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Effect of barley grain genotype and processing on lamb performance in Morocco†

B. Boulanouar*, O. Tarzouti* and A. Sahnoun**
*Researchers in Animal Production, INRA,
P.O. Box 6570, Rabat, Morocco
**Livestock Office, Ministry of Agriculture, Rabat, Morocco

SUMMARY - This study was conducted to investigate differences in the feeding value of barley grain due to genotype and processing when fed in a barley grain based diet to lambs. One local landrace (a six-row type) and two improved cultivars (a two row- and a six-row type) were either, cracked, rolled or left whole to make up nine possible dietary combinations in a 3 x 3 factorial design. Barley grain was fed along with sunflower cake, a commercial concentrate and a mineral vitamin pre-mix. Data did not show a significant difference in animal performance and carcass merits due to barley genotype and processing. Regarding *in vivo* DM digestibility of the ration, processing had a significant effect only on ACSAD 60 (a two-row improved cultivar) and the local landrace. In ACSAD 60, cracking gave the highest DM digestibility of the diet. With the local landrace, both processing types outperformed the whole grain. Diet digestibility with Laanaceur (a six-row improved cultivar) was not affected by processing. The results indicate that the barley breeding programme conducted at INRA for higher producing varieties does not necessarily compromise grain feeding value for animals. We can also infer from the results that grain processing, with the associated energy cost, is not necessary prior to sheep feeding.

Key words: Sheep, barley, genotype, processing, carcass.

RESUME - *Effet du génotype de l'orge grain et du traitement mécanique sur les performances d'agneaux au Maroc". Cette expérimentation a été menée pour étudier les différences de la valeur alimentaire de l'orge grain dues au génotype et au traitement mécanique dans des rations offertes à des agneaux. Pour cela, 3 génotypes - une population locale (Rabat 071 : 6 rangs), deux variétés améliorées (ACSAD 60 : 2 rangs et Laanaceur : 6 rangs) - et 3 formes de grain - concassage, aplatissage et grain entier - ont été arrangés dans un 3 x 3 dispositif expérimental factoriel. Les rations ont été composées d'orge grain, de tourteau de tournesol, d'un aliment composé commercial et d'un complément minéral et vitaminé. L'eau et la paille de blé étaient disponibles à volonté. Les résultats n'ont pas montré de différences significatives dans les performances et la qualité de la carcasse dues au génotype et au traitement du grain. La digestibilité* in vivo *des rations a été significativement affectée par le traitement dans le cas d'ACSAD 60 et de la population locale, alors que ce paramètre a été indifférent au traitement quand la ration a été à base de Laanaceur. En conclusion, les résultats ont montré que le programme d'amélioration génétique conduit par l'INRA pour produire des variétés plus productives peut se faire sans compromettre la valeur alimentaire de ces variétés. Par ailleurs, cette expérimentation a montré que le traitement mécanique de l'orge grain n'a pas eu d'effet positif sur la valeur alimentaire quand il était destiné aux ovins.*

Mots-clés : *Ovin, orge, génotype, traitement, carcasse.*

Introduction

Starch utilization may be markedly enhanced by proper grain processing. Aside from particle size reduction, processing alters starch structure and thus improves its availability to both ruminal microbial and pancreatic enzymes. Processing is also believed to shift the site of starch digestion from the intestines to the rumen with concomitant increases in percentage digested in both sites while decreasing fermentation loses in the *ceacum* and large intestine (Theurer, 1986). Hale (1973)

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hypothesized from histological studies that disrupting the matrix between starch and protein may be essential in improving digestion of processed grain.

The extent of improvement in utilization is primarily dependent upon the ruminant species, grain source and method of processing. Grain processing has less impact on starch digestion in sheep and goats than in cattle (Hale, 1973; Orskov, 1976). Also the magnitude of improvement is inverse to the starch digestion values for non-processed grains (i.e., utilization of sorghum grain starch is improved most by processing, and then corn, with little improvement in barley starch digestion). This undoubtedly relates to inherent differences among these grains in starch and protein digestibility. Apparent digestibility of both starch and protein are lowest for sorghum, followed by corn and then barley (Theurer, 1986).

There is a great deal of variability among barley because of cultivar, geographical location, growing conditions, and year. Ovenell *et al.* (1993b) compared different spring and winter cultivars fed to steers and showed that there were variations in animal performance, carcass characteristics, and diet digestibility among cultivars. The authors concluded that fiber digestibility, methane production, and ME content are three of the most important factors contributing to cultivar variability and subsequent feeding value for ruminants. The authors indicated that upon review of the literature, it appears that differences in feeding value among barley varieties for ruminants are not as pronounced as in non-ruminants but are still economically important. In these experiments barley grain was fed at high levels (i.e., 83% DM of the diet). Ovenell *et al.* (1993) found also variations in cultivar feeding value in sheep, with nitrogen digestibility and metabolism contributing to these differences. The changes in results from year to year made prediction of cultivar feeding value challenging.

