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Effect of feeding diets containing barley, wheat and corn distillers dried grains with solubles on carcass traits and meat quality in growing rabbits

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ABSTRACT

The effect of dietary inclusion of distillers dried grains with solubles (DDGS) on carcass and meat quality of *longissimus* muscle was studied in 100 growing rabbits from 28 to 59 days old. Diets with no DDGS (C), barley (Db20), wheat (Dw20) and corn (Dc20) DDGS at 20% and corn (Dc40) DDGS at 40% were formulated. No effects on most of the carcass traits, texture and water holding capacity were found. Barley and corn DDGS led to a higher dissectible fat percentage. Meat redness was higher with Dw20 and pH was higher with Dw20 and Db20 than with Dc20. Protein and saturated fatty acids concentration declined as corn DDGS level increased. Dc40 led to the lowest saturated/unsaturated fatty acid ratio, atherogenic index and thrombogenic index. In conclusion, dietary inclusion of these DDGS at 20% did not affect most of the carcass and meat quality traits in rabbits.

1. Introduction

Distillers dried grains with solubles (DDGS) of barley, wheat and corn are co-products of the industry of bioethanol frequently used in livestock feeding. These products have high potential for inclusion in the formulation and manufacture of diets for rabbits, as they are good sources of digestible energy (11.9–15.7 MJ kg DM), digestible protein (16.8–26.3%), fat (7.2–14.4%) and soluble fiber (20–21.7%) (Alagón, 2013; De Blas, Mateos, & García-Rebollar, 2010), allowing an adequate growth performance when they are included up to 20% in the diet (Alagón et al., 2014; Youssef, Abd El-Magid, Abd El-Gawad, El-Daly & Ali, 2012).

The determination of optimum levels of DDGS in farm animal feed diets is usually based on the evaluation of production and economic performance. However, the use of DDGS may affect both carcass and meat quality. Typically, DDGS contain 7 to 15% of fat, with 70 to 80% of mono and polyunsaturated fatty acids (Alagón, 2013; Xu et al., 2010) and monogastrics tend to show a fatty acid profile in the meat similar to the profile of the diet (Bee, Gebert, & Messikomer, 2002; Dalle Zotte, 2002).

In pigs, the use of DDGS has led to a reduction in dressing out percentage in some studies (Bregendahl, 2008; Whitney et al., 2006), and increased levels of corn DDGS at 20–30% in growing-finishing diets reduced pork fat firmness (Whitney et al., 2006), while other authors found no change in dressing out percentage due to the use of these co-products (McEwen, 2006). In chickens, dietary levels above 12% of corn DDGS increased the level of fatty acids in thigh meat, increasing the oxidation during storage (Schilling et al., 2010). In steers, feeding with diets that included levels of 20 or 40% of wheat and corn DDGS did not lead to differences in carcass and meat quality (Aldai et al., 2010). However, no information is available about the effect of dietary inclusion of DDGS on carcass and meat quality in rabbits.

The aim of the present study was therefore to evaluate the effect of the dietary inclusion of barley, wheat and corn DDGS at 20% and corn DDGS at 40% on carcass and meat quality of growing rabbits.

2. Material and methods

2.1. Diets

Five isoproteic, isoenergetic and isofibrous diets were formulated according to the nutritional requirements for growing rabbits (De Blas & Mateos, 2010), including distillers dried grains with solubles (DDGS) as follows: diet C (control diet, 0% of DDGS), diet Db_{20} (with 20% of barley DDGS), diet Dw_{20} (with 20% of wheat DDGS), diet Dc_{20} (with 20% of corn DDGS) and diet Dc_{40} (with 40% of corn DDGS). From each diet, both medicated (66 ppm of robenidine; 29 ppm lincomycin + 29 ppm spectinomycin; 120 ppm neomycin; and 50 ppm

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tiamulin, normally used in rabbit farms with high incidence of mucoid enteropathy) and unmedicated versions of the feeds were prepared. The ingredients, chemical composition, nutritive value and fatty acid composition (Tables 1 and 2) were determined as described by Alagón et al. (2014).

