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RABBIT DIVERGENT SELECTION FOR TOTAL BODY FAT CONTENT: EFFECT ON PROXIMATE COMPOSITION AND FATTY ACID PROFILE OF MEAT

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ABSTRACT

The purpose of the present study was to investigate the effect of a divergent selection for total body fat content (Lean *vs* Fat Lines) of 10-week-old rabbits, measured by computer tomography, on their meat quality. The first 4 generations of selection were considered. Offspring of the selected rabbits were slaughtered at the age of 11 weeks. Proximate composition of hind leg (HL) meat of 120 rabbits (15 samples x Line x Generation) was analysed, whereas fatty acid (FA) profile was determined on the HL meat of generation IV rabbits. At generation IV of selection, the lipids content of the meat was significantly higher (5.58 vs 4.73 g/100 g; P<0.001) and the water content significantly lower (75.0 vs 76.2 g/100 g; P<0.05) in the Fat Line. The FA profile of the HL meat was also significantly modified by the divergent selection, resulting in differences for monounsaturated FA (26.4 vs 30.8% total FA; P<0.001) and polyunsaturated FA (32.3 *vs* 28.5% FA methyl esters; P<0.001) for Lean and Fat lines, respectively, with a more favourable *n*-6/*n*-3 ratio for Fat Line (16.1 vs 13.0, for Lean and Fat lines, respectively; P<0.001). It can be concluded that the divergent selection for total body fat content was effective in modifying the meat fatness and the FA profile of its lipids, while maintaining the protein content unchanged.

Key words: Rabbit, Divergent selection, Meat, Proximate composition, Fatty acid profile.

INTRODUCTION

Genetics, age, and feeding strategy are the most effective tools to modify the carcass and meat quality of rabbits (Cullere and Dalle Zotte, 2018). The potential of divergent genetic selection has been extensively applied and studied in rabbits with different purposes: reproductive performance (Blasco *et al*., 2005), rabbit live performance (Larzul *et al*., 2005), carcass yield (Szendrő *et al*., 2012), and meat traits (Martínez-Álvaro *et al*., 2016, 2018), the last mentioned selecting for the intramuscular fat (IMF) content. The potential of divergent selection (DS) for total body fat content on carcass yield and lipids content in rabbit meat has been studied (Szendrő *et al*., 2016) with the dual purpose of obtaining healthier meat (leaner) and fattier bodies of rabbit does for improving their reproduction efficiency. Results from the first two generations of selection showed its effectiveness in modifying the carcass fatness significantly. The research continued until the fourth generation with the aim of evaluating the effect of DS for total body fat content on the proximate composition and on the fatty acid (FA) profile of the meat of fattened rabbits, which is the objective of the present study.

MATERIALS AND METHODS

Animals and experimental design

The experimental design related to the divergent selection (DS) procedure and animal management has been well described by Szendrő *et al*. (2016). In short, the DS process for total body fat content measured by computer tomography (CT) was done over four generations on the Pannon Ka rabbit genetic line. At each generation, the rabbits with the lowest fat index were designated to the Lean selected (Lean Line) and those of the highest values were designated to the Fat selected (Fat Line) animals. Offspring from the four generations were slaughtered at the age of 11 weeks, and the hind leg (HL) meat of 15 rabbits per Line and per Generation (15 HL x 2 Lines x 4 Generations = 120 samples) were used for chemical analyses. The HL were analysed at the MAPS Department of Padova University (Italy), for proximate composition and FA profile. Hind legs were deboned, and the meat was finely ground and freeze-dried. The dry matter, protein and ash content were determined according to the AOAC (2012) methods. Proximate composition was expressed as g/100 g of fresh weight. Lipids extractions and FA profiles were performed as described by Dalle Zotte *et al*. (2018). The average amount of each FA was used to calculate the sum of the respective classes: saturated (SFA), monounsaturated (MUFA), polyunsaturated FA (PUFA), total omega-6 (*n*-6) FA, total omega-3 (*n*-3) FA and their ratio.