In Morocco, different types of barley grain processing (namely cracking, dry rolling and to a lesser extent grinding) are suggested to farmers in order to improve their feeding efficiency in ruminants. However the benefit, if there is any, from these processing methods over the grain fed whole is not quantified.

When asked about possible differences in grain feeding value due to genotype, many livestock owners declare their preference of the local genotypes as compared to improved varieties (personal observation). This negative assessment has hindered the adoption of these new released cultivars with high production level. Farmers reasoning behind such distinction is based on empirical observation of higher proportion of intact grain in the feces of animals fed improved varieties. Other times farmers rational seems to be rather unclear and, at times, subjective.

Objectives

Based on lamb performance data, the current study intends to test differences in barley grain feeding to sheep due to grain processing and/or grain genotype.

Working hypothesis

The barley genetic improvement program does not necessarily compromise grain feeding value; and there is no benefit from mechanical processing of barley grain when fed to sheep.

Materials and methods

Animals

Fifty four Sardi fall-born lambs were used in a 60-day growth/fattening trial. At the onset of the experiment, lambs were 8 to 10 months old and weighed between 25 and 30 kg. Lambs were stratified by weight and assigned to nine groups of 6 lambs each. Each group received one of nine diets in a completely randomized design.

Diets

All diets consisted of a concentrate composed of barley grain, sunflower cake and a sheep mineral-vitamin premix. An additional 200 g head^{-1} of commercial concentrate was added at the end of each day during the whole period of the trial. Wheat straw and water were offered *ad libitum* (Table 1). To make up the nine possible dietary treatments (3 x 3 factorial), two improved barley varieties and a landrace (Table 2), were either left whole, dry rolled or cracked. Within a dietary treatment, animals were group-fed with enough bunk space to avoid competition for feed.

During a five-day adaptation period the barley based concentrate was offered at 500 g head^{-1} day^{-1} to insure animal adjustment after which a 700 g feed allowance was offered. As the animals adjusted, the daily barley based concentrate allowance was adjusted upwards to 800 g head^{-1} three weeks after the trial was started.

Table 1. Diet composition and feed allowance

Ingredients	Dry matter (%)	Feed allowance (g head^{-1} day^{-1})
Concentrate		
Barley grain	70	500 during adaptation
Sunflower cake	28	700 during first 3 weeks
Sheep min-vit premix†	2	*800 thereafter*
Commercial concentrate††		200
Wheat straw		*Ad libitum*

†12% P, 18% Ca, 2% Mg, 1% S, 0.003% Co, 0.26% Fe, 0.0075% I, 0.375% Mn, 0.001% Se; and 750 IU A, 400 IU D_3, 1 IU E per g of the mix
††11% CP, 1.5% fatty substances, 0.7 FU per kg, Ca 1.00%, P 0.4%, 300,000 UI A and 40,000 UI D_3 per 100 kg

Table 2. Characteristics of the genotypes studied

Characteristics	Varieties		
	ACSAD 60	Laanaceur	Rabat 071 (Local landrace)
Type	2 rows	6 rows	6 rows
Release year	1984 (ACSAD/ INRA-Morocco)	1991 (INRA-Morocco)	1956 (INRA-Morocco)
Adaptation zone	Arid and semi-arid zones	Arid and semi-arid zones	Mountain
Growing cycle	Medium	Long	Very long
Straw length	Short	Long	Very long
Productivity	Good	Very good	Low

Measurements

A-three consecutive days liveweight was obtained at the beginning and at the end of the growth trial and bi-weekly liveweight throughout the trial. Average daily gain was then calculated for each dietary treatment.

For the animals receiving whole grain diets, undigested grain was isolated and weighed in a-300 g of the composite fecal sample collected during the *in vivo* trial. This parameter was considered as an estimate for hardness of different barley genotypes. The quantity of intact grain as a percent of the quantity of grain ingested was then calculated for each variety.

At the end of the growth trial an *in vivo* digestibility trial was conducted on two animals per dietary group. Animals were fed individually to a restricted level to avoid orts (800 g of the concentrate and 500 g of straw). Animals were adjusted to fecal collection bags for four days and actual collection lasted five days. Daily fecal output was weighed and a composite subsample was gathered for each animal at the end of the 5-day collection to determine an average DM content of the feces. Daily subsamples of the ration and straw were taken and combined within animal to determine the DM content of the ration. Dry matter *in vivo* digestibility of the ration was then computed.

Additionally, rations were analysed for total nitrogen in order to determine the crude protein intake. The three varieties were analysed for crude protein, neutral detergent fiber (NDF) and acid detergent fiber (ADF) content in order to characterize possible differences between them.