2.2. Animals

The experimental procedure followed both the Spanish Royal Decree 1201/2005 on protection of animals used for scientific purposes (Boletín Oficial del Estado, 2005) and the recommendations for applied nutrition research in rabbits described by the European Group on Rabbit Nutrition (Fernández-Carmona et al., 2005), as approved by the Committee of Ethics and Animal Welfare of the Universidad Politécnica de Valencia.

A total of 475 weaned rabbits 28 days old of both sexes from a three way cross were used in the experiment. Animals were reared in 5 rounds. Rabbits were allocated to individual cages and fed until 59 days old with one of the 5 experimental diets. Diets were medicated from 28 to 49 days of age and unmedicated from 49 to 59 days. Daily feed intake in the whole period is available at Alagón et al. (2014), which was used to determine ether extract (EE) and fatty acid intake of the animals.

2.3. Slaughter traits and carcass composition

At 59 days of age, 100 rabbits (20 per diet; 4 per diet and round) were weighed (slaughter weight, SW), electrically stunned and slaughtered at the abattoir in the farm. No fasting was applied. The slaughtering and carcass dissection procedures followed the recommendations of Blasco and Ouhayoun (1996).

The slaughtered rabbits were bled and the skin, genitals, urinary bladder, full gastrointestinal tract and distal part of the legs were removed. The full gastrointestinal tract was weighed and expressed as percentage compared to SW (FGTP). The hot carcasses obtained were weighed (HCW) and then chilled at +4 °C for 24 h in a ventilated room. The chilled carcasses were weighed (CCW) and the dressing out percentage (DoP) was calculated as CCW × 100/SW. The drip loss percentage (DLP) was calculated as (HCW-CCW)/HCW × 100. Liver, inguinal fat, perirenal fat and scapular fat were removed, weighed and expressed as percentage compared to CCW (LvP, IFaP, PFaP and SFaP, respectively). Dissectible fat percentage (DFaP) was calculated as the sum of IFaP, PFaP and SFaP. Both sides of the *longissimus* muscles were excised from the carcass and used to determine the meat quality parameters.

Table 1
Ingredient composition of the experimental diets (g/kg dry matter).

	C[a]	Db_{20}	Dw_{20}	Dc_{20}	Dc_{40}
Barley grain	150	160	150	160	170
Wheat bran	270	150	190	135	0
Soybean meal 44%	120	30	0	60	0
Alfalfa hay	220	250	200	160	100
Defatted grape seed	90	130	100	97	104
Beet pulp	33	0	0	16.5	0
Oat hulls	30	0	90	95	160
Soybean hulls	34	0	0	17	0
Soybean oil	35	49	32	22.8	10.6
Beet molasses	0	9.4	10	12.5	25
DDGS evaluated	0	200	200	200	400
Calcium carbonate	4.2	5	5	4.6	5
Dicalcium phosphate	0	0	5	4.5	9
Sodium chloride	4	4	4.2	4	4
L-Lysine HCL	0.3	2.7	3.4	1.7	3.2
L-Threonine	0.5	0.9	1.4	0.4	0.2
Vitamin/trace element premix[b]	5	5	5	5	5
Coccidiostac[c]	1	1	1	1	1
Antibiotics[d]	3	3	3	3	3

[a] C: control diet, 0% DDGS; Db_{20}: diet with 20% of barley DDGS; Dw_{20}: diet with 20% of wheat DDGS; Dc_{20} and Dc_{40}: diets with 20 and 40% of corn DDGS, respectively.
[b] Supplied per kg of feed: vitamin A: 8375 IU; vitamin D3: 750 IU; vitamin E: 20 mg; Vitamin K3: 1 mg; vitamin B1: 1 mg; vitamin B2: 2 mg; vitamin B6: 1 mg; nicotinic acid: 20 mg; choline chloride: 250 mg; magnesium: 290 mg; manganese: 20 mg; zinc: 60 mg; iodine: 1.25 mg; iron: 26 mg; copper: 10 mg; cobalt: 0.7 mg; butyl hydroxylanysole and ethoxiquin mixture: 4 mg.
[c] Cycostat (66 ppm of robenidine).
[d] Only in medicated versions of feeds: Linco-spectin (29 ppm lincomycin + 29 ppm spectinomycin), 120 ppm neomycin, Apsamix Tiamulin (50 ppm tiamulin), normally used in rabbit farms with high incidence of mucoid enteropathy.

