Effects Of Poor Quality Desert Grass And Subsequent Refeeding On A High Plane Of Nutrition On Growth And Body Composition Of Sudan Desert Lambs.

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Keywords: Sudan Desert sheep – Undernutrition – Compensatory growth – Live-weight growth, Carcass composition.

Summary

Forty two, 21 males and 21 females, weaned Sudan Desert lambs were divided according to sex and live weight into three equal groups (3 x 14). Each group was randomly fed ad libitum *for 11 weeks on one of three diets: humra* Aristida funiculata *Trin. & Rupr., humra plus limited amound of cotton seed cake, and a balanced ration. After those 11 weeks of differential feeding, each group was fed* ad libitum *on the balanced ration for 12 weeks. Six lambs (3 males and 3 females, 2 from each group), were randomly slaughtered at the start of the differential feeding period. Half of the remaining lambs (3 x 6) in each treatment group (3 x 12) were slaughtered at the end of the differential feeding period and the other half (3 x 6) at the end of the experiment.*
Live-weight growth of lambs fed humra, with or without supplemental cottonseed cake, was restricted compared to lambs fed the balanced ration. Upon refeeding, previously restricted growing lambs expressed compensatory growth. The pattern of relative increase in weight of body components was not affected by nutritional history but was influenced by body weight. Following refeeding, animals fed earlier humra with or without cottonseed cake, recovered in body conformation and composition.
It was concluded that, supplementation of range lambs with a source of protein during the season of graze scarcity and afterwards feeding them on high energy yielding rations shortly before slaughter is recommended under the conditions of the Sudan.

Résumé

Deux lots de 21 agneaux et 21 agnelles Désertique du Soudan, sevrés, ont été partagés en 3 lots sur la base du sexe et du poids vif. Les animaux de chaque lot ont reçu au hazard l'une des 3 rations suivantes: (1) Humra, (2) Humra plus tourteau de coton et (3) une ration équilibrée. Après 11 semaines les rations expérimentales ont été arrêtées. Les animaux de chaque lot ont reçu une ration équilibrée ad libitum *pendant 12 semaines. Six animaux (3 mâles et 3 femelles, 2 de chaque lot), choisis au hazard, ont été abattus au début de l'expérience. La moitié des animaux de chaque essai ont été abattus à l'arrêt des rations expérimentales. Les animaux de l'autre moitié ont été abattus à la fin de l'expérience. Les animaux qui ont reçu du Humra avec ou sans supplément de tourteau de coton ont manifesté un taux de croissance limité. Ceux qui ont reçu une ration équilibrée ont manifesté un meilleur taux de croissance. La réalimentation avec une ration équilibrée des animaux ayant reçu une ration restreinte a entraîné une compensation de la croissance. La tendance de croissance du poids vif des différentes parties de la carcasse n'a pas été affectée par le mode de nutrition. Les animaux ayant reçu du Humra seul ou du Humra avec un supplément de tourteau de coton ont manifesté un recouvrement de la conformation et la composition de la carcasse suite à leur réalimentation.*
En conclusion, la supplémentation des agneaux de parcours avec une source riche en protéine pendant la saison où le fourrage est rare et leur alimentation avec une ration riche en énergie juste avant l'abattage est recommandée dans les conditions du Soudan.

1. Introduction

Desert sheep are found in the area of the Sudan extending from 13°N to 22°N latitude and between 26° to 37° E longitude (13). They make up about two-third of the 16 million Sudan sheep population (17). This area receives an annual rainfall that ranges from a trace to 300 mm, most of which falls between July and October. Apparently no nutritional problems are present during the rainy season because there is plenty of good natural pastures. However, these pastures deteriorate both in quality and quantity as the dry season progresses. For example, the crude protein content of the dry matter of semi-desert grasses decreased from 7.5% in August to 4.4% in March (10). As lambs are born during the rainy season, they face a problem of undernutrition at weaning if they are kept on natural pastures without supplementation. The ultimate effect of raising lambs only on natural pastures is a low level of productivity.

