PJN
ISSN 1680-5194

PAKISTAN JOURNAL OF NUTRITION

ANSInet
308 Lasani Town, Sargodha Road, Faisalabad - Pakistan
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Pakistan Journal of Nutrition 3 (2): 107-111, 2004

The Effect of Feeding a Milk Diet Versus Concentrate and Hay Diet on the Meat Quality and Fatty Acid Profile of Lambs

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Abstract: The object of this study was to compare carcass and meat quality characteristics of conventionally reared lambs with others reared solely on milk. Eighteen crossbred lambs weaned at 5 weeks of age were randomized within each sex into 2 groups. The first group was fed reconstituted whole milk and the second, commercial lamb pellets and hay. Both diets were offered *ad libitum* for 9 weeks. Animals were subsequently slaughtered under standard commercial conditions. Samples of shoulder joint were taken for dissection and meat quality assessment was made using the 6 - 12th rib section of the *Longissimus doris* muscle. Lambs on the concentrate and hay diet had significantly larger reticulo-rumens, livers and generally were less fat ($p < 0.01$) than milk-fed lambs. Dietary treatment had little effect on meat quality. Lambs reared on the milk diet contained higher proportion of unsaturated fatty acids in subcutaneous fat than lambs fed concentrate and hay. The milk diet did not appear to produce the typical pale "veal" colour in lambs as might be expected from studies on veal production.

Key words: Milk diet, hay diet, meat quality, fatty acid, Lambs

Introduction

Veal is produced by continuing feeding a milk diet to calves beyond the normal weaning time, and slaughtering them for meat at less than 30 weeks of age. The characteristic white or light pink colour is judged by the customer to be a guarantee of exclusive milk feeding which he associates with specific organoleptic quality (Charpentier, 1970). The light pink colour of veal actually reflects an anaemic condition resulting from the relatively low iron content of milk (Blaxter *et al*., 1957; Charpentier, 1966). Pommier *et al*. (1995) reported that calves reared on a milk diet were in a continuous negative iron balance (-7.5 mg/day).

Access to roughage produces a darker veal colour. Milk fed calves have been found to be fatter (Seeward and Eichinger, 1987; Warner *et al*., 1988) and produce veal with higher drip losses (Smulders and Visser, 1987) than calves fed concentrates and roughage. However, incorporation of just a lingo-cellulosic raw material (maturex) into the milk diet did not affect growth rate and meat colour, but rather improved tenderness (Renerre *et al*., 1989). Inclusion of anabolic agents into veal calf diets improved average daily gain and interestingly had no effect on meat colour (Garssen *et al*., 1995; Renerre *et al*., 1989). Recently, Andrighetto *et al*. (1999) reported that increasing space allowance and freedom of movement to veal calves resulted in increased rate of gain, redder meat colour and improved veal calf welfare. The feeding system used in veal calf production has digestive, metabolic and muscle histochemical ramifications. Uninterrupted milk feeding keeps the oesoghageal groove open resulting in sustained rumen bypass and suppression of reticulo-rumen function and development (Ørskov, 1982). The digestive mechanism of the calf yields products akin to that of the monogastric, and subsequent post absorptive intermediary metabolic pathways followed may be accordingly affected. Such changes may have an impact on muscle metabolism and the subsequent rate of postmortem glycolysis, and hence meat quality. This study was therefore designed to study the effect of uninterrupted milk feeding on rumen development, meat quality, fatty acid distribution and muscle histochemical attributes of lambs.

Materials and Methods

Animal rearing and slaughter: A group of eighteen 5-weeks old Grey x Dutch Texel crossbred lambs comprising of 12 females and 6 males were

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Table 1: Tissue composition of the shoulder joint, organ weight and meat quality characteristics of lambs fed a milk diet or concentrate and hay diet

Parameter	Milk diet (n = 9)	Concentrate and hay diet (n = 9)	SED	Sig.
Carcass composition, by dissection (%):				
Subcutaneous fat	16.55	12.87	1.818	NS[1]
Intermuscular fat	9.83	7.03	1.346	NS[1]
Total fat	26.38	19.90	2.097	**
Lean	51.13	54.63	2.206	NS
Bone	22.50	25.48	1.963	NS
Lean/fat	2.11	2.78	0.294	*
Organ weight (g):				
Rumen + reticulum	322.8	902.3	33.99	***
Liver	699.1	931.8	64.56	**
Meat quality				
pHi	6.50	6.49	0.944	NS
pHu	5.66	5.62	0.026	NS
Cooking loss (%)	31.80	30.79	0.994	NS
Sarcomere length (um)	1.60	1.64	0.040	NS
Shear force (kg)	4.81	4.42	0.538	NS

[1]p = 0.06; NS = not significant; * = p < 0.05; ** = p< 0.01; *** = p < 0.001.

