15 min immediately. Plasma was separated and kept in an ice bath. Lactic acid, glucose, cholesterol and triglyceride analysis were carried out on all blood samples after the last blood sample had been taken.

Chemical Analyses

The grain samples of the concentrated feed ingredients were analyzed in the Selcuk University Veterinary Faculty Feed Analysis Laboratories with regard to levels of dry matter, ash, crude protein, ether extract, and cellulose [8]. NDF and ADF levels were measured in an Ankom Fiber Analyzer, using Goering and Van Soest's [9] method. In blood plasma samples, lactic acid (Sigma, St. Lois, Procedure No: 735), glucose, triglyceride and cholesterol (Randox, Catalog No: 2623, 200, 210) levels were measured by a Shimadzu UV 2100 spectrophotometer. Heart rates were recorded by the Polar Horse 810i Heart Rate Monitor and examined with Equine Software 3.

Statistical Analyses

All response variables were analysed according to the General Linear model in SPSS [10]. The model used for all dietary variables had diet, period and horse as a fixed part.

RESULTS

No difference was found blood samples of the horses to which the exercise test was applied, with regard to levels of plasma lactic acid, glucose, cholesterol and triglyceride *(Table 3)*.

Table 3. *Plasma lactic acid, glucose, cholesterol and triglyceride level of horses with DSBP (12.5%, 25%, 37.5% DSBP) and without DSBP (control)*
Tablo 3. *Kurutulmuş şeker pancarı posası verilen (12.5%, 25%, 37.5%) ve verilmeyen (kontrol) atların plazma laktik asit, glikoz, kolesterol ve trigliserid düzeyleri*

Ration	Blood Sampling Periods							
	0	1	2	3	4	5	6	7
Plasma lactic acid level, mg/dl								
Control	4.76	7.97	4.91	3.65	10.81	61.94	46.00	19.45
12.5% DSBP	5.31	8.54	5.63	3.41	6.19	60.82	47.06	19.09
25.0% DSBP	8.69	11.99	8.00	5.50	11.91	71.22	52.89	27.11
37.5% DSBP	5.68	9.66	5.69	4.03	6.78	71.96	55.48	20.32
SEM	0.68	1.07	0.80	0.57	1.60	7.79	7.52	3.20
P-value	0.92	2.73	0.92	0.65	0.85	1.01	0.17	0.11
Plasma glucose level, mg/dl								
Control	92.73	127.93	103.24	93.81	57.28	64.45	85.26	110.44
12.5% DSBP	94.64	114.50	101.71	83.5	76.96	81.09	94.96	112.80
25.0% DSBP	91.45	112.86	103.58	93.51	70.20	71.09	79.60	107.86
37.5% DSBP	87.59	98.3	89.56	80.72	71.25	72.98	78.18	107.86
SEM	2.87	5.27	6.63	2.72	3.17	5.62	3.96	3.77
P-value	0.20	1.14	0.71	4.34	3.16	0.81	1.39	0.11
Plasma cholesterol level, mg/dl								
Control	98.80	81.82	87.54	97.20	87.17	104.41	100.42	87.87
12.5% DSBP	97.19	83.31	92.22	101.57	93.63	102.33	100.21	92.49
25.0% DSBP	100.17	91.29	97.99	105.52	97.14	100.61	101.42	90.06
37.5% DSBP	100.09	88.47	97.18	110.05	98.54	105.01	105.77	94.66
SEM	4.96	8.70	8.51	4.37	8.11	7.26	7.70	6.35
P-value	0.058	0.39	0.44	0.53	0.47	0.06	0.11	0.12
Plasma triglyceride level, mg/dl								
Control	28.96	24.47	27.41	30.83	34.46	39.93	34.04	27.92
12.5% DSBP	33.66	27.94	31.11	32.94	34.53	37.13	30.53	28.13
25.0% DSBP	36.83	33.59	37.78	38.95	40.61	42.27	38.71	34.66
37.5% DSBP	26.51	21.98	28.76	32.31	36.14	39.07	35.92	28.72
SEM	2.30	4.05	2.13	1.81	1.76	1.89	1.66	1.46
P-value	2.02	1.58	1.26	0.97	0.68	0.32	1.35	1.12