The objective of this study was to investigate the effect of feeding dry desert grass, locally known as humra, with or without protein supplementation, and subsequent refeeding on a high plane of nutrition on live-weight gain and body composition of lambs.

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2. Material and methods

Forty two, 21 males and 21 females, weaned Sudanese Desert lambs 3-5 months old and weighing 16-24 kg were used in the study. The lambs were allowed a standardisation period of two weeks during which they were fed *ad libitum* cottonseed cake and humra and dosed with broad-spectrum anthelmintic. Humra is a seasonal desert grass collected at the end of the rainy season and sold as dry animal feed. At the end of the standardisation period, the lambs were divided according to weight and sex into three groups of 14' (each consisting of 7 males and 7 females). Two animals (a male and a female) were chosen at random from each group and slaughtered at the beginning of the trial to provide pre-experimental data (Reference Group). The groups (3 x 12 lambs) were then assigned at random to one of the following treatments: Group A was fed *ad libitum* dry humra; Group B was fed *ad libitum* dry humra plus a daily allowance of 100 g of cottonseed cake, 8 g of common salt and 3 g of vitamin and mineral mixture per sheep; Group C was fed *ad libitum* a balanced ration. The allowance of cottonseed cake fed to Group B was calculated to meet the daily maintenance requirements for protein (3). Humra was chopped, other ingredients were ground and all were mixed to make the balanced ration fed to Group C. Composition of the balanced ration and chemical composition of all feeds are given in Table 1. Crude protein content of the diet was determined by Kjeldahl method, fat content by soxhlet ether extraction, crude fiber by acid & base hydrolysis and gross energy by bomb calorimetry (2). Each group of lambs was fed on its respective feed for 11 weeks. Animals of Group A and C were group-fed whereas lambs of Group B were individually fed during the differential feeding period. At the end of the differential feeding period, 3 lambs of each sex were selected randomly from each group and slaughtered. The remaining animals in each group (3 x 6 lambs) were fed *ad libitum* for 12 weeks on the same balanced ration offered to Group C during the differential feeding period. and then slaughtered. Lambs were housed throughout the experiment in partially shaded outdoor pens.

TABLE 1

Chemical composition of the diets used in the experiment (% on dry matter basis)

	Experimental diets		
	Humra	Cottonseed cake	Balanced ration*
Crude protein	4.6	23.1	13.5
Crude fibre	46.3	21.5	21.6
Ether extract	2.2	18.3	6.4
Ash	6.6	4.1	3.7
Kcal/g DM	3.9	4.8	4.1

* Composition:

		%
Dura sorghum grain	:	44
Cottonseed cake	:	25
Dry humra	:	29
Common salt	:	1.5
Vitamins and minerals mixture	:	0.5
Total	:	100

After "fasting" for 12 lambs were slaughtered the Muslim "Halal" way and dressed according to normal slaughter house procedures. Internal organs were weighed immediately after slaughter. Empty body weight was determined as the difference between weight of animal at slaughter and weight of gut fill. Carcasses were stored at 4°C for subsequent examination. After chilling overnight, the carcass was weighed and the following carcass measurements were taken using a tape and calipers to the nearest mm: carcass length, carcass depth, width of barrel, leg length, leg width, anterior and posterior circumference of buttocks. The carcass was then split into wholesale cuts following the procedures of Levie (12). The cuts included: leg, loin, rack, plate, brisket + fore shank and shoulder + neck. Cuts from the left half of the carcass were dissected into subcutaneous and intermuscular fat, muscle, bone and other tissues (connective tissue, nerves, blood vessels and glands).