Table 2: Effect of diet on the colour of the *Longissimus dorsi* muscle

Colour parameter	Milk diet (n = 9)	Concentrate and hay diet (n = 9)	SED	Sig.
L* (lightness)	38.41	37.50	3.013	NS
a* (redness)	9.46	9.93	1.338	NS
b* (yellowness)	7.19	9.30	0.656	**
C* (metric chroma)	11.94	13.73	1.290	NS
H^0 (hue angle)	37.70	44.79	3.685	NS[1]
Reflection (525nm)	10.09	9.75	1.840	NS

[1]p = 0.07; NS = not significant; ** = p< 0.01.

randomized within each sex into 2 groups. The first group was fed reconstituted whole milk (1 part dry power to 6 parts warm water) and the second, commercial lamb pellets and hay. Both diets were offered *ad libitum* for 9 weeks. Lambs were subsequently slaughtered in a meat factory under conventional factory conditions. The reticulo-rumen and liver were collected. The reticulo-rumen was cut open, the ingesta washed out under running water and hung on a rail until it no longer dripped water. The weights of the liver and washed reticulo-rumen were noted. The initial (pHi) was measured on the 9th rib region of the *Longissimus dorsi* muscle (LD) at 45 min. post slaughter using a spear point probe (Orion 8163 Ross^{Tm} combination pH electrode) connected to a portable pH meter (Re 357 Tx Microprocessor pH meter, EDT Instruments). Carcasses were held at 1-3^{o}C until analyzed. The shoulder of each carcass was removed and physically dissected into lean, fat and bone.

Meat quality determination: Meat quality measurements were made on the 6-12 rib section of the LD. Reflectance spectra were assessed after 24 h post mortem using the Monolight Spectrophotometer Model 6800 Controller fitted with a 0/45^{o} reflectance head (Macam Photometrics, Scotland). Samples for sarcomere length determination were fixed in 5% glutaraldehyde solution (Koolmees *et al.*, 1986) and measured using the laser diffraction technique (Cross *et al.*, 1981). Ultimate pH (pHu) was assessed by measuring the pH of 1 g muscle sample homogenized in 10 ml distilled water. A sample of approximately 100 g was cooked at 80^{o}C for 60 min. and the percentage loss on cooking noted. Six cores of diameter 1.04 cm, drilled along fibre long axis, were obtained per sample and transversely sheared using the Warner-Bratzler equipment mounted on an Instron Universal Testing Machine.

Fatty acid analysis: Samples of subcutaneous fat were obtained from the midline area of the 9-12th rib section of each carcass. Fat was extracted following the method of Folch *et al.* (1957) and methylated according to method 6 of B.S. 6844 (1980). Fatty acids profiles were determined using the Varian Star 3400 Gas Chromatograph equipped with a capillary silicon based column, CP-SIL 88 (Chrompack, The Netherlands).

Table 3: Per cent fatty acid distribution at the back fat[a]

Fatty	Milk diet (n = 9)	Concentrate and hay diet (n = 9)	SED	Sig.
$C_{10:0}$ (capric acid)	0.04	0.17	0.021	***
$C_{12:0}$ (lauric acid)	1.28	0.28	0.094	***
$C_{14:0}$ (myristic acid)	6.84	3.86	0.185	***
$C_{14:1}$ (myristoleic acid)	0.42	0.28	0.020	***
$C_{15:0}$ (pentadecylic acid)	0.33	0.63	0.065	***
$C_{16:0}$ (palmitic acid)	22.60	25.43	0.509	***
$C_{16:1}$ tans (palmitelaidic acid)	0.00	0.27	0.051	***
$C_{16:1}$ cis (palmitoleic acid)	3.78	2.30	0.116	***
$C_{16:1}$ cis + trans	3.78	2.57	0.115	***
$C_{17:0}$ (margaric acid)	0.95	2.32	0.285	***
$C_{18:0}$ (stearic acid)	14.27	15.86	0.523	***
$C_{18:1}$ (oleic acid)	43.97	42.21	0.713	*
$C_{18:2}$ cis (linoleic acid)	4.56	4.97	0.258	NS
$C_{18:2}$ trans (linoelaidic acid)	0.05	0.21	0.016	***
$C_{18:2}$ cis + trans	4.61	5.18	0.253	*
$C_{18:3}$ (linolenic acid)	0.83	1.05	0.064	**
$C_{20:0}$ (arachidic acid)	0.04	0.06	0.020	NS
Totals				
Saturated fatty acids	46.40	48.72	0.869	*
Monounsaturated fatty acids	48.17	45.07	0.734	***
Polyunsaturated fatty acids	5.43	6.23	0.296	*

NS = not significant; * = $p < 0.05$; ** = $p < 0.01$; *** = $p < 0.001$. [a] Expressed as percentage of total fatty acids measured.

Statistical analysis: Treatment means were calculated for each parameter and compared for significant difference using the t test.

