Effect of energy sources, physical form and protein levels on nutrient digestibility and growth in Karadi lambs

I. Effect of physical form, energy source and protein level on nutrient digestibility and some blood parameters

S.A.Shamoon[1] *J.N.H.Saleh[2]*

[1]Dept. of animal resources, College of Agri. & Forestry, University of Mosul, [2]Dept. of Animal production, college of Agri., university of Dohuk

Abstract

In digestibility trial twenty four yearling Karadi lambs were divided into six groups, 4 lambs each, and individually fed on one of the six rations which based mainly on whole barely (13% or 15% protein) (T1&T2), ground barely (13 or 15 % protein) (T3& T4) and ground yellow corn (13 or 15% protein) (T5&T6). All lambs were fed for 10 days as a pre period and 5 days for feces collection. Blood samples were taken from the jugular vein on day 15.

Results showed that the physical form of barely had a significant effect on DM, OM, P and EE digestibility. However, protein levels had significant effect only on OM, P, EE and NDF. On the other hand, source of energy had significant effect only on ADF. Interaction results showed that there were a significant interaction between energy source and protein levels on DM, OM, P, EE and ADF digestibility. Results of biochemical analysis of blood pointed that physical form, energy source and protein levels had no significant effect on total protein, albumin and globulin but have a significant effect on glucose, triglyceride and urea concentration

Introduction

Food value can be determined by many methods, the most common one is the coefficient of digestibility. There are many factors which may affect the nutrient digestibility, of these factors, kind of feed, feed intake, feeding intervals and chemical composition of the diet. Review of the literature concerning the effect of these factors on nutrient digestibility was contrast. Studies investigating the effect of protein levels on nutrient digestibility showed that increasing protein levels in the rations causing a significant improvement in dry and organic matter(DM,OM), protein(P), ether extract(EE), and fiber (Al-_Mahdawy 2002, Ludden et al 2002, Al_Mallah 2007). In contrast, other workers reported that protein levels had no significant effect on dry and organic matter digestibility (Haddad et al 2001, Dabiri and Thonny 2004), or protein digestibility (Saleh2001). Fiber and fether extract digestibility also improved as protein levels increased.

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Energy sources also found had a significant effect on dry and organic matter digestibility (Garces_yepez et al 1997, Al_mallah 2007); also they reported that the improvement in nitrogen digestion was associated with yellow corn ration as compared with the ration based on barley. Although, the result of many workers indicated that energy sources had no significant effect on fiber digestion (Hussein et al 1991, Garces_Yepez et al 1997, Al_Mahdawi 2002). Recently Al_mallah (2007) indicated that both acid detergent fiber and neutral detergent fiber digestibility significantly ($p<0.01$) improved when lambs fed rations based on barley. The physical form of diet is also noted to play a significant role on nutrient digestibility, for example, whole barley had lower digestibility as compared with ground barley. However, the effect of physical form on nutrient digestibility depends on kind of the diet (for example cereal or roughage).

Little information is available about the interaction between the effect of physical form, energy source and protein level on nutrient digestibility. The aim of this study was to investigate the effect of physical form, energy sources and protein levels on nutrient digestibility and some blood parameters

Material and methods

Twenty four yearling Karadi lambs, 8-9 months of ages were divided into 6 groups 4 lambs each. They were housed in individual cages (1.5×1.5 M^2). Each group of lambs was individually fed on one of six rations which based either on ground or whole barely or ground yellow corn as a source of energy, and contain 13 and 15% protein respectively. The experimental rations was as follow: whole barely (13% protein) (T1), whole barely (15% protein) (T2), ground barely (13% protein) (T3), ground barely (15% protein)(T4), ground yellow corn (13% protein)(T5) and ground yellow corn (15% protein) (T6). Ingredients and chemical composition are shown in table (1). All lambs were individually fed according to NRC (1985) for 15 days. The first 10 days were considered as adaptation period to access concentrate mixture. On day 10 the lambs were held in metabolic cages for feces collection. On day 11, feces were collected for 5 successive days. Feces sample presented about 25%of daily output was taking every day and stored at 4C°. At the end of fecal collection period, all the subsamples of feces were well mixed together, and sample presented 25% of the total feces output was taken, dried at 60C°, then kept in nylon back until further analysis. Blood sample was taken on day 15 from the jugular vein and centrifuged at 4000 RPM for 15 minutes. The serum was kept in glass tubes and stored at -20C° until further analysis. The rations and feces were chemically analyzed for dry matter (DM), organic matter (OM), protein (P), ether extract (EE) according to AOAC (1984). Neutral detergent fiber (NDF) and acid detergent fiber (ADF) were determined according to Van Soest et al (1991).Biochemical analysis of blood was done using syrbio kits.

