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Use of agro-industrial by-products for fattening lambs: pasta factory residues. Influence on meat production and meat quality

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ABSTRACT

Thirty-four male crossbred lambs were divided at weaning (40 days) into two groups, averaging the same liveweight (13.5±0.25 kg). During the experimental period, all of the animals received one of two different types of concentrate over a period of 70 days. The control concentrate contained barley as the main source of starch, the experimental feed was prepared with pasta factory residues (PFR) partially substituting the barley. Body liveweight and average daily gain during the first five weeks of the trial were significantly higher ($P<0.01$) in the PFR group; during the second part of the experiment no significant differences were found between the two groups. The feed conversion ratio was not affected by the diet. Slaughtering data (30 kg final body weight) showed no significant differences between groups. Chemical and fatty acid compositions of *longissimus thoracis lumborum* muscle were not significantly different between control and PFR lambs. No differences in sensory traits or shear force values for *semimembranosus* muscle were detected when comparing all carcasses in each group. Considering the overall results and the availability of PFR, this by-product could be profitably included in diets for small ruminant.

KEY WORDS: lambs, nutrition, meat quality, pasta factory residues

INTRODUCTION

Use of agro-industrial by-products in small ruminant nutrition to reduce breeding costs has met with great interest in recent years. In a trial conducted by Vicenti et al. (1993) the use of almond hulls and safflower cake in fattening lambs was investigated : when fed a diet containing 10% mechanically extracted safflower cake lambs showed a higher dressing percentage at slaughtering compared to the control group; 15% almond hulls added to the diet gave as a result higher pelt and head percentages. Centoducati et al. (1994) conducted an experiment aimed at assessing the effects of diets containing different amounts of trub, a beer brewing by-product, on lamb carcass and meat quality; higher liveweight gains were observed for the control group, while a lighter colour of meat was the only effect of trub on product quality. Recently, Ragni et al. (1997) carried out a series of experiments on the effects of grape skins in lamb-meat nutrition: performance, carcass and meat characteristics of lambs fed with mixed diets made up of grape skins were satisfactory and competitive when compared with the control group.

Among other agro-industrial by-products, pasta factory residues have aroused little interest in the past, even though many farmers in southern Italy are interested in the possibility of using them as an animal feed. Including pasta factory residues in mixed feeds could reduce livestock feeding costs. In the present work, this by-product was added to the diet of a group of fattening lambs. The experimental treatment was compared to a control diet in which barley was the main cereal in the ration.

MATERIAL AND METHODS

Animals and feed

Thirty-four male crossbred lambs (Bergamasca x Comisana/Leccese) reared on the same farm were used in this trial. Lambs were divided at weaning (40 days) into two groups of 17 animals, averaging the same liveweight (13.5± 0.25 kg). Before weaning all lambs were fed a commercial concentrate with the following composition (% as fed): moisture 13.0, crude protein 17.8, crude fibre 6.0, ether extract 4.0, and ash 7.2. During the 70-day experimental period, the two groups of animals received twice daily (07.00 and 18.00 h) two different types of concentrate, formulated to be isonitrogenous and isoenergetic (Table 1): a control (C), with barley as the main source of starch, and an experimental feed (PFR) in which pasta factory residues, based on wheat meal, were used to partially substitute the barley (Table 1). The composition of PFR was as follows (% as fed): moisture 11.7, crude protein 11.4, ether extract 0.4, crude fibre 0.2, and ash 0.7. Lambs

TABLE 1

Ingredients and chemical composition of concentrates, % as fed[1]

