UFT Academic Publishing House, Plovdiv

Food Science and Applied Biotechnology
e-ISSN: 2603-3380

Journal home page: www.ijfsab.com
https://doi.org/10.30721/fsab2019.v2.i1

OPEN ACCESS

Research Article

Fatty acid profile of the backfat layers in four pig breeds

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Abstract

The aim of this study was to describe and compare the fatty acid profile of the backfat layers in four pig breeds – Landrace, Pietrain, Duroc and Large White. Six gilts per breed were used for the analysis. While differences between the examined breeds were limited to the content of C18:1n-9 and the total level of monounsaturated fatty acids (MUFA), which were highest in the inner backfat layer of Duroc pigs, the two layers differed substantially. Generally, the inner backfat layer was more saturated when compared to the outer layer. On the other hand, the content of the polyunsaturated fatty acids (PUFA) was higher in the outer layer. The differences in the fatty acid profile between the two backfat layers were most visible in the Landrace pigs. The latter showed significantly higher content of C18:0 ($P<0.001$), which was also found in Duroc ($P<0.05$), as well as total saturated fatty acids (SFA) ($P<0.01$) in the inner layer. Furthermore, higher levels of C18:2n-6 ($P<0.05$), C18:3n-3 ($P<0.01$) and the total amount of PUFA ($P<0.05$) were found in the outer backfat layer in the animals of the Landrace breed.

Keywords: pigs, fatty acids, backfat, breeds

Abbreviations:

GLC - gas–liquid chromatography
FAME - fatty acids methyl esters
MUFA - monounsaturated fatty acids
PUFA - polyunsaturated fatty acids
SFA - saturated fatty acids

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Article history:
Received 5 June 2018
Reviewed 23 July 2018
Accepted 8 September 2018
Available on-line 19 March 2019

https://doi.org/10.30721/fsab2019.v2.i1.66

Introduction

Adipose tissue is of major importance in the farm animals, since its percentage of the body weight is a major determinant for the efficiency of transferring nutrients from feed into food products and thus for the economic value of meat producing animals (Sauerwein et al. 2014). In addition to its functions as an energy reservoir and endocrine organ, the adipose tissue of pigs, is an important component of meat together with the other major components - protein, water, and ash (Seman 2008). Much of the carcass fat accumulates in the subcutaneous depots (backfat) surrounding the major wholesale cuts, and other fat exists as intermuscular, lying between the muscles. A third, and very important part of the fat is located in the intramuscular spaces, and its amount and distribution as well as its fatty acid composition influence the sensory quality and dietary value of meat (Wood et al. 2008). Despite the importance of the intramuscular fat, the backfat is also of interest, since it is used in meat processing. The fatty acid composition of the adipose tissues in pigs can be modified through the diet (Morel et al. 2006), however, recent studies (Zhang et al. 2016; van Son et al. 2017) reveal that it is also a heritable qualitative trait and hence breed specific profile of the lipids will not be surprising. The knowledge about the differences that might exist between the breeds is important for the breeding practices aiming to produce animals with high quality meat and also for the further processing into meat products. The aim of this study was to describe and compare the fatty acid profile of the backfat and its layers in four pig breeds – Landrace, Pietrain, Duroc and Large White, which participate in the crossbreeding schemes for pork production.

Materials and Methods

Animals, slaughtering and sampling. The study was carried out in the pig farm Golyamo Vranovo Invest AD with a total of 24 gilts divided into four groups according the breed: Landrace (n=6), Pietrain (n=6), Duroc (n=6) and Large White (n=6). During the finishing period the pigs were reared according to the requirements described in Regulation 21/14.12.2005. Two phase feeding was applied during the finishing period, as the first phase was in the period 40-80 kg (protein content-19.05%, ME- 34.24kcal), while the second phase was from 80 kg until slaughter (protein content-18.89%, ME-3423 kcal). The fattening of the pigs started at 90 ± 5 days and they were slaughtered at 165 ± 5 days of age. After slaughtering, the carcasses of the pigs were skinned. The carcass weight was as follows: Landrace – 83.39 kg (SEM 0.55), Pietrain 84.06 (0.89), Duroc 84.06 (0.89) and Large white 84.84 (0.76). 24 h post mortem, samples from the inner and outer backfat layer were taken at the last rib from the left side of each carcass for analysis of the fatty acid composition of the adipose tissue.