Samples from the muscles, *supraspinatus, longissimus thoracic et. lumborum and biceps femoris* were measured for muscle fibre thickness using an ocular micrometer inserted in the eye-piece (X10) of standard light microscope after being separated by means of an electric blender. The average thickness of 50 fibres was recorded and converted into microns. Samples from the muscles: *supraspinatus, longissimus thoracic et. lumborum and biceps femoris* were minced, dried and analysed for content of protein and ether extract following the previously described procedures (2).
Data from all slaughter points, in each treatment group, were pooled and analysed by regression. Huxley's (8) allometric equation $Y = ax^b$, in the logarithmic form, was used to study the growth of carcass components in each treatment group relative to EBW or carcass weight. In the equation X is the whole (carcass weight) of which Y is a part, b is the regression coefficient and a is the intercept. A value of b greater than 1.0 indicate that part Y increased in weight at a faster rate than X, a b value less than 1.0 indicate the opposite while a b value not different from 1.0 indicate that Y grew at similar rate to X. Analysis of covariance using carcass measurements was used to compare regression lines of treatment groups in slope and adjusted means. Cube root of carcass weight was used as a covariate to allow comparisons with linear measurements. Means were adjusted to a common geometric mean along the slope of the regression line. All the statistical methods used in the experiment followed those of Snedecor and Cochran (16).

3. Results

Humra had a low nutritive value (Table 1). It has exceptionally high crude fibre and low crude protein contents compared with the balanced ration and cottonseed cake. Lambs fed on humra only during the differential feeding period (Group A) lost weight, those fed on humra plus a limited amount of cottonseed cake (Group B) made a very slight gain in weight, and lambs fed on the balanced ration (Group C) grew at a significantly ($P<0.01$) faster rate than the other two groups (Table 2). The difference in mean live weight at the end of the differential feeding period between Group C and A was 8.17 kg and between Group C and B was 6.78 kg (Table 2). On refeeding, lambs of Group A or B grew significantly faster ($P<0.05$) than those of Group C, but despite this rapid rate of gain, neither Group A nor Group B closed weight gap between them and Group C which was established by the end of the differential feeding period.

There was no significant effects of nutritional history on experimental animals carcass conformation, except on leg width which was wider in lambs fed the balanced ration throughout the experiment than in other two groups of lambs (Table 3).

TABLE 2

Mean live weight and gain in live weight (kg) of lambs fed humra (A), humra plus cottonseed cake (B) or balanced ration (C), and refed the balanced ration at different stages of the experiment.

ITEM	Experimental Group A	Experimental Group B	Experimental Group C	SE	F-value# & differences between means
Initial live weight	22.7^{a}	22.8^{a}	21.5^{a}	1.2	0.2
Live weight at the end of differential feeding	21.8^{b}	23.1^{b}	29.9^{a}	2.0	9.2**
Weight gain during differential feeding	-1.0^{b}	0.3^{b}	8.4^{a}	0.7	5.9**
Final live weight	32.5^{b}	33.4^{a}	36.9^{a}	1.3	3.7*
Weight gain during refeeding	10.8^{a}	10.3^{a}	7.0^{b}	0.5	3.5*

± standard error of means (SE)
Means on the same line denoted by the same letter do not differ significantly (P>0.05).
With (2,15) degrees of freedom.

TABLE 3

Adjusted mean# final carcass measurements (mm) of lambs fed humra (A), humra + cottonseed cake (B) or a balanced ration (C) during differential feeding period and refed balanced ration.

Carcass measurement	Adjusted means + SE: A (n=6)	B (n=6)	C (n=6)	SE	F-value $ & Difference between means
Carcass length	560	580	560	14	1.2
Carcass depth	250	250	250	12	0.8
Width of barrel	600	600	610	16	1.6
Leg length	320	330	330	7	2.0
Leg width	20	20	40	6	4.5*
Anterior circumference of buttocks	590	590	590	14	0.5
Posterior circumference of buttocks	600	590	590	8	1.4

± standard error of means (SE)
Adjusted to an average cube root of carcass weight (2.19) along the slope of the common regression line
$ With (2,15) degrees of freedom.

TABLE 4

Adjusted mean# weights of major carcass tissues (g) in the half carcass of lambs fed humra (A), humra plus cottonseed cake (B) or a balanced ration (C) during differential feeding period and refed a balanced ration and coefficients of growth relative to carcass weight.