Table 2
Chemical composition, nutritive value and fatty acids composition of the experimental diets.

	C[a]	Db_{20}	Dw_{20}	Dc_{20}	Dc_{40}
Chemical composition (g/kg DM)					
Dry matter, DM	907	911	908	909	903
Ash	61	61	59	60	55
Crude protein, CP	169	167	167	180	182
CP bound to NDF	43	48	44	55	49
Starch	186	154	149	159	129
Ether extract	57	81	68	75	82
Neutral detergent fiber, NDF	370	410	396	390	389
Acid detergent fiber	191	216	196	189	184
Acid detergent lignin	50	74	63	54	56
Insoluble hemicelluloses	179	194	200	201	206
Cellulose	141	142	133	135	128
Neutral detergent soluble fiber	84	88	117	104	107
Lysine	10.3	10.6	9.5	8.7	9.4
Methionine	2.1	2.2	2.5	3.0	3.1
Threonine	7.1	7.7	8.0	8.7	7.6
Nutritive value[b]					
Digestible energy, DE (MJ/kg DM)	11.2	11.9	11.3	11.7	11.9
Digestible protein, DP (g/Kg DM)	133	132	133	140	148
Ratio DP/DE (g/MJ)	11.9	11.1	11.8	11.9	12.4
Fatty acid composition (g/kg DM)					
C14:0 (myristic)	0.4	0.6	0.4	0.3	0.2
C16:0 (palmitic)	12.7	15.5	12.5	13.2	11.8
C16:1 (palmitoleic)	0.9	1.2	1.1	0.8	0.3
C17:1 (heptadecenoic)	0.1	0.1	0.1	0.0	0.0
C18:0 (stearic)	3.8	4.6	3.3	3.5	2.2
C18:1 n-9 (oleic)	16.3	19.4	14.8	19.1	17.2
C18:1 n-7 (vaccenic)	2.6	2.8	2.2	1.8	1.6
C18:2 n-6 (linoleic)	14.7	17.0	16.6	22.3	28.7
C20:0 (arachidic)	0.1	0.1	0.1	0.1	0.0
C20:1 (eicosenoic)	0.3	0.5	0.3	0.4	0.2
C18:3 n-3 (linolenic)	1.6	1.7	1.7	1.6	1.3
C20:2 (eicosadienoic)	0.5	1.0	0.5	0.6	0.4
SFA[c]	17.0	20.8	16.3	17.1	14.2
MUFA	20.2	24.1	18.5	22.2	19.3
PUFA	16.8	19.7	18.7	24.6	30.3
PUFA/SFA	1.0	0.9	1.1	1.4	2.1
n-6 linoleic/n-3 linolenic	9.3	10.0	10.0	13.9	22.7

[a] C: control diet, 0% DDGS; Db_{20}: diet with 20% of barley DDGS; Dw_{20}: diet with 20% of wheat DDGS; Dc_{20} and Dc_{40}: diets with 20 and 40% of corn DDGS, respectively.
[b] Calculated from pooled faeces of 5 rabbits/diet in a digestibility trial according to Pérez et al. (1995).
[c] SFA, saturated fatty acids [C14:0 + C16:0 + C18:0 + C20:0]; MUFA, monounsaturated fatty acids [C16:1 + C17:1 + C18:1n-9 + C18:1n-7 + C20:1]; PUFA, polyunsaturated fatty acids [C18:2n-6 + C18:3n-3 + C20:2].

2.4. Meat quality

2.4.1. Color measurements

Color measurements in the CIELAB space (Lightness, L*; redness, a* and yellowness, b*; CIE, 1976) were measured at 24 h post-mortem using a Minolta Chromameter (Minolta CR-300, Osaka, Japan). Carcass color was determined on the surface of the right *longissimus* muscle at the level of the fourth lumbar vertebra (Pla, Hernández, & Blasco, 1995). Meat color was measured in the transversal section of the *longissimus* muscle at the level of the 7th lumbar vertebra.