Statistical Analysis

Data were analysed using SAS 9.1.3 statistical software package for Windows (SAS, 2004). Proximate composition data were subjected to a two-way ANOVA, by considering Line (Lean, Fat) and Generation (I, II, III, IV) as fixed effects, and their interaction. The FA profile was analysed with a one-way ANOVA, considering Line as fixed effect. Least square means were obtained using the Bonferroni test and the significance was calculated at a 5% confidence level.

RESULTS AND DISCUSSION

Results of the present study showed that, overall, the DS significantly affected the proximate composition of HL meat of the rabbits (Table 1).

Table 1: Proximate composition (g/100 g) of hind leg meat of rabbits divergently selected for the total body fat content (Lean *vs* Fat Lines) for 4 generations (G)

Generation (G)	**I**				**II**				**III**				**IV**				**Sign.**
Line	Lean	Fat	MSE[1]	Sign.	Lean	Fat	MSE[1]	Sign.	Lean	Fat	MSE[1]	Sign.	Lean	Fat	MSE[1]	Sign.	G
Water	75.1	74.8	0.87	ns	75.2	74.4	0.66	**	74.1	73.3	0.61	**	76.2	75.0	0.74	***	***
Protein	19.1	19.0	0.87	ns	18.9	19.1	0.27	**	19.0	19.0	0.35	ns	17.9	18.1	0.62	ns	***
Lipids	4.62	5.03	0.87	ns	4.76	5.35	0.51	**	5.52	6.27	0.65	**	4.73	5.58	0.56	***	***
Ash	1.26	1.26	0.14	ns	1.17	1.15	0.05	ns	1.44	1.42	0.10	ns	1.23	1.31	0.12	ns	***

[1]Mean square error. **: P<0.01; ***: P<0.001.

In the Generation I, the two rabbit Lines were similar in terms of HL meat quality. From generation II, however, Fat rabbits started displaying a higher lipids content compared to Lean rabbits (P<0.01), to the detriment of the water (P<0.01) and protein (P<0.01) content. These differences were maintained through generations III and IV. In relation to this trend, the sole exception regarded the protein content which did not differ between Lean and Fat rabbits in the subsequent III and IV generations. In generation IV, Lean rabbits were characterised by a leaner and by a higher water content of HL meat (4.73 vs 5.58 g lipids /100 g meat, 76.2 vs 75.0 g water /100 g meat; P<0.001) compared to Fat rabbits. This finding highlighted that the desired objective of the DS was reached: Lean rabbits provided meat with a reduced fat content which is in line with current consumer preference (Cullere and Dalle Zotte, 2018). To the other hand, the HL meat of Fat rabbits displayed higher IMF content, which suggests that the selection strategy also effectively worked in the opposite direction to improve the body fat depots, thus indicating that it is possible to improve the body condition of rabbit does, the latter being a key factor of enhancing does reproduction efficiency (Castellini *et al.*, 2010). The constant differentiation of the Lean and Fat lines due to the action of the DS was also highlighted by the overall effect of the generation, which demonstrated significant results for all the studied traits (P<0.001). Results of our experiment are consistent with previous findings concerning the possibility to divergently select rabbits for high HL muscle volume and low fat depot volume (Szendrő *et al.*, 2012), thus highlighting the efficacy of this selection strategy by CT on the rabbit species. Table 2 depicts the effect of the rabbit lines on the FA profile of their HL meat, analysed at generation IV of DS.

Table 2: Fatty acid profile (% total FA methyl esters) of hind leg meat of rabbits divergently selected for the total body fat content at generation IV (Lean vs Fat Lines)