Results

The total dissectible fat (subcutaneous + intermuscular) was significantly higher ($P < 0.01$) in lambs reared on the milk diet than lambs reared on the concentrate and hay diet (Table 1) Per cent lean and bone contents were similar in both treatments, whereas lean to fat ratio was significantly lower ($P < 0.05$) in milk fed lambs. Lambs on the concentrate plus hay diet had significantly heavier reticulo-rumens ($P<0.001$) and livers ($P < 0.01$) than lambs on the milk diet. The papillae on the inner surface of the rumen of lambs fed concentrate and hay were clearly larger in size and darker. Differences in pHi, pHu, cooking loss, sarcomere length and shear force were not statistically significant ($P > 0.05$).

The effect of dietary treatment on lamb colour is shown in Table 2. Lambs reared on milk had significantly higher b* ($P<0.01$) than lambs on concentrate and roughage. Lambs fed the milk diet recorded slightly lower C* (metric chroma) and slightly higher L* (lightness) than lambs on the concentrate and hay diet. Differences were however not significant ($P>0.05$).

Fatty acids profiles of the back fat are presented in Table 3. Per cent contents of capric acid, $C_{10:0}$ was significantly lower ($P < 0.001$) whereas lauric acid, $C_{12:0}$ and myristic acid, $C_{14:0}$ contents were significantly higher in lambs on the milk diet than lambs on the concentrate and hay diet. Lambs reared on the concentrate and hay diet had significantly higher palmitic acid, $C_{16:0}$ ($P < 0.001$) and stearic acid, $C_{18:0}$ ($P < 0.01$) than lambs reared on the milk diet. In general, the back fat of lambs fed the milk diet was less saturated ($P < 0.05$) and contained smaller percentage of polyunsaturated fatty acids ($P < 0.05$) but more monounsaturated fatty acids ($P < 0.001$) than lambs fed concentrate and hay.

Discussion

The large difference in mean reticulo-rumen weight between lambs fed the milk diet and lambs fed the concentrate and hay diet (322.8 versus 902.3 g) was expected; and is in accordance with earlier reports (Harrison *et al.*, 1960; Smith, 1961; Church, 1976). This result once more demonstrates the fact that inclusion of concentrate and roughage in the diets of young ruminants results in faster development of the rumen. The fatter carcasses from milk feeding compared to concentrate and hay feeding is in agreement with similar studies in cattle (Seewald and Eichinger, 1987; Warner *et al.*, 1988; Pommier *et al.*, 1995). The difference in fat deposition may be due to the lower protein to calorie ratio of milk in comparison to any typical lamb concentrate.

Milk feeding did not result in significantly paler meat than concentrate and hay feeding, as was expected based on reports from cattle. Holland *et al.* (1991) reported higher concentration of iron in the liver of lambs than in calves, whilst St. Laurent and Brisson (1968) indicated a

positive relationship between liver iron concentration and blood haemoglobin status later in life. The implication is that lambs may be more tolerant of low iron diets than calves. Furthermore, the lamb being the smaller animal should consume more feed (and acquire more iron) per unit bodyweight than the calf. Thirdly, it has been found that veal calves reared on a milk diet suffered continuous negative iron balance (Pommier *et al.*, 1995) which means that faecal plus urinary iron losses exceed dietary iron intake. Consequently, and all others factors remaining the same, the deficiency of iron will exacerbate the longer animals subsist entirely on a milk diet. This suggests that if lambs were reared for a time interval longer than 14 weeks of age (as was the case in this study) significantly paler meat may result. It is well established that red fibres contain more myoglobin and cytochromes than white fibres (Lawrie, 1991) and one of the objectives of this study was to investigate whether changes in meat colour due to myoglobin content might also be reflected in changes in histochemical profile. Muscle samples for fibre type determination were frozen in liquid nitrogen and stored at -80°C. However, due to a breakdown in the freezer, ice recrystallisation in muscle samples made studies in histochemistry impossible. This aspect still requires investigation.

The proportion of $C_{12:0}$, $C_{14:0}$ and $C_{16:0}$ fatty acids of milk fed lambs were somewhat lower whilst those of $C_{18:0}$ and $C_{18:1}$ were higher in this study than the corresponding values for veal reported by Seewald and Eichinger (187). This may be due to differences in species. Fatty acid distribution of concentrate and hay fed lambs reported here are generally within the range of values reported in sheep experiments where similar diets were offered (A1-Shabibi and Juma, 1973; Johnson *et al.*,1988; Safari *et al.*,1988; Solomon *et al.*, 1990). The large differences in fatty acid distribution between lambs on the two treatments reflect differences in reticulo-rumen form and function and the composition of the diets offered each group. The type of feed offered a ruminant affects the pattern of rumen fermentation, which in turn affects the composition of fat depots (Johnson and McClure, 1972; Duncan *et al.*, 1974; Ørskov *et al.*, 1975; Casey *et al.*, 1988). In general the fatty acid profile obtained for the milk fed lambs resembled those of milk. To further elucidate these differences in fat and muscle metabolism due to milk feeding, it would be necessary to investigate the effect of age. Such studies may help in understanding the relationship between fibre type profile and meat quality.

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