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Alternative legume seeds and lamb meat quality

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SUMMARY – Barbaresca male lambs were divided, after weaning, into four different trials to test the use of alternative legume seeds (faba bean, peas, chickpeas) in the diets. Growth and slaughter performances and meat quality on *longissimus dorsi* were assessed. Faba bean in total replacement of soybean meal and cereal grains enhanced hind leg bone proportion but improved meat sensory characteristics as compared to soybean diet. Faba bean associated to carob and orange pulps produced paler meat but reduced the intensity of all meat sensory attributes. Peas diets increased meat drip losses compared to soybean diet. The diet with partial replacement of soybean meal and maize by chickpeas (C20) tended to improve average daily gain and final weight compared to total replacement (C42) and to soybean diet (SBM). Lean/bone ratio resulted higher in hind leg from lambs fed chickpea diets than in those fed soybean meal diet. Diet with the higher level of chickpea inclusion significantly enhanced C12:0, C18:2 *trans* C18:3 n-6, C18:2 CLA, C22:5 n-3 and the total n-3 series proportions in meat as compared to soybean diet. The proportion of C18:1 *trans* vaccenic acid was higher in C42 and SBM groups than in C20.

Keywords: Alternative legume seeds, lamb, fattening, meat quality.

RESUME – *"Les graines de légumineuses alternatives et la qualité de la viande d'agneau". Des agneaux mâles de race Barbaresca ont été divisés, après le sevrage, en quatre essais différents pour tester l'utilisation de graines de légumineuses (fèves, pois, pois chiches) comme régime alternatif. On a évalué les performances de croissance et à l'abattage et la qualité de la viande sur le* longissimus dorsi*. Les fèves en remplacement total de la farine de soja et des graines de céréales augmentaient la proportion d'os dans la jambe arrière mais amélioraient les caractéristiques sensorielles de la viande par rapport au régime à base de soja. Les fèves associées à de la pulpe de caroubes et d'oranges produisaient une viande plus pâle mais réduisaient l'intensité de tous les attributs sensoriels de la viande. Le régime à base de pois augmentait les pertes exudatives de la viande par rapport au régime de soja. Le régime substituant partiellement la farine de soja et de maïs par les pois chiches (C20) tendait à améliorer le GMQ et le poids final comparé au remplacement total (C42) et au régime de soja (SBM). Le rapport viande maigre/os était supérieur dans la jambe arrière des agneaux recevant les régimes de pois chiches par rapport à ceux recevant le régime de farine de soja. Le régime ayant la plus forte incorporation de pois chiches augmentait significativement C12:0, C18:2 trans, C18:3 n-6, C18:2 CLA, C22:5 n-3 et les proportions totales des séries n-3 dans la viande comparé au régime de soja. La proportion d'acide vaccénique C18:1 trans était supérieure dans les groupes C42 et SBM par rapport à C20.*

Mots-clés : *Graines de légumineuses alternatives, agneau, engraissement, qualité de la viande.*

Introduction

The restriction to the use of animal protein (BSE-problem) in last years increased attention toward vegetable protein sources in animal diets. Among vegetable protein sources soybean meal (SBM) is the favourite because its high nutritional value depending on its protein level compared to other vegetable protein sources. However, SBM is largely diffused around the world as genetically modified organism (GMO).

A part of European consumers is predisposed against GM feedstuffs and favourably towards "organic" foods (Christodoulou *et al*., 2005). Consequently numerous studies in animal nutrition are, actually, addressed to the replacement of GMO feedstuffs with alternative and "organic" protein and energy sources. Then, a great attention was focussed toward alternative home-grown legume seeds for their adequate nutritional value, depending on high protein (19-35% CP on as DM basis) and starch contents (over 40% DM), despite a presence of anti-nutritional factors which could be inactivated by heat treatments (Yu *et al*., 2002).

Moreover, legume crops have a positive ecological role when rotated with cereal grains to reduce soil nitrogen depletion and breaking the pest and disease cycles (Caballero, 1999).

Literature showed that the use of alternative legume seeds in lamb diets did not negatively affect growth and slaughter performances (Purroy *et al*., 1993; Hadjipanayiotou, 2002; Antongiovanni *et al*., 2002).

In this paper there are reported the main results of four experiments concerning the use of different legume seeds, as main protein and energy sources alternative to soybean meal and cereal grains, in lamb diets and the relative effects on growth, slaughter performances and meat quality.