	Concentrates	
	control	pasta factory residues
Ingredients		
barley meal	54.50	13.00
pasta factory residues	–	36.50
soyabean meal	30.00	31.00
wheat middlings	7.50	7.50
wheat straw	–	4.00
molasses	2.00	2.00
soyabean oil	1.00	1.00
dicalcium phosphate	2.50	2.50
calcium carbonate	2.00	2.00
vitamin-trace elements supplement	0.50	0.50
Chemical composition, %		
dry matter	90.25 ± 0.82	90.80 ± 1.03
crude protein	20.22 ± 0.42	20.95 ± 0.28
crude fat	2.92 ± 0.11	2.48 ± 0.39
ash	7.14 ± 0.30	7.18 ± 0.05
NDF	14.88 ± 0.32	11.67 ± 0.02
ADF	6.62 ± 1.05	6.14 ± 1.51
ADL	1.35 ± 0.82	1.38 ± 0.35

[1] chemical analysis according to AOAC, 1990

were fed the same amount of concentrate daily (300 g/10 kg liveweight). Grass hay was available *ad libitum* during the trial. All animals were slaughtered at a mean body weight of about 30 kg.

Measurements

During the trial liveweight and feed intake were measured weekly. Rumen dry matter degradability was measured in three animals per group. Triplicate samples (200 mg) of the two experimental concentrates were placed in 2 x 3 cm nylon bags (average pore size 50 μm) and inserted in the rumen through an oesophageal cannula at 48, 8 and 6 h before slaughtering. After slaughtering, bags were recovered and washed under running tap water and dried at 60°C for 48 h. Ruminal pH values were measured by placing the probe into the rumen before emptying. Rumen contents were squeezed through a double layer of cheesecloth and then frozen at -20°C for volatile fatty acid determination (AOAC, 1990). Metaphosforic acid was used to preserve samples. Carcass weight was measured at slaughtering. The value of pH in

longissimus thoracis lumborum (LTL), *semitendinosus* (St) and *semimembranosus* (Sm) muscles was measured 24 h after slaughtering by using a portable pH-meter (Hanna Instruments, HI 8424, Ingold pH-electrode T 406). Samples of LTL (between the 6th and the 7th rib) were taken from all carcasses and quickly frozen along with the right hind legs, then transferred to laboratory and stored at -20°C until analyses were performed. Chemical composition was determined in LTL samples (AOAC, 1990); to evaluate fatty acid composition, neutral lipids were extracted from meat samples (Bligh and Dyer, 1959), then methyl esters were obtained from neutral lipids (Sukhija and Palmquist, 1988) which were subjected to gas-chromatographic analysis for fatty acids using a Perkin Elmer (model 8700) gas chromatograph with a flame ionization detector and a fused silica capillary column, film thickness 0.25 μm (Supelco, 30 m x 0.25 mm i. d.). Helium was used as the carrier gas and column temperature was held at 160°C for 2 min, and then increased at a rate of 3°C/min from 160°C to a final temperature of 240°C, held for 9 min (36.6 min total time of the gas chromatographic analysis).

Seventeen samples (9 control and 8 PFR) of Sm muscles were randomly taken and tested for sensory analysis (panel test) and shear force. Four carcasses from the control group were light carcasses and five heavy (under or over 13 kg, respectively); three PFR carcasses were light and five heavy. The frozen legs were thawed for 48 h at 4°C at our laboratory and cooked in an electric oven at a temperature of 160°C until 75°C were reached in the inner part. A thermocouples probe was put in the center of the Sm muscle to monitor the temperature. Immediately after cooking, samples of Sm muscle were taken for sensory analysis and shear force measurement. For the sensory characteristics, cubes (1.27 x 1.27 x 1.9 cm) were cut and served on pre-heated trays to maintain the samples at about 50°C (Cross et al., 1978). At each session, six trained panelists evaluated 2 or 3 samples on the basis of a 9-cm line scale by placing a mark on the line to indicate their score for the following attributes: juiciness, tenderness and lamb flavour. Scores were recorded in cm and had a possible range from 0 (very dry, very tough, low intensity, respectively) to 9 (very juicy, very tender, high intensity, respectively). Shear force was determined in cylindrical samples (diameter of 12.5 mm) of Sm muscle by using an Instron 1011 with a Warner-Bratzler device according to Trevisani (1993). Results of the panel test and shear force measurement were evaluated considering the two different diets and the weight of carcasses; those of the panel test were evaluated also considering the day when the session took place (direct comparison between control and PFR carcasses within the same weight class).

