Proceedings of the 11th International Symposium
Modern Trends in Livestock Production
October 11-13, 2017

BACKFAT FATTY ACID PROFILE AFTER GROWING PERIOD IN IBERIAN PIGS FED WITH OLIVE CAKE IN A DRY OR WET (SILAGE) FORM

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Original scientific paper

Abstract. The traditional production system of Iberian pig is characterized for having a finishing period called *montanera*, which is based on acorn intake. This kind of handling has an influence on both product quality and animal welfare issues. Acorn based diet during *montanera* has a positive effect on meat quality since increases the oleic content. However, *montanera* has an uneven effect on animal welfare, on one hand it is a semi-extensive system which is positive but, on the other hand, a restricted diet is required during pre-*montanera* period to prevent a non-desirable fatness percentage in final pig products. This restriction diet implies feeding stress. The use of olive by-products during the growing phase diet of Iberian pigs could be the solution to avoid this stress. Here, we studied the effect of three different dietary regimens given to Iberian pigs in growing period (42 kg to 95 kg) on backfat fatty acid composition. A control standard diet group (CD) was compared with two diets based on olive by-products, one incorporating dry olive pulp in the feed (DD), and the other one incorporating olive cake in wet form (WD). This last one consisted of olive cake in a silage presentation offered *ad libitum* and supplemented with a specific feed given once a day in a restricted regimen as the CD and DD diets. A significantly higher oleic acid values was observed for DD and WD diets compared with CD diet. Therefore, the diets based on olive cake seem to be an alternative to more expensive diets based on high-oleic raw material. However, before implementation in feeds used for the growing period, further studies analyzing their effects on meat quality and production costs should be carried out.

Key words: Iberian pig, olive by-products, growing period, backfat fatty acids

Introduction

Montanera is the finishing fattening period (up to 160 kg approx.) of the traditional Iberian pig production system. During this period, that lasts three to five months (from November to March), animal's diet is based on an *ad libitum* intake of acorns and grass *(López-Bote, 1998*). As the previous growing period (up to 100 kg approx.) lasts a long time, sometimes more than one year, feeding and management are aimed to prepare the pigs to that crucial fattening stage. A strongly restricted diet is required to decrease growing rate and prevent animals for getting a higher fatness percentage than desirable. However, this restriction causes a non-desirable feeding stress, as it means a negative effect on animal welfare. Low energy diets that allow a daily intake similar to an *ad libitum* one during the growing period could be an alternative to minimize this problem.

In Iberian pig production, olive-based by-products have been proposed as raw material of feed components for growing or finishing pigs *(Benito et al., 1998; Hernández-Matamoros et al., 2011; Joven et al., 2014; González-Sánchez et al., 2016)*. In addition, *Hernández-Matamoros et al. (2011)* reported changes in fatty acid profile on backfat at 104 kg live weight except for linoleic, producing an increase in the percentage of oleic and a decrease of the saturated fatty acids. However, there are no studies using *montanera* pigs bred into the traditional restricted period.

The objective of the current study was to analyze fatty acid profile (FA) at the end of the growing period in Iberian pigs fed with two different olive cake-based diets, in dry and wet form, respectively.

Material and Methods

Description of the by-products

Treatments and types of by-products along olive oil extraction are diverse. In the case of the material used in this work, olive oil and crude olive cake (COC) were obtained in the first place. COC consisted of olive pulp, skin and stone, containing a 72% of water and constituting a semiliquid paste. After that, a second extraction of the olive oil was made, and the main part of the olive stone was retired. The resulting pastry was then dehydrated, and the olive pulp (OP) obtained, which was composed by skin, pieces of olive stones and a small part of olive oil. Table 1 shows the fatty acid composition of the by-products and the remaining analytical composition of these by-products is described in a previous study (*García-Casco et al., 2017*).

Table 1. Fatty acid composition of the olive pulp (OP) and crude olive cake (COC) by-product, silage and the control (CD), dry olive pulp (DD) and wet crude olive cake (WD) experimental feeds (g/100g total lipids).

	By-products			Diets		
	OP	COC	Silage	CD	DD	WD
C14:0	0,05	0,16	0,46	0,76	0,41	0,40
C16:0	13,81	13,60	13,96	19,56	12,68	17,55
C16:1	0,85	1,04	1,07	1,06	0,72	0,26
C17:0	0,09	0,07	0,12	0,19	0,14	0,14
C17:1	0,11	0,11	0,23	0,17	0,16	0,10
C18:0	3,91	3,27	3,72	6,92	3,96	3,82
C18:1	69,17	65,98	66,09	36,15	59,14	25,51
C18:2	9,78	13,41	11,59	31,00	19,33	46,21
C18:3	0,87	1,08	1,00	2,80	1,95	4,96
C20:0	0,62	0,56	0,67	0,34	0,59	0,41
C20:1	0,42	0,33	0,68	0,85	0,58	0,64
C20:2	0,32	0,40	0,41	0,20	0,33	0,00