Generation		**IV**		
Line	**Lean**	**Fat**	**MSE[1]**	**Sign.**
C6:0	0.23	0.16	0.02	ns
C10:0	0.30	0.24	0.02	ns
C12:0	0.27	0.20	0.02	ns
C14:0	1.83	2.27	0.06	***
C15:0	0.57	0.46	0.02	*
C16:0	24.4	25.5	0.30	ns
C17:0	0.78	0.65	0.02	***
C18:0	8.60	7.54	0.10	***
C20:0	0.30	0.22	0.04	ns
C22:0	0.13	0.10	0.01	ns
C14:1	0.13	0.17	0.01	**
C15:1	0.08	0.08	0.01	ns
C16:1	1.28	2.84	0.10	***
C17:1	0.25	0.30	0.01	*
C18:1 *n*-9	24.4	27.0	0.33	***
C18:1 *n*-11	1.24	1.28	0.04	ns
C20:1 *n*-9	0.32	0.37	0.03	ns
C22:1 *n*-9	0.19	0.12	0.01	**
C18:2 *n*-6 ct	23.3	21.3	0.60	ns
C18:3 *n*-6	0.17	0.18	0.02	ns
C20:2 *n*-6	0.14	0.12	0.02	ns
C20:3 *n*-6	0.28	0.18	0.03	*
C20:4 *n*-6	2.65	1.69	0.16	***
C22:2 *n*-6	0.08	0.07	0.01	ns
C18:3 *n*-3	1.43	1.59	0.07	ns
C20:3 *n*-3	0.15	0.15	0.02	ns
C20:5 *n*-3	0.12	0.09	0.01	ns
C22:6 *n*-3	0.04	0.03	0.00	ns
SFA	37.5	37.4	0.41	ns
MUFA	27.9	32.1	0.38	***
PUFA	28.4	25.4	0.73	*
UFA/SFA	1.53	1.56	0.03	ns
n-6	26.6	23.6	0.67	*
n-3	1.74	1.88	0.07	ns
n-6/*n*-3	16.1	13.0	0.34	***
PI[2]	39.9	34.0	1.09	**

[1]Mean square error. [2]PI: Peroxidability index = (% monoenoic x 0.025) + (% dienoic x 1) + (% trienoic x 2) + (% tetraenoic x 4) + (% pentaenoic x 6) + (% hexaenoic x 8); *: P<0.05; **: P<0.01; ***: P<0.001.

Despite some SFA differences in the two rabbit Lines, the sum of total SFA remained unaffected. Diversely, the DS significantly changed both MUFA (P<0.001) and PUFA percentages (P<0.05). Specifically, the Lean line had a lower proportion of MUFA and a higher proportion of PUFA than the Fat line. In the case of MUFA, this was mainly attributable to C18:1 *n*-9 and C16:1 FA, whereas in the case of PUFA the C20:3 *n*-6 and the C20:4 *n*-6 FA were mainly responsible for the change (P<0.01). Notably, the overall *n*-3 PUFA fraction remained unaffected. This led to another finding: the selection for higher total body fat content resulted in healthier meat due to the observed negative relationship between the total body fat content (Fat line) and the *n*-6/*n*-3 ratio. Similar changes, with some exceptions, were described by Martinez-Alvaro *et al.* (2016, 2018) who divergently selected rabbits for IMF content. They also proved that FA profile of loin meat showed high heritability, and found positive correlations between IMF and carcass fat depots, and between IMF content and MUFA; however, contrary to our results, they found negative correlations with n-3 PUFA. The FA profile change found in our study changed the susceptibility of meat lipids to the oxidative phenomena, highlighted by the lower peroxidability index in the Fat line compared to the Lean line (P<0.01).

CONCLUSIONS

The divergent selection by CT on total body fat content was effective in obtaining HL meat with different lipids content, but maintaining the same protein amounts, thus satisfying the objective of the present study. The selection process also modified the FA profile of the rabbit meat: the Fat line had the lower *n*-6/*n*-3, thus producing healthier meat.

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RABBIT DIVERGENT SELECTION FOR TOTAL BODY FAT CONTENT:

EFFECT ON PROXIMATE COMPOSITION AND FATTY ACID PROFILE OF MEAT

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12th World Rabbit Congress November 3-5 2021 – Nantes France

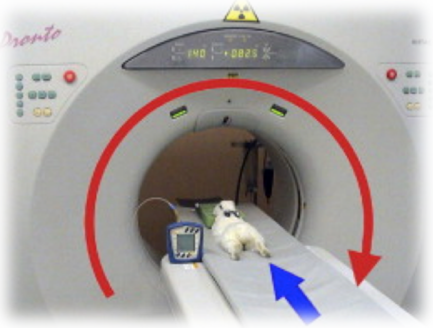
INTRODUCTION

- **Genetics, age, and feeding strategy** are the **most effective** tools to modify the **carcass** and **meat quality** of **rabbits**