All data were subjected to ANOVA using the GLM procedure of SAS (SAS, 1996) and results were expressed as least squares means.

RESULTS AND DISCUSSION

Rumen dry matter degradability of C and PFR concentrates at 6 h (76.1 ± 9.3 vs 69.8 ± 8.5), 8 h (81.1 ± 4.4 vs 76.2 ± 14.0), and 48 h (92.0 ± 4.5 vs 97.0 ± 1.4) of incubation was not statistically different. Both samples of concentrates showed a degradability pattern similar to the one observed for starch (Michalet-Doreau and Sauvant, 1989). Volatile fatty acids and pH of rumen contents were also similar between samples (Table 2). Acetic, propionic, and butyric acid, as well as total volatile fatty acid production, were negatively correlated ($P < 0.001$) to rumen pH. The acetate : propionate ratio was not affected by the relatively high proportion of concentrate in the diet (64-66% of total dry matter intake). Overall feed intake throughout the trial was 86.3 ± 17.3 and 81.5 ± 17.2 g DM/kg metabolic weight (MW) for C and PFR groups, respectively. Hay intake increased from week 1 (12 g DM/kg MW for both groups) to week 7 (40 g and 44 g DM/kg MW for PFR and C groups, respectively) and then remained consistent until the end of the trial. Concentrate intake progressively increased throughout the trial (for PFR and C groups, respectively: 47 and 53 g DM/kg MW at week 1 and 75 and 71 g DM/kg MW at week 10). This could be partially explained by the high substitution rate of concentrate (Ørskov, 1986) and the local climate conditions (high values of temperature and relative humidity).

TABLE 2

Volatile fatty acids (mM/ml) and pH value of rumen contents, mean±s.e.

	Diet	
Fatty acid	control	PFR
$C_{2:0}$	0.0584 ± 0.0053	0.0626 ± 0.0051
$C_{3:0}$	0.0240 ± 0.0016	0.0255 ± 0.0015
$C_{4:0}$	0.0136 ± 0.0017	0.0141 ± 0.0016
$C_{5:0}$	0.0027 ± 0.0003	0.0033 ± 0.0003
$\Sigma (C_{2:0}\text{-}C_{5:0})$	0.0988 ± 0.0082	0.1054 ± 0.0079
pH	6.22 ± 0.10	6.08 ± 0.10

Body liveweight and average daily gain during the first five weeks of the trial were significantly higher for the PFR group (Table 3). However, during the second part of the experiment, no significant differences were found between the two groups. The feed conversion ratio was not affected by diet: it decreased from 2.7 (first 3 weeks) to 4.5-5.5 during the last part of the experiment for both groups. These results confirm previous findings by Muscio et al. (1994) with Wurttemberg x Ile de France x Gentile di Puglia crosses and by Lanza et al. (1983) with Barbaresca x Comisana crosses slaughtered at 100 and 130 days of age, respectively. Overall performance observed in this trial demonstrates the superiority of crosses

TABLE 3

Weekly body weight (kg) and average daily gain (g) of lambs, mean±s.e.