DSBP: *Dried sugar beet pulp*
0: *Before feeding,* ***1:*** *2 h after feeding,* ***2:*** *5 min walking before trotting,* ***3:*** *5 min after trotting,* ***4:*** *15 min after cantering,* ***5:*** *2 min after galloping,* ***6:*** *5 min walking after galloping,* ***7:*** *45 min after exercise*

While the differences in the heart rates according to the diets were not important, the heart rates increased according to the levels of exercise *(Table 4)*.

The researchers explain this result as being produced by the high production levels of the volatile fatty acids in the cecum and colon consumed by the metabolism as

Table 4. *Heart rates of horses with DSBP (12.5%, 25%, 37.5% DSBP) and without DSBP (control), beat/min*
Tablo 4. *Kurutulmuş şeker pancarı posası verilen (%12.5, %25, %37.5) ve verilmeyen (kontrol) atların nabız sayıları, atım/dakika*

Ration	Heart Rate Periods									
	1	2	3	4	5	6	7	8	9	10
	Heart Rate									
Control	34.75	57.25	92.00	125.75	166.25	95.25	68.50	55.50	53.75	40.25
12.5% DSBP	32.75	56.00	98.50	119.75	169.00	95.00	61.00	51.75	47.50	38.50
25.0% DSBP	33.25	58.75	92.25	112.50	166.75	86.50	66.50	55.25	50.00	37.75
37.5% DSBP	32.50	56.50	101.50	118.25	173.25	98.00	76.00	57.25	55.00	39.50
SEM	0.69	2.22	2.87	2.95	3.09	2.53	3.56	2.83	2.60	1.34
P-value	0.86	0.07	1.56	1.45	0.41	2.97	0.50	1.12	0.18	0.13

DSBP: *Dried sugar beet pulp*
1: *Before exercise,* ***2:*** *5 min, walking before trotting,* ***3:*** *5 min after trotting,* ***4:*** *15 min after cantering,* ***5:*** *2 min after galloping,* ***6:*** *5 min walking after galloping,* ***7:*** *5 min after exercise,* ***8:*** *10 min after exercise,* ***9:*** *15 min after exercise,* ***10:*** *45 min after exercise*

DISCUSSION

Lactic acid is formed as a result of liver and muscle glycogen. When there is a lack of oxygen, no more ruin appears and lactic acid accumulates in muscles and blood [11,12]. During the resting period lactic acid is added to energy metabolism, along with pyruvic acid in the presence of oxygen [13,14].

Plasma lactic acid levels in the control group, and those with 12.5%, 25% and 37.5% DSBP were 4.76, 5.31, 8.69 and 5.68 mg/dl respectively during the resting period. These levels were found to be 61.94, 60.82, 71.22 and 71.96 mg/dl respectively during the most intense period of exercise. These findings are harmonious with another study [2] which shows that 15% of the digestible energy demand can be supplied by dried sugar beet pulp and that there are no statistically important differences between the groups during the periods of highly intense exercise. The lactic acid levels are harmonious with the other studies [15] that applied the similar exercise tests when the ration composition was ignored. However, in these studies, when the lactic acid level is 5.4-7.2 mg/dl during the resting period, the levels were increased up to 80-140 mg/dl during the period of highly intense exercise [12]. In another study [13], the lactic acid concentrations were found to be below 20 mg/dl during the short period of run speed below 10 m/s. In many experiments the difference in the results showed that the horses' condition, diet, envoironmental conditions and intensity of exercise affected the lactic acid concentrations.