- The potential of **divergent genetic selection** has been **extensively applied and studied** in **rabbits** with different purposes: **to improve live performance, reproductive performance, carcass yield, meat and fat content**

OBJECTIVE

TO INVESTIGATE THE EFFECT OF A DIVERGENT SELECTION FOR TOTAL BODY FAT CONTENT (LEAN *VS* FAT) OF 10-WEEK-OLD RABBITS (PANNON KA), MEASURED BY COMPUTER TOMOGRAPHY (CT) ON THEIR MEAT QUALITY



Computer Tomography (CT)

Animal Selection
(for trial)

Meat Quality

- **Results** from the first **2 generations** of selection **displayed** its **effectiveness** in **modifying** the **carcass fatness significantly**, thus the **research continued** until the **fourth generation…….**

MATERIAL AND METHODS

Experiment Layout

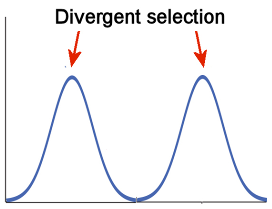
- Feed (pellet) and water: *ad libitum*
- Morbidity and Mortality were daily monitored

ANIMAL SELECTION

Computer Tomography (CT) »

(Pannon Ka)

- First Generation
- Second Generation
- Third Generation
- Fourth Generation



Highest fat index (Fat Line)

Lowest fat index (Lean Line)

Slaughtered (age of 11 weeks)

MATERIAL AND METHODS

Samples collection

- **Hind legs**
  n=120 (15 hind legs x 2 Lines x 4 Generations)

Chemical analyses

- **Proximate composition**
- **Fatty acid profile**

Computations and Statistical analysis

- **Proximate composition**
- **Fatty acid profile**

Deboned>Ground>Freeze Dried>Ground

RESULTS

PROXIMATE COMPOSITION (g/100 g MEAT) OF HIND LEG MEAT OF RABBITS DIVERGENTLY SELECTED FOR THE TOTAL BODY FAT CONTENT (LEAN *VS* FAT LINES) FOR GENERATIONS I AND II

Generation	I		
Line	Lean	Fat	Sign.
Water	75.1	74.8	ns
Lipids	4.62	5.03	ns
Protein	19.1	19.0	ns
Ash	1.26	1.26	ns

ns: not significant

Generation	II		
Line	Lean	Fat	Sign.
Water	75.2	74.4	**
Lipids	4.76	5.35	**
Protein	18.9	19.1	**
Ash	1.17	1.15	ns

**: P<0.01; ns: not significant

RESULTS

PROXIMATE COMPOSITION (g/100 g MEAT) OF HIND LEG MEAT OF RABBITS DIVERGENTLY SELECTED FOR THE TOTAL BODY FAT CONTENT (LEAN *VS* FAT LINES) FOR GENERATIONS III AND IV

Generation	III		
Line	Lean	Fat	Sign.
Water	74.1	73.3	**
Lipids	5.52	6.27	**
Protein	19.0	19.0	ns
Ash	1.44	1.42	ns

**: P<0.01; ns: not significant

Generation	IV		
Line	Lean	Fat	Sign.
Water	76.2	75.0	***
Lipids	4.73	5.58	***
Protein	17.9	18.1	ns
Ash	1.23	1.31	ns

***: P<0.001; ns: not significant

Considering the overall 4 generations, the divergent selection reached the target to differentiate the lipid content of Lean and Fat rabbit lines (P<0.0001)

RESULTS

THE MAIN FATTY ACID CLASSES (% total FAME) OF HIND LEG MEAT OF RABBITS DIVERGENTLY SELECTED FOR THE TOTAL BODY FAT CONTENT (LEAN *VS* FAT LINES)