In order to assess the effect of dietary treatment on carcass quality, two lambs per group were slaughtered at the end of the trial and the following carcass characteristics were measured: (i) hot carcass weight; (ii) weight of full and empty gastrointestinal tract; (iii) mesenteric fat weight; (iv) internal fat score (1 to 5 scale); (v) external fat score (1 to 5 scale); (vi) carcass conformation score (1 to 5 scale); and (vii) carcass yield.

In order to compare the energy consumption associated with each type of grain processing, the time necessary to process a 100 kg of grain with the roller and the grinder was recorded.

Statistical analysis

The experiment was a 3 x 3 factorial laid out in a completely randomized design. Animals within dietary treatment were considered as replications. All data was subjected to an analysis of variance using GLM in SAS. The model tested for variety and processing method main effects and their interactions.

Results

Lamb performance

The results showed that there was no effect of grain genotype (P=0.4) and processing (P=0.08) on lamb performance. Likewise, no significant interaction between grain genotype and processing on lamb performance was noted. Although not significant, the trend in the data showed that processing may be associated with some reduction in animal performance. Generally speaking, Laanaceur tended to have the highest performance, whereas ACSAD 60 and the landrace were similar (Table 3).

These results are opposite to those of Ovenell *et al.* (1993a,b) and Overnell *et al.* (1993) working with steers and sheep, respectively. These authors found differences in animal performance due to barley genotype. This may be due to the fact that they used steers Ovenell *et al.* (1993a,b) and that they fed high level of barley in the diet with sheep (83% DM). Ovenell *et al.* (1993) attributed the differences in sheep performance to differences in nitrogen digestion and metabolism among cultivars. Boss and Bowman (1996a) reported that steers fed a two-row malting barley at 80% DM of the diet, had greater average daily gain, carcass quality grade and intake of digestible starch than did steers fed two-row feed type barleys. The same authors in a concomitant study (Boss and Bowman, 1996b) indicated that the examined varieties did not differ in the amount or site of starch digestion when used in high-concentrate diets for beef steers. However, differences were seen between barley varieties in nitrogen digestion. Efficiency of microbial growth was greater for steers fed a two-row malting variety than for those fed a two-row feed variety.

Table 3. Lambs average daily gain (g day^{-1})

Processing method	Varieties			
	ACSAD 60	Laanaceur	Local	Mean (SEM)[†]
Cracking	138	167	168	157 (10)
Dry rolling	179	208	157	181 (10)
Whole	196	185	184	188 (10)
Mean (SEM)	171 (10)	187 (10)	169 (10)	

[†]SEM: Standard error of the mean

Several workers (Morisson, 1956; Orskov *et al.,* 1974a; Hadjipanayioutou and Georphiades, 1985; Economides *et al.,* 1989; Economides *et al.,* 1990) reported that any processing of cereal grains given to sheep is likely to be of no value, and suggested that barley should be fed whole to adult sheep. Moreover, the feeding of whole cereal grains prevented the development of rumenitis (Orskov, 1973) and soft fat syndrome (Orskov *et al.,* 1974b), and altered rumen fermentation pattern in lambs (Orskov *et al.,* 1974b) and increased milk fat content and yield in ewes and goats (Economides *et al.,* 1989).

Data compiled by Theurer (1986) showed that in sheep, only small increases in total and ruminal starch utilization were observed by rolling or flaking as compared to feeding the whole grain. This minimal impact of processing may be expected because total tract digestibilities for non processed grains averaged several percent units higher for sheep than cattle (96 *vs* 91%) and average percentage of starch escaping ruminal fermentation in sheep is markedly lower than that for cattle (11 *vs* 30) (Theurer, 1986).

Diet *in vivo* DM digestibility

This parameter was affected by processing type (P<0.0001) but not by grain genotype (P=0.17). Moreover there was a significant interaction between these two factors (P<0.01). An analysis of variance by genotype indicated that processing had a significant effect only on ACSAD 60 (P<0.001) and the local landrace (P<0.001). In ACSAD 60, cracking gave the highest DM digestibility of the diet (65, 58 and 55 for ground, rolled and whole grain, respectively). With the local landrace, both processing types outperformed the whole grain (Table 4). Diet digestibility with Laanaceur was not affected by processing (P=0.72). The reason why animal performance did not reflect these differences in digestibility remains unanswered.