	Diet		
	control	PFR	significance
Weekly body weight, week			
1	15.14 ± 0.26	16.51 ± 0.25	***
2	17.09 ± 0.28	17.50 ± 0.27	n.s.
3	18.44 ± 0.37	19.22 ± 0.36	n.s.
4	19.96 ± 0.40	21.68 ± 0.39	**
5	20.84 ± 0.53	21.56 ± 0.51	n.s.
6	22.34 ± 0.57	23.44 ± 0.56	n.s.
7	24.44 ± 0.68	24.67 ± 0.64	n.s.
8	27.08 ± 0.78	27.57 ± 0.73	n.s.
9	28.57 ± 0.77	28.97 ± 0.72	n.s.
10	30.00 ± 0.82	29.99 ± 0.77	n.s.
Average daily gain:			
week 1-5	144.30±11.4	193.60±11.0	**
week 5-10	254.16±14.7	233.26±13.8	n.s.

significance: ***: P<0.001; **: P<0.01; n.s.: not significant

when compared with pure Comisana and Leccese lambs, which are considered milk type breeds (Vicenti et al., 1989). Nevertheless, the data indicate that caution should be used in fattening this type of cross beyond 95-100 days of age because of the high feed conversion ratio and the low average daily gain.

Slaughter data showed no significant differences between groups. Final body weight was 30.0±0.8 and 29.9±0.8 kg and carcass weight was 13.3±0.4 and 13.2±0.4 kg for the C and PFR groups, respectively. The pH values were in the range of normal values and comparable between C and PFR treatment in LTL (5.57±0.04 vs 5.61±0.04), St (5.65±0.05 vs 5.65 ± 0.04) and Sm (5.51±0.02 vs 5.50±0.02) muscles. Our results were similar to those obtained in other experiments conducted in the past (Chrystall and Hagyard, 1976; Petersen and Blackmore, 1982; Severini et al., 1990). Chemical and fatty acid compositions of the LTL muscle are shown in Table 4. Chemical composition was similar to that obtained with lambs slaughtered at the same age and fed agro-industrial by-products (Marsico et al., 1994; Severini et al., 1994). As for fatty acid composition, data did not show significant differences between C and PFR lambs and were comparable to those obtained by Solomon et al. (1990). Thus, the quality of meat and fat was on a good standard level.

Results of sensory analysis and shear force measurements according with the two different diets are given in Table 5. No significant differences in sensory characteristics and shear force were detected between the control and PFR groups. Little differences in sensory traits were observed only when light and heavy car-

TABLE 4

Chemical composition (%) and fatty acids composition (g/100 g total fatty acids) of intramuscular fat of muscle *longissimus thorcis lumborum*, mean=s.e.

	Diet	
	control	PFR
Dry matter	23.74 ± 0.21	24.25 ± 0.11
Crude protein	19.20 ± 0.19	20.18 ± 0.17
Crude fat	2.51 ± 0.16	2.73 ± 0.14
Ash	1.12 ± 0.01	1.12 ± 0.01
$C_{14:0}$	3.05 ± 0.32	3.61 ± 0.30
$C_{16:0}$	24.37 ± 0.66	25.29 ± 0.62
$C_{16:1}$	1.45 ± 0.10	1.43 ± 0.09
$C_{18:0}$	22.26 ± 2.26	21.60 ± 2.15
$C_{18:1}$	37.10 ± 0.90	35.74 ± 0.85
$C_{18:2}$	10.78 ± 1.47	11.22 ± 1.40
$C_{18:3}$	0.99 ± 0.10	1.10 ± 0.09
SFA	49.70 ± 1.83	50.50 ± 1.74
UFA	50.32 ± 1.83	49.50 ± 1.74
MUFA	38.55 ± 0.98	37.18 ± 0.93
PUFA	11.77 ± 1.55	12.32 ± 1.48

TABLE 5

Sensory traits and shear force value of Sm muscle, mean ± s.e.