Animals, diets and samples

A total of 45 Iberian pigs were controlled from 6.5 months to commercial slaughter age, starting with an average weight of 42± 8.6 kg. Animals were evenly and randomly allocated in three different pens of 110 m^2, with both outdoor and covered areas. Three feeding systems were applied during the growing period: the analytical and ingredient composition of these diets is described in a previous study *(García-Casco et al., 2017)*. CD was based on a feed formulated in order to cover the protein and energy requirements for the growing period. DD was based on a feed with a 45% of OP by-product in a pelleted form. Lastly, WD was composed by two elements: COC by-product in a silage form to ease its conservation and use, and a specific feed (WD) as a complement. To prepare the silage, a mix with a 75% of COC and 25% of barley straw was made. This mix was packaged at a high pressure containing 42.5% of dry matter. Table 1 shows fatty acid profile analysis of the silage and the three feeds.

All these feeds were supplied in a pelleted form, once a day under a restriction feeding management. COC by-product of the WD regimen was supplied *ad libitum.* Pigs remained on these feeding conditions for 191 days, when they reached an average body weight (BW) of 95±13.7 kg.

At the end of the growing period, backfat biopsies were taken from the rear body part of each pig, close to the tail. Animal manipulations were performed according to the Spanish Policy for Animal Protection (RD1201/05), which meets the European Union Directive 86/609 for the protection of animals used in experimentation.

Fatty acid profile

Backfat from the biopsies was homogenized with chloroform until total dissolution of fat. Chloroform is collected and evaporated under nitrogen stream. Fatty acid profile was determined by gas chromatography after an acid transesterification in the presence of sulfuric acid *(Cava et al., 1997)*. Fourteen fatty acids were analysed and the results are expressed as percentages of the total fatty acids.

Statistical analyses

Data were analyzed with the following linear model:

$$y = Xb+e$$

Where *b* represents the diet supplied during the growing period as a three-leveled factor for the fatty acids and *e* represents the residual effects. Analyses were carried out on R environment using the functions *lm, anova* and *Tukey HSD*. Fisher test was applied to test the effects of factors and Tukey test was used to make pair-wise comparisons. A *p-value* ≤ 0.05 was considered as a significant difference between the different diets.

Results

Table 2 shows the mean values of the 14 fatty acids analyzed and the sum of saturated (SFA), monounsaturated (MUFA) and polyunsaturated (PUFA) fatty acids. Significant differences were observed between the treatment groups for most of them. Control diet (CD) showed higher values for the main saturated FA (C14:0, C16:0, C18:0). Dry and wet olive diets (DD and WD), with clearly higher levels of unsaturation than CD (C16:1, C18:1, C18:2, C18:3), are not very different among them. Only some less abundant FA mean values were significantly different

(C14:0, C17:0, C20:1, C20:2, C20:3) for DD and WD. An exception was found for the stearic acid (C18:0) for which CD showed a lower value than WD, but the sums of FA were similar.

Table 2. Comparison of backfat fatty acid composition between Control (CD), dry olive pulp (DD) and wet crude olive cake (WD) experimental diets. Standard error of the mean (SEM) and *p-value* corresponding to the Fisher test of the *ANOVA*.

Trait	CD	DD	WD	SEM	*p*
C14:0	1.40^{a}	1.14^{c}	1.27^{b}	0.15	$1.90x10^{-06}$
C16:0	24.30^{a}	21.54^{b}	20.87^{b}	1.90	$1.35x10^{-09}$
C16:1	2.67^{a}	2.36^{b}	2.29^{b}	0.25	$1.76x10^{-05}$
C17:0	0.41^{b}	0.50^{a}	0.42^{b}	0.08	$4.21x10^{-04}$
C17:1	0.42	0.41	0.39	0.05	0.476
C18:0	11.40^{a}	8.62^{c}	10.32^{b}	1.47	$2.68x10^{-08}$
C18:1	46.69^{b}	49.83^{a}	49.22^{a}	2.12	$2.24x10^{-05}$
C18:2	9.44^{b}	12.20^{a}	11.38^{a}	1.48	$3.27x10^{-09}$
C18:3	0.70^{b}	0.87^{a}	0.91^{a}	0.13	$1.71x10^{-06}$
C20:0	0.23	0.22	0.22	0.03	0.400
C20:1	1.36^{b}	1.31^{b}	1.51^{a}	0.14	$1.37x10^{-05}$
C20:2	0.63^{b}	0.65^{b}	0.75^{a}	0.08	$2.28x10^{-05}$
C20:4	0.18	0.19	0.19	0.03	0.577
C20:3	0.18^{b}	0.16^{c}	0.25^{a}	0.04	$2.64x10^{-12}$
SFA	37.75^{a}	32.03^{b}	33.10^{b}	3.12	$8.54x10^{-10}$
MUFA	51.13^{b}	53.90^{a}	53.42^{a}	2.06	$1.93x10^{-4}$
PUFA	11.12^{b}	14.07^{a}	13.49^{a}	1.64	$5.53x10^{-09}$