Table 4. *In vivo* dry matter digestibility of the diet (% DM)

Processing method	Varieties		
	ACSAD 60	Laanaceur	Rabat 071
Cracking	65.3^a	60.0^a	59.0^a
Dry rolling	58.5^b	60.5^a	62.1^a
Whole	55.3^b	58.7^a	51.7^b
Mean (LSD)[†]	59.7 (4.5)	59.7 (4.5)	57.6 (4.6)

[†]LSD: Least significant difference
a,b: Means within the same column followed by different superscripts differ at P<0.05

Chemical characteristics of the diet and varieties

The barley grain based concentrate averaged 18, 21, and 19% CP (DM basis), for the Local, Laanaceur and ACSAD 60, respectively. Crude protein content was 9.4, 13.6 and 8.2% DM in the local, Laanaceur and ACSAD 60, respectively. ADF content was highest in improved varieties 11.7 and 10.8% DM, respectively in Laanaceur and ACSAD 60, whereas the local landrace had only 7.2% DM. Likewise, NDF concentration was lowest in local landrace (20% DM) and highest in the improved cultivars (30 and 28% DM in Laanaceur and ACSAD 60, respectively). The straw used contained 3.5% CP, 75% NDF and 46% ADF on a dry matter basis. The commercial concentrate had 13.2% CP (DM basis). McCann (1985) and Hajjaji (1995) reported that barley grain composition differed among regions in Morocco. However both authors did not give information on what varieties and under what cultural practices these samples were grown. The values in these samples varied from 9 to 13.7% CP and from 7.1 to 8.6% ADF. Hajjaji (1995) studied the chemical composition of the grain in 14 barley varieties (Table 5). Differences in the results reported from one study to another could be due to differences in the climate during the cropping season and the location from which the sample was collected with which the varieties interact to express different grain composition.

Table 5. Chemical composition of the varieties studied

Varieties	Hajjaji (1995)			Present study		
	CP	ADF	Starch	CP	NDF	ADF
ACSAD 60	15.7	5.0	62.8	10.8	28	10.8
Laanaceur	10.5	7.1	62.8	13.6	30	11.7
Rabat 071	15.9	6.4	59.4	9.4	20	7.2

Carcass characteristics

Neither the genotype nor the processing did affect carcass characteristics and carcass yield (Table 6). These results should be considered with caution since only two animals per treatment were slaughtered.

Undigested grain

Although no statistical analysis was run on this parameter, the data show that Laanaceur had the least grain recovery rate in the feces compared to the other varieties (Table 7). The local landrace had an intermediate value. Apparently theses differences are not big enough to create differences in animal performance. Grain hardness is only one aspect of the feeding value. Other parameters such as (protein and starch contents and their digestibility, amino acid profile of the protein, may cause differences in animal performance) (Ovenell *et al.,* 1993a,b; Ovenell *et al.,* 1993).

Energy cost of grain processing

Both the roller and the grinder had a power of 7.5 HP and it took 14 and 8 min to roll and grind 100 kg of grain, respectively (regardless of variety). Therefore the energy cost of rolling was 75% higher than in grinding.

Implications

This work showed that variety and processing did not affect lamb performance when fed 700-800 g daily (40% of the diet) of barley. In this regard one might speculate that possible differences may be revealed at higher level of barley incorporation in the diet.

Table 6. Carcass characteristics and carcass yield

Variety/treatment	Live-weight at slaughter	Hot carcass weight	Empty gastro-intestinal tract	Mesenteric fat weight	Internal fat score	External fat score	Conformation score	Carcass yield (%)
Genotype								
ACSAD 60	48.5	22.6	3.21	0.649	3.05	4.00	3.89	47
Laanaceur	48.7	23.9	3.11	0.575	3.32	4.03	4.55	49
Rabat 071	48.6	23.3	3.18	0.616	2.96	4.01	3.85	48
SEM†	0.35	0.62	0.08	0.060	0.17	0.17	0.24	1
Processing method								
Cracking	48.9	23.4	3.10	0.658	3.09	3.91	3.98	48
Rolling	48.5	22.5	3.29	0.516	3.05	4.03	3.89	46
Whole	48.5	23.9	3.12	0.667	3.19	4.10	4.41	49
SEM	0.4	0.7	0.10	0.067	0.19	0.19	0.27	1

†SEM: Standard error of the mean

Table 7. Undigested grain in the feces when barley is fed whole as a % of the quantity of grain fed†

Variety	Weight of intact grain recovered in the feces day^{-1}	Weight of grain fed (g day^{-1})	Grain undigested w/w (%)
ACSAD 60	60	560	10.8
Laanaceur	14	560	2.6
Rabat 071	37	560	6.7

†No statistical analysis was run on this parameter

Therefore, the barley breeding program for higher producing varieties does not necessarily compromise grain feeding value for animals. However this statement has to be assessed in light of the effect of breeding on straw yield and quality.

We can also infer from the results that no processing, with the associated energy cost, is necessary prior to barley grain feeding to sheep.

Last but not least, sheep is probably not the appropriate experimental model to test varietal and processing differences in barley grain. It could be hypothesized that the use of cattle as the experimental animal may have helped detecting differences.

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