Materials and methods

After weaning (age: 46-60 days), Barbaresca entire male lambs were involved in four fattening trials. The number of animals involved were 18 (1^{st} trial), 14 (2^{nd} trial), 30 (3^{rd} trial) and 27 (4^{th} trial). In each trial the lambs were divided into two or three groups homogenous for number and live weight and allotted into collective boxes.

Diets were designed to assess the use of alternative legume seeds (faba beans, peas and chickpeas) as protein and energy sources in partial or total replacement of soybean meal and cereal grains and were completely pelleted or finely ground and supplied *ad libitum*.

In trial 1, faba bean (*Vicia faba* var. *minor*) totally replaced soybean meal and cereals (Lanza *et al*., 1999). In trial 2, faba bean was associated to two local feedstuffs such as carob pulp and orange pulp (Lanza *et al*., 2001). In trial 3, peas (*Pisum sativum*) partially (P18) and totally (P39) replaced soybean meal and barley (Lanza *et al*., 2003a). In trial 4, chickpeas (*Cicer arietinum*) was used in partial (C20) or total (C42) replacement of soybean meal and maize (Lanza *et al*., 2003b; Priolo *et al*., 2003). Ingredients and chemical composition of diets are reported on Table 1.

Dietary crude protein, ether extract and ash were assessed according to AOAC (1995). Fibre fractions were measured according to Goering and Van Soest (1970). Soluble protein, non protein nitrogen, NDIN (neutral detergent insoluble nitrogen) and ADIN (acid detergent insoluble nitrogen) were assessed according to procedure described by Licitra *et al*. (1996).

Slaughter ages were 101 (trial 1), 120 (trial 2), 103 (trial 3) and 132 (trial 4) days. Final weight ranged between 25-35 kg. Animals were weekly weighed to calculate average daily gain and feed intake was measured to calculate conversion ratio. At slaughter, carcasses were weighed and classified for fatness according to 15-point scale according to Dransfield *et al*. (1990), afterwhat they were chilled at 4°C.

At 24 h *post mortem* meat ultimate pH was measured in the *longissimus dorsi* by a pHmeter with a penetrating glass electrode. Carcasses were subjected to different ageing time at 4°C (72-96 hours) afterwhat they were divided into two sides and from the right side hind leg were separated to measure lean, fat and bone proportions. *Longissimus dorsi* muscles was removed to assess color CIEL*a*b*, drip, cooking losses and shear force.

Meat chemical analyses were performed according to AOAC (1995). Concerning the trial 4, intramuscular fatty acid composition was determined on *longissimus dorsi* by crude fat extraction according to Folch *et al*. (1957) and fatty acid quantification as methyl esters (French *et al*., 2000). The GC used was a Thermo Finnigan, TRACE (Thermo Finnigan, San Jose, CA, USA), interfaced to a flame ionization detector (F.I.D.).

With regard to trials 1 and 2 a sensory analysis was carried out on *longissimus lumborum* cooked in a waterbath until reaching 75°C as internal temperature. Flavour, tenderness, juiciness and overall acceptability were evaluated such as palatability attributes by trained panels (10-12 members) according to a 9-point hedonic (trial 1) or an intensity scale (trial 2). All data were processed by GLM procedure of Minitab statistical software (Minitab, 1995).

Table 1. Composition of diets and main chemical analyses

	Diet treatments									
	Trial # 1		Trial # 2		Trial # 3			Trial # 4		
	FB	SBM	BP	CG	P39	P18	SBM	C42	C20	SBM
Ingredients (%, weight basis)										
Lucerne hay	-	-	-	-	27	30	30	-	-	-
Grass hay	36.7	33.6	-	-	-	-	-	-	-	-
Wheat straw	-	-	20	20	-	-	-	-	-	-
Lucerne dehydrated	-	-	-	-	-	-	-	20	20	20
Maize	-	18.6	-	12	20	23	20.5	-	18	30
Barley	-	16.6	-	12	3	9	21	27	23	25
Soybean meal	-	20.6	-	-	-	9	16	-	7	13
Carob pulp	4.2	5	10	-	5.5	5.5	7	6	7	7
Orange pulp	-	-	10	-	-	-	-	-	-	-
Brewer's yeast	2.5	2.7	3	3	3	2.5	2.5	2.5	2.5	2.5
Vitamin-mineral premix	2.8	2.9	3	3.8	2.5	3	3	2.5	2.5	2.5
Faba bean	53.8	-	54	49.2	-	-	-	-	-	-
Peas	-	-	-	-	39	18	-	-	-	-
Chickpeas	-	-	-	-	-	-	-	42	20	-
Chemical Composition										
Dry matter (%)	90.0	90.9	87.1	87.4	89.2	88.8	88.8	88.8	88.5	88.0
CP (% DM)	18.2	18.6	17.4	18.2	14.3	15.4	17.0	16.6	16.4	16.3
NPN (% CP)	38.8	20.2	20	27.5	10	8.7	9	27	20.1	11
Soluble P (% CP)	44.4	28.9	25.7	35.5	36.2	27.4	23.1	47.5	31.7	18.8
NDIN (% CP)	10.8	17.3	15.4	11.0	17.4	16.9	15.1	11.3	11.2	13.7
ADIN (% CP)	2.8	3.2	6.1	3.5	7.3	9.6	9.0	5.4	8.6	6.2
NDF (% DM)	36.9	38.3	27.7	29.5	34.0	36.4	34.7	25.3	25.0	26.6