Fatty acid analysis. The total lipids of the backfat were extracted according to the method of Bligh and Dyer (1959). Methyl esters of the total lipids, isolated by preparative thin layer chromatography, were obtained using 0.01 % solution of sulfuric acid in dry methanol for 14 h, as described by Christie (1973). The fatty acid composition of the total lipids was determined by gas–liquid chromatography (GLC) analysis using a chromatograph C Si 200 equipped with a capillary column (DM-2330:30 m×0.25 mm×0.20 μm) and hydrogen as a carrier gas. The oven temperature was first set to 160°C for 0.2 min, then raised until 220°C at a rate of 5°C/min and then held for 5 min. The temperatures of the detector and injector were 230°C. Methyl esters were identified through comparison to the retention times of standards. Fatty acids are presented as percentages of the total amount of the methyl esters (FAME) identified (Christie 1973).

Statistical evaluation. The statistical evaluation of the results was done using JMP v7. software package. The differences between the breeds were assessed through one way ANOVA and Tukey post – hoc comparisons. The differences between the backfat layers of each breed were evaluated through t-test.

Results and Discussion

As shown on Table 1, we identified 9 fatty acids in both backfat layers of the four examined breeds, with the highest content belonging to C18:1n-9, followed by C16:0 and C18:2n-6. Differences among the breeds were found in regard to C18:1n-9 which showed higher levels in the inner backfat layer of the Durocs (P<0.05), compared to the other breeds. In this study we did not observe strong influence of the breed on the fatty acid composition of the backfat. Contrary to our results, Raj et al. (2010) reported significant differences in the backfat fatty acid profile between 4 breeds including Belgian Landrace, Duroc, Hampshire and observed that Pietrain pigs had less SFA and more PUFA in comparison with the other breeds. Similarly, Klensporf-Pawlik et al. (2012) found that Pietrain had lowest amount of SFA and highest of PUFA in the subcutaneous fat. These authors also reported lowest content of C18:1n-9 and total MUFA in Durocs which is opposite to what we found in our study. The higher content of C18:1n-9 and the total MUFA in the inner layer of the backfat in Durocs corresponds to the increased levels of these fatty acids in the intramuscular lipids in this breed that we found in another study (Popova and Nakev, in press). In line with our results, Olivares et al. (2009) and Bertol et al. (2013) found limited effect of the genotype on the fatty acid composition of the backfat in pigs.