SFA, MUFA, PUFA: Sum of saturated, monounsaturated and polyunsaturated fatty acid, respectively

Discussion

Production of dry-cured Iberian pig products is oriented to high quality markets. The traditional *montanera* system, based on an acorn and grass feeding during the fattening period, conferred to fresh meat the ideal properties to resist a long curation period of hams and forelegs *(Ventanas et al., 2005)*. Fatty acid composition of subcutaneous fat is a key to this process and one of the main responsible of the unique organoleptic properties associated to Iberian pig products. High levels of oleic acid (> 53%) at slaughter weight are required from industries, as well as low values for palmitic (< 22%), stearic (< 10.5%) and linoleic (< 10.5%) acids.

In this scenario, fatty acid profile before *montanera* period must be controlled by farmers. Growing diets resulting in high SFA levels cannot be corrected with the acorn feeding, and the final quality of products could be affected. Formulation of pre-*montanera* feeds used for Iberian pigs take into account this situation and many of them have a high oleic composition obtained from raw material as sunflower seeds.

Our results of fatty acid profiles in subcutaneous fat point out to the use of diets based on olive by-products during growing period being an alternative to more expensive feeds to reach appropriate levels of oleic acid before *montanera*. Although linoleic acid levels were also higher in DD and WD diets than in CD one, the massive consume of acorn will likely result in a decrease of the linoleic fatty acid at the end of *montanera* period.

Fatty acid profile at the end of *montanera* and other meat quality traits are currently being analyzed to contrast potential undesirable influences of olive-based by product diets. Previous results on growth and slaughter traits *(García-Casco et al., 2017)* showed that they are not affected by DD and WD diets.

Conclusion

The incorporation of olive cake to the diet of Iberian pigs during the growing period has positive effect on fatty acid profile at the end of that period, increasing total unsaturation level. Although its use seems to be suitable, further studies analyzing final fatty acid profile and meat quality traits and production costs should be performed.

Profil masnih kiselina leđne slanine kod iberijskih svinja hranjenih maslinovom pogačom u suvom ili vlažnom (silažnom) obliku

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Rezime

Tradicionalni sistem proizvodnje iberijske svinje karakteriše završni period nazvan *montanera*, koji se zasniva na konzumiranju žira, što ima uticaj na kvalitet proizvoda i pitanje dobrobiti životinja. Ishrana zasnovana na žiru tokom *montanere*

ima pozitivan efekat na kvalitet mesa, jer povećava oleinski sadržaj. Međutim, *montanera* ima nejednak efekat na dobrobit životinja, s jedne strane radi se o polu-ekstenzivnom sistemu koji je pozitivan, ali sa druge strane je potreban ograničena ishrana u periodu pre *montanere* kako bi se sprečila pojava neželjene masnoće finalnih svinjskih proizvoda. Ova restriktivna ishrana podrazumeva stres. Korišćenje maslinovih nusproizvoda tokom ishrane iberijskih svinja u fazi rasta može biti rešenje da se izbegne ovaj stres. Ovde smo proučavali efekat tri različita režima ishrane iberijskih svinja u periodu porasta (42 kg do 95 kg) na kompoziciju masnih kiselina leđne slanine. Kontrolna standardna dijetalna grupa (CD) je upoređena sa dve ishrane zasnovane na maslinovim nusproizvodima, od kojih je jedna sa suvom maslinovom pulpom u obroku (DD), a druga sa maslinovom pogačom u vlažnom obliku (VD). Ova poslednja se sastojala od maslinovoe pogače u silažnom obliku, *ad libitum* i dopunjena specifičnom hranom koja se daje jednom dnevno u ograničenom režimu, kao i CD i DD obrocima. Znatno veće vrednosti oleinske kiseline primećene su za DD i VD obroke, u poređenju sa CD obrokom. Dakle, ishrana zasnovana na maslinovoj pogači izgleda kao alternativa skupljim obrocima zasnovanim na visoko-oleinskoj sirovini. Međutim, prije implementacije u ishrani tokom perioda porasta, trebalo bi izvesti dodatne studije koje analiziraju njihove efekte na kvalitet mesa i troškove proizvodnje.

Ključne reči: periodi gajenja, maslinovi nusproizvodi, masne kiseline leđne slanine, iberijske svinje

Acknowledgements

This study has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 634476 (project acronym TREASURE). The content of this paper reflects only the author's view and the European Union Agency is not responsible for any use that may be made of the information it contains.

The authors are also grateful to the employees of the farm Puerto Lobo (Cabeza la Vaca, Badajoz, Spain) and especially to the owner Francisco de Borja Ramírez.

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