	Diet		
	control	PFR	significance
All carcasses (no=17)	n=9	n=8	
juiciness	4.98 ± 0.19	4.83 ± 0.18	n.s.
tenderness	5.45 ± 0.20	5.03 ± 0.19	n.s
flavour	3.74 ± 0.17	3.70 ± 0.17	n.s.
shear force (N)	48.96 ± 4.10	40.63 ± 3.71	n.s.
Light carcasses (no=7)	n = 4	n = 3	
juiciness	5.58 ± 0.30	4.17 ± 0.30	**
tenderness	6.17 ± 0.31	4.25 ± 0.30	***
flavour	3.85 ± 0.22	3.62 ± 0.22	n.s.
shear force (N)	42.97 ± 4.35	39.38 ±1.90	n.s.
Heavy carcasses (no=10)	n = 5	n = 5	
juiciness	4.77 ± 0.27	5.03 ± 0.23	n.s.
tenderness	4.97 ± 0.27	5.43 ± 0.23	n.s.
flavour	3.80 ± 0.29	3.79 ± 0.25	n.s.
shear force (N)	54.95 ± 6.04	41.39 ± 6.13	n.s.

significance: **: P<0.01; ***: P<0.001; n.s.: not significant

cases were separately considered. However, as the number of carcasses in each group was small, these results only indicate trends upon which further experiments can be based. Mean values of juiciness and tenderness of Sm muscles of light carcasses (< 13 kg) were higher in the control group than in the PFR group (Table 5). Direct comparison was possible only in two panel sessions. In one session control carcasses showed higher values of juiciness, tenderness and flavour, but only tenderness was higher in the other session. On the other hand, no significant differences were detected in the value of shear force between all light carcasses of the two groups. No significant differences in sensory characteristics and shear force were detected between Sm muscles of heavy carcasses (> 13 kg) of the two groups (Table 5). However, direct comparison in the panel test showed that values of juiciness, tenderness and flavour in the heavy carcasses of the PFR group were slightly higher than in control carcasses, in three of four sessions.

CONCLUSIONS

Our data point to the possibility of including pasta factory residues in a diet for fattening lambs. No significant effects on animal performance, carcass quality or meat composition were found. The results of panel tests showed that the Sm muscle from PFR light carcasses had a slightly lower quality than control carcasses, but such a difference was not detected in heavy carcasses and the panelists expressed even a moderate preference for PFR carcasses. No significant differences in sensory traits or shear force value between the control and PFR groups were detected when comparing all carcasses in each group. Furthermore, no differences in shear force value were observed when evaluating light and heavy carcasses separately.

Therefore, on the basis of our overall results and considering the availability and the low price of this by-product, pasta factory residues could be an interesting choice for farmers to reduce feeding costs in small ruminant breeding.

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STRESZCZENIE

Zastosowanie rolno-przemysłowych produktów ubocznych w tuczu jagniąt: odpady przy produkcji makaronu. Wpływ na produkcję i jakość mięsa

Trzydzieści cztery jagnięta-tryczki podzielono przy odsadzeniu (40 dni) na 2 grupy, o podobnej masie ciała (13,5 ± 0,25 kg). W ciągu doświadczenia, przez 70 dni, wszystkie zwierzęta otrzymywa-

ły jedną z dwóch różnych rodzajów paszy treściwej. Kontrolna pasza treściwa zawierała jęczmień jako główne źródło skrobi. Pasza doświadczalna była przygotowana z odpadów przemysłowych przy produkcji makronu (PFR), którymi częściowo zastąpiono jęczmień. W pierwszych pięciu tygodniach doświadczenia masa ciała i średnie dzienne przyrosty były istotnie większe ($P<0,01$) u jagniąt z grupy PFR niż kontrolnych; w dalszej części doświadczenia nie stwierdzono istotnych różnic między grupami. Rodzaj dawki nie miał wpływu na wykorzystanie paszy. Nie stwierdzono także różnic między grupami w wynikach ubojowych (30 kg waga końcowa). Skład chemiczny i skład kwasów tłuszczowych mięśnia *longissimus thoracis lumborum*, a także właściwości sensoryczne oznaczone w mięśniu *semimembranosus* oraz siła łamania kości nie różniły się między porównywanymi grupami.

Na podstawie otrzymanych wyników można sądzić, że PFR może być wartościowym składnikiem dawki dla małych przeżuwaczy.