Data were statistically analyzed using complete random design (CRD) in tow factors, the first, the physical form of rations (whole or ground) and the second, protein levels (13 or 15 %) according to the following model :

YijK= μ + Ti+ Pj + Tpij+ eijk

Where: yijk = the value of observation that affected by physical form (i) and protein level (j) in the replicate (K). μ= all over mean that sample was taken from it. Ti= effect of physical form, Pj= effect of protein levels, eijk= the value of experimental error for the experimental unit affected by physical form (i) and protein level (j) in the replicate (K)

Test of significant differences between the mean was done using multiple range Duncan test (Duncan 1955) using statistical program SAS (SAS2001)

Table (1): Ingredient and chemical composition of the experimental rations.

Ingredient (%)	Whole and Ground barley		Ground yellow corn	
	13%	15%	13%	15%
Barley	64	61	_	_
Corn	_	_	58	55
Soybean meal	7	12	7	14
Wheat bran	22	21	27	22
Wheat straw	6	5	6	7
Urea	_	0.2	_	0.6
Limestone	1	0.8	1	0.7
Salt	_	_	1	0.7
Chemical composition (%)				
Dry matter	94.69	93.74	94.80	95.69
Organic matter	89.43	88.28	90.33	90.07
Crude protein	12.07	15.04	12.01	14.9
Ash	5.26	5.46	4.47	5.62
Ether extract	5.31	4.37	4.71	5.44
Acid detergent fiber	13.09	14.43	10.55	12.60
Neutral detergent	52.11	52.10	52.84	53.19
fiber	2.51	2.52	2.54	2.56
ME Mcal/kg diet *				

*** ME= Metabolizable energy calculated from AL-Khawaja et al (1978).**

Results and Discussion

Results presented in table (2) showed that the physical form (whole & ground barley) had a significant (p<0.01) effect on DM& OM digestibility which were (76.32 vs. 84.02%) and (77.55 vs. 85.69%) respectively. However, DM& OM digestibility improved as the level of protein increased from 13 to 15% but not

significant for DM digestibility, it was (78.28 vs. 82.06%) and (79.44 vs. 83.80%) respectively. These results may be expected since grinding barley may increase the degradability of starch which is the main source of energy, and increasing protein intake will provide additional nitrogen in the rumen which may altered the microorganisms activities then increase DM & OM digestibility. These results are in agreement with those found by AL-Mallah (2007) who reported that the DM & OM digestibility improved by increasing protein level in the rations up to 16% but not more, which cause a depression in DM & OM digestibility, because increasing protein intake may cause decreases in energy balance in the rumen. The interaction between the physical form and levels of protein was significant (p<0.01) when using whole barley but not ground barley (Table 2). The reasons for these variations may be due to the slow rumen fermentation of whole barley which may affected rumen environment such as PH or ammonia concentration.

Results showed that both the physical form and protein levels had a significant (p<0.01) effect on P digestibility (Table 2)which was (80.93 and 85.43%) for whole and ground barley and (80.30 and 86.07%) for 13 and 15% protein respectively. Again their was significantly (p<0.01) interaction between protein level and physical form when using whole but not ground barley (Table2). These results were similar to those found by Haddad et al (2001), Ludden et al (2002) and Dabiri and Thonney (2004), but not with those found by Saleh (2001) who reported that the levels of protein did not affect protein digestibility.

It is clear from the results presented in table (2) that both the physical form and level of protein had a significant (p<0.01) effect on EE digestibility, which were (78.33 vs.

83.81%) for whole and ground barley and (77.04 vs 85.10%) for 13 and 15% protein respectively. A significant ($p<0.01$) interaction between the physical form and levels of protein were shown in table (2). The reasons for these variations

Table (2): Effect of physical form , protein level and their interaction on nutrient digestibility.