FB: faba bean diet; SBM: soybean meal diet; BP: by products plus faba bean diet; CG: cereal grains plus faba bean.
P39: peas 39% diet; P18: peas 18% diet; C20: chickpeas 20% diet; C42: chickpeas 42% diet.
CP: crude protein; NPN: non protein nitrogen; NDIN: neutral detergent insoluble nitrogen.
ADIN: acid detergent insoluble nitrogen; NDF: neutral detergent fiber.

Results and discussion

Despite dietary inclusions in similar proportions, peas diets showed lower protein level compared to the chickpeas and faba bean diets (Table 1). Faba bean diets (trials 1 and 2) showed the highest protein levels on the whole, because of their high protein content and percentage of inclusions (range 49-54% on as fed basis). There was a trend towards increasing dietary soluble protein, rapidly degradable in the rumen, as alternative legume seed proportions increased (Table 1). It is well known that the protein fraction of legume seeds such as faba bean and peas, is highly soluble and easily degradable in the rumen (Goelema *et al.*, 1998). When faba bean was associated to carob and orange pulp, rich in soluble carbohydrates, a better balance among dietary protein fractions at different rumen degradability was achieved as compared to diet in which faba bean totally replaced or was combined with cereal grains.

In trial 1 faba bean diet (FB) did not affect growth and slaughter performances but enhanced ($P<0.05$) bone percentages of hind leg, probably because of the higher NPN (non protein nitrogen) which negatively affected rumen efficiency and amino acid absorption with lower lean deposition as compared to SBM diet (Table 2). Consequently, lean/bone ratio was lower ($P<0.05$) in FB group than in SBM one. Furthermore it improved almost all meat sensory attributes even though at different statistical levels (flavour, $P<0.10$; juiciness, $P<0.05$; overall acceptability, $P<0.10$) (Lanza *et al.*, 1999).

In trial 2 faba bean associated to carob and orange pulps (BP diet) produced paler (P<0.05) meat than when it was associated to cereal grains (CG), probably depending on the higher condensed tannins content in carob pulp thus causing a reduction in myoglobin in muscle (Table 2). Indeed, BP diet showed a higher content of condensed tannins as compared to CG diet (3.80 *vs* 2.1 g equivalent leucocyanidin/kg DM) (Lanza *et al*., 2001). Literature showed that condensed tannins could reduce utilisation of the absorbed iron needed to synthesize myoglobin affecting meat colour (Priolo *et al*., 2000). BP diet treatment determined less intensity in flavour (P<0.01), juiciness (P<0.01), tenderness (P<0.01) and overall acceptability (P<0.05) of meat as compared to CG diet (Table 2).

Table 2. Main results of the trials.