Tissue	Adjusted means A	B	C	SE	F-value$ & Difference between means	Regression coefficient (*b*) Overall A	B	C	During refeeding A	B	C
Muscle	2760	2890	2830	50	1.29	0.96	0.98	0.96	0.98	1.04	0.98
Bone	1190	1160	1070	62	1.00	0.60*	0.62*	0.65*	0.66*	0.64*	0.64*
Fat	540	700	900	83	10.73**	3.85*	2.24*	2.13*	2.52*	2.91*	3.36*

± standard error of means
Adjusted to an average geometric mean half carcass weight (5.15 kg).
$ With (2,36) degrees of freedom between adjusted means.

TABLE 5

Mean muscle fibre diameter (μ) of selected muscles in lambs fed humra (A), humra plus cottonseed cake (B) or a balanced ration (C) and refed the balanced ration.

Muscle	Slaughter Points: Reference (n=6)	End of differential Feeding A (n=6)	B (n=6)	C (n=6)	Final Slaughter A (n=6)	B (n=6)	C (n=6)	SE	F-value# & Difference between means
m. supraspinatus	24.4^{c}	31.5^{b}	27.3^{b,c}	22.5^{c}	40.9^{a}	42.9^{a}	41.5^{a}	2.83	5.18**
m. longissimus thoracis et. lumbourum	21.8^{c}	28.2^{b}	24.3^{b,c}	20.9^{c}	34.0^{a}	34.5^{a}	33.9^{a}	1.88	5.24**
m. biceps femoris	27.9^{b}	30.0^{b}	29.7^{b}	25.3^{b}	49.1^{a}	50.2^{a}	49.1^{a}	3.61	5.50**

± standard error of means (SE)
With (5,35) degrees of freedom
Means on the same line without or denoted with the same letter do not differ significantly (P>0.05)

TABLE 6
Mean protein and fat contents (on dry matter basis) of selected muscles of lambs fed humra (A), humra plus cottonseed cake (B) or balanced ration (C) and refed the balanced ration.

Muscle	Slaughter Points							SE	F-value# & Difference between means
	Reference	End of differential Feeding			Final slaugther				
		A (n=6)	B (n=6)	C (n=6)	A (n=6)	B (n=6)	C (n=6)		
m. supraspinatus									
protein	91.6[a]	84.8[b]	92.1[a]	83.7[b]	75.8[c]	80.1[b]	80.8[b]	0.42	3.54**
fat	4.1[d]	10.9[c]	3.5[d]	1.9[d]	19.6[a]	15.7[b]	14.9[b]	0.82	5.03**
m. longissimus thoracis et. lumborm									
protein	90.8[a]	83.2[b]	91.8[a]	82.9[a]	74.2[d]	76.4[c]	78.3[c]	0.63	5.09**
fat	3.4[d]	12.9[c]	2.8[d]	2.6[d]	21.4[a]	17.4[b]	16.6[b]	0.76	5.19**
m. biceps femoris									
protein	91.8[a]	84.4[b]	90.3[a]	83.2[b]	74.5[c]	75.2[c]	72.5[c]	0.54	4.99**
fat	4.4[c]	11.1[b]	3.9[c]	2.3[c]	21.3[a]	19.0[a]	20.3[a]	1.88	5.28**

± standard error of means (SE)
with (5,35) degrees of freedom
Means on the same line without or denoted with the same letter do not differ significantly (P>0.05).

During the differential feeding period and the refeeding period, total carcass muscle in all three treatment groups grew at a similar rate (regression coefficient not different from 1.0), whereas bone grew at a slower rate (coefficient less than 1.0) than carcass weight (Table 4). Carcass fat was deposited at a faster rate (regression coefficient higher than 1.0) than carcass weight. On refeeding, there was no significant treatment effect on the rate of growth of muscle and bone (Table 4). However, fat was deposited at a significantly faster rate in lambs previously fed on humra followed by those fed on supplemented humra and lambs fed on balanced ration throughout the experiment respectively. By the end of the experiment, the carcasses of lambs fed on balanced ration throughout the study contained more separable fat than humra supplemented and humra fed lambs at the same carcass weight, whereas muscle and bone contents were similar in all groups (Table 4).
Muscle fibres of animals fed the balanced ration were thicker at the end of the differential feeding period than those of lambs fed humra only (Table 5). However, by the end of the experiment there were no significant differences between the three groups of animals in muscle fibre diameter.