Factor *	Digestibility %					
	Dry matter	Organic matter	Protein	Ether extract	Acid detergen	Neutral detergent fiber
Physical form Whole barley	76.32±1.	77.55±1.	80.93±1.	78.33±2.	34.95±1.	61.60±1.40a
Ground barley	84.02±1.	85.69±1.	85.43±1.	83.81±1.	36.07±0.	61.63±1.08a
levels of protein 13%	78.28±2.	79.44±2.	80.30±1.	77.04±1.	36.28±1.	63.88±0.97a
	82.06±1.	83.80±1.	86.07±1.	85.10	34.74±1.	59.36±0.85b
Interaction Whole barley × 13%	72.63±1.	73.32±0.	76.37±0.	73.67±1.	35.94±2.	64.89±1.09 a
	80.01±0.	81.78±0.	85.49±0.	83.00±1.	33.97±1.	58.32±0.87 c
Whole barley × 15%	83.92±1.	85.56±1.	84.23±0.	80.42±1.	36.62±0.	62.87±1.60 ab
	84.11±2.	85.83±2.	86.64±2.	87.20±1.	35.52±1.	60.39±1.38 bc

*** Means with different letters within each treatment differ significantly (P < 0.05)**

**** Means with different letters within each treatment differ significantly (P < 0.01)**

were not clear, but giving lambs ground barley and increasing protein level to 15% may provide a suitable condition in the rumen for microbial activities, which may lead to improve the EE digestibility. A few studies investigated the effect of protein level and

the physical form on EE digestibility, however, Shams AL-Deen (1997) noted that EE digestibility significantly (p<0.05) increased as protein level increased in the rations which was in agreement with the results found in our study. On the other hand, these results were disagreement with the results found by Saleh (2001), AL-Mahdawy (2002) and AL-Mallah (2007).

Results in table (2) also indicated that the physical form had no significant effect on ADF & NDF digestibility. However, both ADF & NDF digestibility were decreased as protein level increased (36.28 vs. 34.74%) and (63.88 vs. 59.36%) respectively, the differences were only significant (p<0.05) in NDF digestibility. Moreover, the interaction between physical from and protein level had a significant (p< 0.01) effect on NDF digestibility (Table 2). It was clear that increasing protein level from 13 to 15% caused a depression in NDF digestibility. The reasons for this depression are not clear, but rumen environmental condition may play an important role in this variation. However, these results were similar to those reported by Ludden et al (2002), but not with those mentioned by Haddad et al (2001), Saleh (2001) and AL-Mallah (2007).

Results presented in table (3) indicated that both energy source and protein level had no significant effect on DM & OM digestibility .Statistical analysis of the data showed that energy source was significantly (p<0.05) interact with the protein level in case of using yellow corn. Increasing protein level from 13 to 15% in rations based on yellow corn significantly improved DM digestibility (78.26 vs. 85.54%) as well as OM digestibility (80.00 vs. 86.68%) (Table3). These results were in contrast with the results obtained by other workers who reported that the energy source had a significant effect on DM & OM digestibility (AL-Mahdawy, 2002 and Garces-Yepez et al., 1997). However, Hussein et al (1991) found that there were no significant differences in DM & OM digestibility when they compared between barley and yellow corn as a source of energy, which were in agreement with our results (table 3). It is clear that P digestibility is affected by protein level, but not by energy source (Table 3). P digestibility significantly (p<0.05) improved by increasing protein level from 13 to 15% (80.86 vs. 86.37%) respectively. The results in table (3) indicated that protein level was significantly interacting with yellow corn. P digestibility in ration based on yellow corn

containing 15% protein improved (86.11%) as compared with 13% (77.50%). Also, there was a slight improvement in P digestibility as protein levels increased in rations based on barley. The variation in P digestibility in this study may be due in part to the variation in degradability rate of carbohydrate and protein in the rumen, which may provide a suitable condition for rumen microorganism activity to utilize more protein. Results obtained in this study were nearly similar to those found by Hussein et al (1991) and AL-Mahdawy (2002) who reported that energy source had no significant effect on P digestibility.