	Trial # 1		Trial # 2		Trial # 3			Trial # 4		
	FB	SBM	BP	CG	P39	P18	SBM	C42	C20	SBM
ADG (g/d)	219	233	250	249	219	250	218	225^{x}	285^{y}	276^{y}
Final weight (kg)	26.4	27.8	30.2	29.9	28.9	29.4	28	30.8^{x}	34.6^{y}	34.1^{y}
Hind leg bone (%)	30.15^{a}	27.36^{b}	27.25	27.32	23.8	24.2	24	21.82	22.24	23.24
Lean/bone ratio	1.88^{a}	2.18^{b}	2.19	2.22	2.7	2.7	2.7	2.98^{x}	2.82^{x}	2.56^{y}
L*	45.75	44.77	45.27^{a}	43.64^{b}	44.4	44.1	44.3	45.98	49.37	50.41
Drip (%)	n.d	n.d	n.d	n.d	1.6^{A}	1.2^{A}	0.8^{B}	3.01	2.03	1.88
WBS (kg/cm$^{2)}$	3.02	2.37	6.22	6.01	n.d	n.d	n.d	4.92	5.82	6.30
Flavour†	7.48^{x}	7.11^{y}	5.99^{A}	6.57^{B}	n.d	n.d	n.d	n.d	n.d	n.d
Juiciness†	7.6^{a}	6.9^{b}	5.69^{A}	6.44^{B}	n.d	n.d	n.d	n.d	n.d	n.d
Tenderness†	7.79	7.3	5.9^{A}	7.1^{B}	n.d.	n.d.	n.d.	n.d	n.d	n.d
Overall†	7.54^{x}	7.03^{y}	5.86^{a}	6.56^{b}	n.d.	n.d.	n.d.	n.d	n.d	n.d
C12:0††	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.40^{a}	0.17^{b}	0.24^{b}
C18:1 cis n-9††	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	29.23^{a}	33.15^{b}	33.14^{b}
C18:1 trans††	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	2.86^{a}	1.57^{b}	2.53^{a}
C18:2 trans††	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.42^{a}	0.29^{ab}	0.19^{b}
C18:3 n-6††	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.54^{a}	0.40^{ab}	0.26^{b}
C18:2 CLA††	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	0.89^{a}	0.85^{a}	0.49^{b}
C22:5 n-3††	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	1.57^{a}	1.27^{b}	1.25^{b}
n-3 total††	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	n.d.	3.85^{a}	3.22^{b}	3.43^{ab}

A,B = P< 0.01; a,b = P< 0.05; x,y = P<0.10; n.d. = not detected.
FB: faba bean diet; SBM: soybean meal diet; BP: by products plus faba bean diet; CG: cereal grains plus faba bean; P39: peas 39% diet; P18: peas 18% diet;
C20: chickpeas 20% diet; C42: chickpeas 42% diet;
†=1-9 point score hedonic or intensity scale; †=g/100 g methylesters.

In trial 3 peas diets did not affect growth performances even though average daily gain tended to be higher in lambs fed diet where peas partially replaced soybean meal as compared to those fed soybean diet and diet with the higher proportion (39% on as fed basis) of peas in total replacement of soybean meal (P39) (250 *vs* 218 and 219 g/d, respectively) (Table 2). Purroy and Surra (1990) showed better daily gains in lambs fed the diet with partial replacement of soybean meal with peas as compared to total. Both the diets with peas inclusion increased (P<0.01) meat drip losses as compared to SBM diet (Lanza *et al*., 2003a).

In trial 4 lambs fed diet with partial replacement of soybean meal with chickpeas (C20) and SBM diet tended (P<0.10) to grow faster than those fed diet with total replacement of soybean meal by chickpeas (C42), thus affecting final weight which tended to be higher (P<0.10) in SBM and C20 group than in C42. Christodoulou *et al*. (2005) and Hadjipanayiotou (2002) did not show significant effects of the replacement of soybean meal with chickpeas on lamb growth performances. Both chickpeas groups tended to enhance lean proportions in hind leg thus causing a higher (P<0.10) lean/bone ratio as compared to soybean group (Lanza *et al*., 2003b). The diet with the high level of chickpeas inclusion (42% on as fed basis) modified intramuscular fatty acid composition increasing C12:0

(P<0.05), C18:2 *trans* (P<0.05), C18:3 n-6 (P<0.05), C18:2 CLA (P<0.05), C22:5 n-3 DPA (P<0.05) and the total n-3 series (P<0.05) but reduced C18:1 cis n-9 (P<0.05) as compared to SBM group (Priolo *et al*., 2003). Lambs from C42 group showed the highest proportion of C18:1 *trans*-vaccenic probably depending on an incomplete ruminal hydrogenation of dietary α-linolenic acid which resulted higher in chickpeas diets than in soybean one (2.92 and 3.02 *vs* 2.44 g/100 g methylesters, in C42, C20 and SBM diet, respectively) (Table 2).

Conclusions

In conclusion the use of alternative legume seeds in lamb diets, with respect of isonitrogenous and isoenergetic content, could be proposable without detrimental effect on meat quality particularly in "organic" production systems in which soybean and maize, mainly diffused as GM feedstuffs, are not allowed.

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