In one study [16], in the oat based ration the oats were replaced with 38.9% molassed sugar beet pulp and during the high intense exercise (9.5-10 m/s) there was a statistically important drop in plasma lactic acid levels. energy sources without transforming into the glycogen, and this reaction having caused a lower consumption of the glycogen storages.

It was reported that plasma glucose levels were 80-85 mg/dl in warm blooded horses. The plasma glucose levels were increased to 110 mg/dl after the feed intake. During the exercise, the glucose levels decreased to 35-45 mg/dl or more according to the intensity of the exercise [17]. In this study the average plasma glucose levels were found to be 92.73 mg/dl in the control group and in the 12.5%, 25%, 37.5% DSBP groups they were 94.64, 91.45, 87.59 mg/dl respectively, and therefore statistically not important. In the blood samples taken after the feed intake and the next intense exercise period, no difference was found in the plasma glucose levels due to the rations. In a study [16], using the horses fed by molassed sugar beet pulp (MSBP) added rations and exercise, it was found that the addition of MSBP had no effect on plasma glucose levels during the previous period, the course of the exercise or its aftermath, but some decrease in these levels was found after the exercise had taken place. These findings were very close to the plasma glucose levels that had been found in the previous example during the course and aftermath of the exercise. In another study, the plasma glucose levels were found to be higher in the oat based ration than the SBP added ration [18]. The reason for the lower levels of plasma glucose in these studies was that the oats had been replaced by SBP, and it may be that the oats contained high amounts of starch, which is easily converted to glucose. There is no starch in sugar beet pulp, while the oats contained 33-45% starch [2,18]. One of the other reasons for the lower glucose levels is that most of the carbohydrates in the sugar beet pulp that contains high amount of cell wall fragment (NDF) were microbiologically digested and converted into

the volatile fatty acids in the cecum. In this study it was concluded that the reason for there being no differences in plasma glucose levels may be that sugar beet pulp contains molasses and that the NDF value of the oats is higher than the literature values [2,18].

Plasma cholesterol levels in the control group were 81.82-104.41 mg/dl in the samples taken during the different periods. The levels of the 12.5%, 25%, 37.5% DSBP groups were 83.31-102.33, 90.06-105.52 and 88.47-110.05 mg/dl respectively. These values were very close to the results found in the other studies [18,19]. In a study [20], the addition of the sugar beet pulp to the ration of the horses did not affect the plasma cholesterol levels, but in the studies on humans and rats, it was found that by increasing the fiber content of the diet, cholesterol levels decreased. The reason for this may be the extra amount of the cholesterol excreted by the enterohepatic bile acids and the increase of the bile acid circulation [21].

During the study the plasma triglycerid levels in the control, and the 12.5%, 25%, 37.5% DSBP groups varied between 24.47-39.93, 27.94-37.13, 33.59-42.27 and 21.98-39.07 mg/dl respectively. These results are very close to each other and some of them are higher that the literature values [12]. But these values are still within the limits of the results of the studies [11].

The consumption of the DSBP did not affect the plasma triglycerid levels. In one study of a 62.46% DSBP added ration, no difference was found in the plasma triglycerid levels due to the use of the ration [20].

In this study the plasma cholesterol and triglycerid levels made no difference according to the rations. The reason for this may have been that the application time of the rations was not long enough to affect the lipid metabolism, or not all of the rations affected the lipid metabolism in the same way.

In this study, where the DSBP was added to the rations at different levels, it was found that heart rates increased according to the intensity of the exercise and that the addition of the DSBP did not affect heart rates.

In conclusion, in regularly exercised horses, when the DSBP addition to the diets is compared with diets including oats, neither positive nor negative effects have been found in the levels of blood parameters such as lactic acid, glucose, cholesterol, triglycerid levels considered as a performance criteria and heart rates. At the same time, those in the groups consuming DSBP did not have health problems. According to the results of this research, if the energy and protein of the diets is adjusted, DSBP can be used safely instead of oats in horse feeding.

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