Ether extract digestibility was not affected by energy source (table3). However increasing protein level from 13 to 15% significantly (p<0.01) improved EE digestibility from 77.61 to 87.69%. These results were confirmed by the results in table (3) which showed that there was a significant (p<0.01) interaction between energy source and protein level on EE digestibility. Similar results were reported by AL-Mallah (2007).

Results presented in table (3) showed that ADF digestibility was significantly (p<0.05) affected by energy source which were (36.07 and 32.64%) for the ration based on barley and yellow corn respectively. While both energy source and protein level had no significant effect on NDF digestibility. These results were confirmed by the interaction results present in table (3).

Table (3): Effect of source of energy, level of protein and their interaction on nutrient digestibility.

Factor *	Digestibility %					
	Dry matter	Organic matter	Protein	Ether extract	Acid detergent	Neutral detergent fiber
source of energy Barley	84.02±1.45 a	85.69±1.27 a	85.43±1.39 a	83.81±1.75 a	36.07±0.84 a	61.63±1.08a
	81.90±1.94 a	83.84±1.63 a	81.80±2.21 a	81.50±2.85 a	32.64±0.85 b	62.48±1.71a
levels of protein 13%	81.09±1.58 a	83.28±1.35 a	80.86±1.78 b	77.61±1.63 b	35.01±0.90 a	62.21±1.28a
	84.83±1.64 a	86.26±1.44 a	86.37±1.56 a	87.69±1.28 a	33.70±1.15 a	61.90±1.59a
Interaction Barley × 13%	83.92±1.13 ab	85.56±1.00 a	84.23±0.89 a	80.42±1.98 b	36.62±0.78 a	62.87±1.60a
Barley × 15%	84.11±2.92 ab	85.83±2.54 a	86.64±2.70 a	87.20±1.66 a	35.52±1.59 ab	60.39±1.38a
Corn × 13%	78.26±2.24	80.00±2.00	77.50±2.55	74.80±1.80	33.40±1.22	61.54±2.18a
	85.54±1.90	86.68±1.76	86.11±2.01	88.19±2.16	31.88±1.22	63.41±2.88a

*** Means with different letters within each treatment differ significantly(P < 0.05)**

**** Means with different letters within each treatment differ significantly(P < 0.01)**

The effects of energy source on ADF & NDF digestibility were very small; this is may be due to the entire ration contained a large quantity of starch and little quantity of fiber. These results were in agreement with those reported by Hussein et al (1991) who mentioned that ADF& NDF digestibility were not affected when they compared between two rations containing either barley or yellow corn. Similar results were also obtained by AL-Mahdawy (2002).

Results presented in table (4) showed that the physical form had a significant effect on blood glucose concentration (BG); it was 78.13 and 70.38 mg/100ml for whole and ground barley. Also it was noted that protein level had a significant effect (p< 0.01) on blood triglyceride (BT) (19.75 & 31.88 mg/100ml) for 13 and 15% protein, however, differences between whole and ground barley was not significant (26.88 vs. 24.75 mg/100ml).

A significant interaction between the physical form and protein level was also found on BG and BT (Table 4).This is because of slow degradability of whole barley in the rumen which may increase rumen bypass of undigested barley, which will digest in the lower digestive track and release more glucose.Moreover, both the physical form and protein level had no significant effect on total protein, Albumin, globulin and urea concentration. The values of BG in present study were within the normal average (40-80 mg/100ml) (Swanson, 1977), and were in disagreement with those reported by AL-Mahdawy (2002), who mentioned that increasing protein level had no significant effect on BG. In general the values of total protein(TP),albomine (Alb.), globulin (Glob.), and blood urea (BU.) were within the normal average which reported by AL-Mallah (2007) and Saleh (2008).

Results present in table (5) showed that both energy source or protein level had no significant effect on BG, TP, Alb. and Glob. However, BT concentration significantly (p<0.05) increased with rations that contained 15% protein as compared with 13% protein (27.50 vs. 18.00 mg/100ml) respectively. The energy source had a significant

(p<0.01) effect on BU concentration, which were 45.13 and 31.88 mg/100ml for barley and yellow corn rations respectively. These variations may be due to the variation in starch degradation in the rumen for barley and yellow corn. Barely has higher rate of degradability than yellow corn(Al-Atar

Table (4): Effect of physical form , levels of protein and their interaction on some blood biochemical parameter.