Generation	IV		
Line	Lean	Fat	Sign.
Total SFA	37.5	37.4	ns
Total MUFA	27.9	32.1	***
Total PUFA	28.4	25.4	*
Total *n*-6	26.6	23.6	*
Total *n*-3	1.74	1.88	ns
n-6/*n*-3	16.1	13.0	***
PI	39.9	34.0	**

*: P<0.05; **: P<0.01; ***: P<0.001; ns: not significant

RESULTS

FATTTY ACID PROFILE (% total FAME) OF HIND LEG MEAT OF RABBITS DIVERGENTLY SELECTED FOR THE TOTAL BODY FAT CONTENT (LEAN *VS* FAT LINES)

MONOUNSATURATED FATTY ACIDS

Generation	IV		
Line	Lean	Fat	Sign.
C22:0	0.13	0.10	ns
C14:1	0.13	0.17	**
C15:1	0.08	0.08	ns
C16:1	1.28	2.84	***
C17:1	0.25	0.30	*
C18:1 *n*-9	24.4	27.0	***
C18:1 *n*-11	1.24	1.28	ns
C20:1 *n*-9	0.32	0.37	ns
C22:1 *n*-9	0.19	0.12	**

*: P<0.05; **: P<0.01; ***: P<0.001; ns: not significant

POLYUNSATURATED FATTY ACIDS

Generation	IV		
Line	Lean	Fat	Sign.
C18:2 *n*-6 *ct*	23.3	21.3	ns
C18:3 *n*-6	0.17	0.18	ns
C20:2 *n*-6	0.14	0.12	ns
C20:3 *n*-6	0.28	0.18	*
C20:4 *n*-6	2.65	1.69	***
C22:2 *n*-6	0.08	0.07	ns
C18:3 *n*-3	1.43	1.59	ns
C20:3 *n*-3	0.15	0.15	ns
C20:5 *n*-3	0.12	0.09	ns
C22:6 *n*-3	0.04	0.03	ns

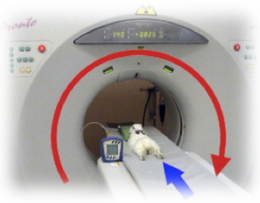
*: P<0.05; **: P<0.01; ***: P<0.001; ns: not significant

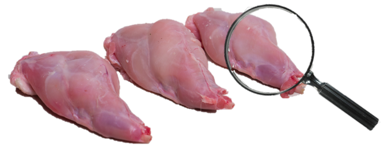
CONCLUSIONS

The divergent selection by CT:

Is effective in producing hind leg meat with different fat content, and maintained the same protein amounts

The selection process also modified the FA profile of the rabbit meat, thus the Fat line had the lower *n*-6/*n*-3, thus producing healthier meat





Thanks!

Any questions?

Fatty acid profile (% total FAME) of hind leg meat of rabbits divergently selected for the total body fat content (Lean vs Fat Lines)

Generation (G)		IV	
Line	Lean	Fat	Sign.
C6:0	0.23	0.16	ns
C10:0	0.30	0.24	ns
C12:0	0.27	0.20	ns
C14:0	1.83	2.27	***
C15:0	0.57	0.46	*
C16:0	24.4	25.5	ns
C17:0	0.78	0.65	***
C18:0	8.60	7.54	***
C20:0	0.30	0.22	ns
C22:0	0.13	0.10	ns
C14:1	0.13	0.17	**
C15:1	0.08	0.08	ns
C16:1	1.28	2.84	***
C17:1	0.25	0.30	*
C18:1 n-9	24.4	27.0	***
C18:1 n-11	1.24	1.28	ns
C20:1 n-9	0.32	0.37	ns
C22:1 n-9	0.19	0.12	**
C18:2 n-6 ct	23.3	21.3	ns
C18:3 n-6	0.17	0.18	ns
C20:2 n-6	0.14	0.12	ns
C20:3 n-6	0.28	0.18	*
C20:4 n-6	2.65	1.69	***
C22:2 n-6	0.08	0.07	ns
C18:3 n-3	1.43	1.59	ns
C20:3 n-3	0.15	0.15	ns
C20:5 n-3	0.12	0.09	ns
C22:6 n-3	0.04	0.03	ns

*: P<0.05; **: P<0.01; ***: P<0.001