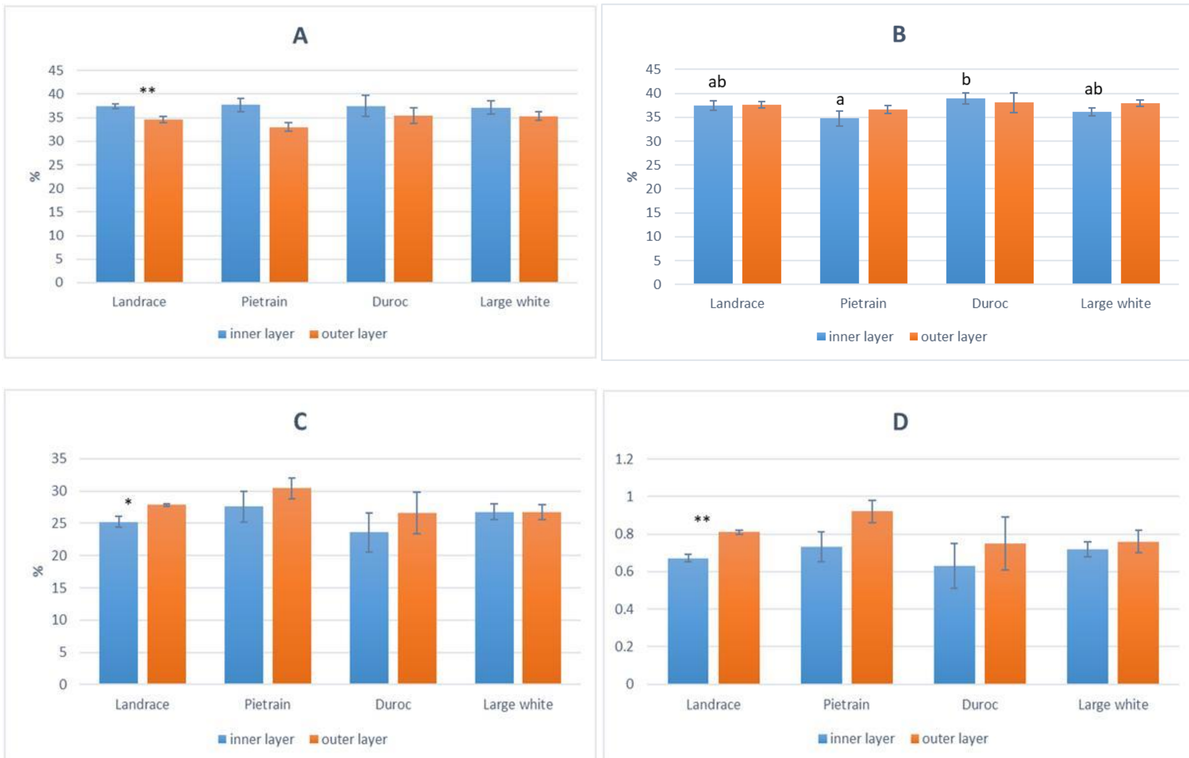
Table 1. Fatty acid composition (% FAME) of the inner and outer backfat layer in the four breeds

Fatty acid	Landrace		Pietrain		Duroc		Large White	
	inner	outer	inner	outer	inner	outer	inner	outer
C14:0	1.90±0.07	1.76±0.06	1.89±0.10	1.55±0.14	1.84±0.12	1.73±0.11	1.80±0.13	1.57±0.13
C16:0	23.77±0.29	22.87±0.37	24.61±1.38	21.80±1.07	23.80±1.14	23.06±0.80	24.17±0.99	23.10±1.10
C16:1n-7	1.94±0.05	2.14±0.10	1.77±0.12	1.74±0.09	1.81±0.22	1.85±0.19	1.83±0.47	1.85±0.15
C18:0	11.72±0.26***	9.93±0.26	11.19±0.86	9.63±0.58	11.84±0.33*	10.59±0.30	11.18±0.41	10.65±0.41
C18:1n-9	35.77±0.94[ab]	35.47±0.58	32.96±1.13[a]	34.88±1.98	37.14±1.39[b]	36.20±0.61	34.29±0.93[ab]	36.11±0.70
C18:2n-6	21.80±0.75*	24.08±0.18	23.91±2.69	26.36±2.78	20.24±2.08	22.96±1.36	23.04±0.94	23.10±1.01
C18:3n-3	1.99±0.06**	2.28±0.03	2.02±0.27	2.30±0.26	1.75±0.17	2.02±0.13	2.11±0.11	2.11±0.13
C20:2n-6	0.84±0.03	0.85±0.04	0.99±0.08	1.04±0.08	0.93±0.11	0.93±0.06	0.96±0.07	0.91±0.06
C20:4n-6	0.57±0.03	0.62±0.01	0.66±0.05	0.70±0.07	0.65±0.05	0.66±0.03	0.62±0.04	0.60±0.03

*The data are presented as Mean± SEM. Differences between the inner and outer backfat layer are significant at *P<0.05; **P<0.01and***P<0.001; The differences among breeds are significant at P<0.05 when connected with different superscripts within the same layer*

The authors showed that the effect of the genotype was much stronger in the internal adipose deposits such as the intramuscular fat.