By the end of the differential feeding period, lambs fed the balanced ration had higher percentage of fat (2-3 folds) and lower percentage of protein in their muscles than those supplemented with cottonseed cake or those fed on humra, respectively (Table 6). During this period lambs supplemented with cottonseed cake had the highest protein contents compared to those fed on humra only or on the balanced ration. Differences in chemical composition were reduced by the end of the experiment following the period of refeeding. However, by then lambs fed on the balanced ration throughout the experiment had higher fat and lower protein contents than those fed on humra or supplemented with cottonseed cake during the differential feeding period.

4. Discussion and Conclusion

Lambs fed on humra only during the differential feeding periods lost weight, which confirms that humra is a poor quality animal feed. In contrast, lambs offered limited amounts of cottonseed cake, to satisfy their protein maintenance requirements during the same period, made a very slight gain in weight. This suggests that lambs given supplement would probably stand a better chance of survival under the harsh environment of the range in the Sudan than those fed humra without a protein supplementation. Supplementation of ruminants on fibrous feeds, such as straw, with feeds high in protein increased live-weight gain and improved efficiency of feed utilisation (11).

Lambs previously fed on humra with or without supplementation put on weight at a faster rate, following refeeding, than lambs *ad libitum* fed throughout the experiment. This indicates that they expressed compensatory growth which is in agreement with the findings in lambs of similar ages (14). Although lambs underfed during the differential feeding period did not catch up in liveweight with those fed well throughout, supplementation with cottonseed cake improved economical gain by increasing the margin over major inputs (6). This suggests that supplementation with a protein source, such as oil cakes which are readily available in Sudan, is beneficial during the dry season to improve gains from sheep raised under range conditions.
Carcass conformation of previously underfed lambs following rehabilitation was similar to that of lambs grown without interruption throughout the experiment. This indicated that undernutrition did not cause permanent retardation of body size of sheep (1). Carcass tissues of sheep in this study grown at different rates. This pattern of growth affects body composition at given weight (7). However, there were no significant treatment effects on the rates of development of body components and tissues, as well as body composition except fat over this small range of live weight. It has been indicated that patterns of relative growth of body components are not affected by the level of nutrition; and that differences in body composition are largely explained in terms of differences in body weight (5, 18, 19). Nutritional treatment only affected the rate of fat deposition (5, 18, 20).

The present findings on relative development of carcass tissues (muscles, bone and fat) of Sudan Desert sheep are in agreement with those reported for temperate breeds (18). Muscle tissue increased in weight at a similar rate, bone at a slower rate and fat at a faster rate than carcass. This implies that the proportion of bone in the carcass decreased, that of fat increased and muscle proportion remained more or less constant with the increase in carcass weight. Better fed lambs had thicker muscle fibres than the underfed ones by the end of the differential period. However, there were no significant differences in muscle fibre size between previously underfed and non-restricted lambs following refeeding. This indicates that finishing lambs on a balanced ration before slaughter will improve meat yield and quality. Differences between the three individual muscles sampled in this study in fibre thickness were not tested statistically. However, some of the apparent differences may be explained in terms of variations in muscle weight, location and muscle function (7, 9).

The present findings agree with the established fact that fat proportion of muscle tissue increases and protein proportion decreases with increasing body weight. The treatment differences in chemical composition of the muscles sampled by the end of the experiment may be explained in terms of differences in live weight between these groups of animals. It has been suggested that chemical composition is a function of body weight (4, 15).

It was concluded that undernutrition in early post-natal life did not affect future recovery in growth of body and body components of Sudan Desert sheep. Supplementation of young lambs raised on range with a source of protein during the dry season in the Sudan followed by feeding them on a well balanced ration shortly before slaughter is recommended.

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