Factor *	Blood					
	Glucose mg/100ml	Triglyceride mg/100ml	Total protein g/100ml	Albumin g/100ml	Globulin g/100ml	Urea mg/100ml
Physical form Whole	78.13±3.38a	26.88±2.55a	7.20±0.24a	3.09±0.06 a	4.11±0.24a	43.63±1.3a
barleyGround	70.38±3.14b	24.75±3.76a	6.91±0.11a	3.04±0.04 a	3.88±0.12a	45.13±2.61a
levels of protein 13%	75.63±4.43a	19.75±1.92b	7.11±0.23a	3.06±0.06a	4.05±0.23a	45.38±2.28a
15%	72.88±2.33ab	31.88±2.61a	7.00±0.16a	3.06±0.04 a	3.94±0.15a	43.38±1.86a
Interaction Whole barley ×13%	84.75±2.93a	22.25 ± 2.39b	7.13 ± 0.49a	3.05 ± 0.12a	4.08± 0.50a	43.50±2.33a
Whole barley × 15%	71.50±3.93b	31.50 ± 3.23a	7.28 ± 0.18a	3.13 ± 0.06a	4.15± 0.17a	43.75±1.89a
Ground barley×13%	66.50±5.24b	17.25 ± 2.69b	7.10 ± 0.06a	3.08 ± 0.06a	4.03± 0.05a	47.25±4.05a
Ground barley×15%	74.25±2.95a	32.25 ± 4.61a	6.73 ± 0.18a	3.00 ± 0.04a	3.73± 0.22a	43.00±3.54a

*** Means with different letters within each treatment differ significantly (p< 0.05)**

1981) which may effected the nitrogen utilization by the rumen microorganisms.

Results present in table (5) pointed out that there was a significant (P< 0.01) interaction between energy source and protein level on blood urea concentration. The reason of this is not clear, but may be because blood urea depends on protein intake and its degradability in the rumen, and the pickup of nitrogen by the microorganisms which depend on availability of energy. There was a significant interaction between energy source and protein level on BT when barley used as main source of energy

Conclusion:

The results revealed that both ground barely and protein level (15%) had significant effects on nutrient digestibility, while both energy source (barely or yellow corn) had nearly the same effect on nutrient digestibility.

Table (5): Effect of source of energy, level of protein and their interaction on some blood biochemical parameter.

Factor *	Blood					
	Glucose mg/100ml	Triglyceride mg/100ml	Total protein g/100ml	Albumin g/100ml	Globulin g/100ml	Urea mg/100ml
source of energy						
Barley	70.38±3.14a	24.75 ± 3.76a	6.91 ± 0.11a	3.04 ± 0.04a	3.88 ± 0.12a	45.13±2.61a
Corn	74.50±4.41a	20.75 ± 2.85a	6.83 ± 0.25a	3.04 ± 0.03a	3.79 ± 0.27a	31.88±2.83b
levels of protein						
13%	73.75±4.36a	18.00 ± 1.74b	6.88 ± 0.17a	3.05 ± 0.03a	3.83 ± 0.17a	38.63±4.13a
15%	71.13±3.33a	27.50 ± 3.73a	6.86 ± 0.22a	3.03 ± 0.04a	3.84 ± 0.24a	38.38±3.21a
Interaction						
Barley × 13%	66.50±5.24a	17.25 ± 2.69b	7.10 ± 0.06a	3.08 ± 0.06a	4.03 ± 0.05a	47.25±4.05a
Barley × 15%	74.25±2.95a	32.25 ± 4.61a	6.73 ± 0.18a	3.00 ± 0.04a	3.73 ± 0.22a	43.00±3.54ab
Corn × 13%	81.00±5.12a	18.75 ± 2.56b	6.65 ± 0.31a	3.03 ± 0.03a	3.63 ± 0.33a	30.00±3.70c
Corn × 15%	68.00±6.04a	22.75± 5.34ab	7.00 ± 0.42a	3.05 ± 0.06a	3.95 ± 0.46a	33.75±4.63bc

* Means with different letters within each treatment differ significantly (p< 0.05)

*** *Means with different letters within each treatment differ significantly (p< 0.01)**

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