The differences between the inner and the outer layer of the backfat in the breeds from our study were much more pronounced than the effect of the breed itself. The SFA in both layers included C14:0, C16:0 and C18:0. The latter differed significantly between the layers in Landrace (P<0.001) and Duroc (P<0.05), showing higher content in the inner layer. This was also observed in the Pietrain gilts, where the content of C14:0 and C16:0 also tended to be higher in the inner layer respectively by 18.52% and 11.42%. Furthermore, tendencies towards higher C14:0 and C16:0 in the inner backfat layer were detected in Landrace as well. The described significant differences and tendencies determined also the patterns in the total amount of the SFA (Fig. 1), which were most visible in the Landrace (P<0.01) and Pietrain pigs and determined the higher extent of saturation of the inner backfat layer (Bee et al. 2002; Monziols et al. 2007; Popova 2014). In line with the general observation for the higher saturation of the inner layer, significant differences were found in the contents of the polyunsaturated C18:2n-6 (P<0.05) and C18:3n-3 (P<0.01) which were higher in the outer layer of the Landrace pigs.



*The data are presented as Mean± SEM. Differences between the inner and outer backfat layer are significant at *P<0.05; **P<0.01and***P<0.001; The differences among breeds are significant at P<0.05 when connected with different superscripts within the same layer*

Figure 1. Total contents of saturated (A), monounsaturated (B), polyunsaturated (C) fatty acids and P/S ratio (D) in the inner and outer backfat layers in the four breeds

The content of these fatty acids tended to be higher also in the outer backfat layer of Duroc and Pietrain gilts, but lacked significance. This is due to considerable variation in the samples in regard to these two fatty acids, which is not uncommon, since they are derived from the diet and their deposition highly depends on the feed intake of the animals. Our results indicate the higher deposition of the C18:2n-6 and C18:3n-3 in the outer backfat layer. Previously we observed this in a study on the adipose tissue of East Balkan pigs (Popova et al. 2015) with higher deposition of C18:3n-3 in the outer backfat layer. Furthermore, Bee et al. (2002) and Monziols et al. (2007) observed higher content of C18:2n-6 in the outer layer of the subcutaneous adipose tissue in pigs. Similar to our results, Daza et al. (2007) determined considerably higher content of C18:2n-6 and C18:3n-3, and hence the long-chain polyunsaturated fatty acids in the outer backfat layer in Iberian pigs raised under free range conditions. The authors also analyzed the sub- inner layer and showed that it is very similar in its fatty acid composition to the inner layer, in regard to the differences in the PUFA with the outer layer. Preferential deposition of these dietary PUFA in the outer layer could be explained by the differences in the lipogenic metabolism between the two backfat layers. According to Camara et al. (1996), the inner backfat layer exhibits higher lipogenic activity than the inner layer, as a results of the higher de novo lipogenesis the PUFA derived from the diet are diluted with more fatty acids of endogenous origin. The total content of PUFA was significantly higher (P<0.05) in the Landrace pigs and also in the Duroc and Pietrain, and the ratio between polyunsaturated/saturated fatty acids (P/S) was also improved in these breeds (Fig. 1 c and d). Besides the positive effect of C18:2n-6 which increases considerably the content of the PUFA and also helps to augment the values of the P/S ratio above the recommended minimum of 0.4, its high content is associated with the decreased firmness of the fat (Wood et al. 2008). In an earlier study, Wood et al. (1989) reported that the contents of C18:2n-6 provides the best prediction of fat firmness. According to Seman (2008), the melting point of C18:2n-6 is -5°C which is considerably lower than that of C18:0 (70.1°C) and even C18:1(16.3°C). The low melting point of the fat is associated is various quality issues in the meat products such as reduced cohesiveness (Gandemer et al. 2002) and separation between the fat and muscle in dry cured products, as well as softer, undesirable texture and fat smearing in fresh sausages (Legan et al. 2007). This suggests that the breeders should find the balance in the rearing strategies so that the requirements for the healthy value are met but also the quality of the fat is not negatively affected.

Conclusions

The results of this study show that it is difficult to discriminate between the four breeds in regard to the fatty acid profile of the backfat. The differences between the layers of the backfat were more pronounced than the differences between the studied breeds, revealing the higher saturation of the inner layer compared to the outer. These discrepancies were observed to a different extent in the examined breeds, but were especially visible in the Landrace pigs.

Acknowledgements

The authors would like to kindly acknowledge Dr. Milenka Dimitrova, Mr. Tihomir Todorov and Mr. Nikolay Vasilev from Golyamo Vranovo Invest AD for their support in this work.

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