# The Fatty Acids Profile of Intramuscular Fat in the Muscle Tissue of Large White and Landrace Pig Breeds

**Olena Kaniuka[1], Olena Metlytska[1]**
[1]*Poltava Scientifc Research Forensic Center Of The Ministry Of Internal Affairs Of Ukraine, Poltava, Ukraine*

***Keywords:*** *pigs, muscle tissue, fatty acids, iodine value, atherogenic index.*

***Abstract.*** *The purpose of this study was to compare the fatty acid profile of intramuscular fat (IMF) in semimembranosus, longissimus dorsi, ventral serratus, rectus abdominis, costal part of the diaphragm, and trapezius muscles in Large White and Landrace pigs.*

*Samples were taken from pair carcasses of pigs at the Taurian Bacon slaughterhouse of ZAO "Freedom Farm Bacon", Kherson. The fatty acid composition of the muscles of the Large White and Landrace pig breeds is similar to each other, especially in m. longisimus dorsi. The greatest differences in fatty acid composition at the interbreed level were noted only for m. semimembranosus ($p > 0.05$, difference is not statistically significant). The lack of statistically significant differences in the composition of fatty acids in different muscles may be due to the insufficient sample size and genetic relatedness of the selected breeds. The largest, statistically significant differences were found in the content of fatty acids in the muscles of different groups, which is associated with the peculiarities of their structure and metabolism. Meat of Large White and Landrace pigs, grown in ZAO "Freedom Farm Bacon" in terms of iodine value met the requirements of processing technology, and the ratio of PUFA/SFA in muscle tissues exceeded the recommended norms by 2 times with overestimated values of the atherogenic index in m. semimembranosus.*

## Introduction

Animal muscle tissue is the main human food, due to the high content of complete proteins, essential amino acids, fats, vitamins A, E, D, F and a number of trace elements. Pork and products made from it are traditionally used as food by the population living on the territory of Ukraine, which is an important element of national food traditions (Makedonskyi & Babaiev, 2009). At present, the requirements of the modern market are not only related to the sale of products of high palatability and manufacturability, but also specific properties related to human health, in which the content and the profile of fatty acids (FA) are important factors.

Animal fats (with the exception of fish oil), including pig lard, generally contain a higher proportion of saturated fatty acids (SFA) than most vegetable oils, which are predominantly unsaturated (UFA) fatty acids. It has been shown that excessive consumption of SFA in humans is associated with an increase in low-density lipoprotein cholesterol and can potentially lead to obesity, insulin resistance, liver steatosis, the development of coronary heart disease and oncological diseases (colon, breast and prostate cancer) (Rubio, Martinez et al., 2008). On the contrary, the introduction of a balanced amount of UFA into the daily diet reduces the risk of developing atherosclerosis and coronary heart disease (Picklo, Idso et al., 2017). Therefore, an important factor in assessing the dietary value of meat products is to determine the balance of saturated and unsaturated fatty acids UFA/SFA, as well as to calculate the potential health risk, i.e., the atherogenic index (AI), which takes into account those fatty acids that affect changes in cholesterol levels (Stajića, Zivkovića et al., 2011).

The process of obtaining "dietically healthy meat" is possible by introducing unsaturated fatty acids of plant origin into the diet of pigs (Coates & Ayerza, 2009). However, significant problems arise in the processing of such products, since negative correlations have been established between a high content of UFA and organoleptic indices of meat, its shelf life and other technological parameters (Bryhni, Kjos et al., 2002).

The main standard for a comprehensive assessment of the meat products quality is the chemical composition of *m. longissimus dorsi* in animals. With the development of industrial technologies for pork processing, changes in the quality parameters of meat (decrease in the content of intramuscular fat, marbling of meat) in connection with selection aimed at reducing the lard content pig carcasses, it has become necessary to study the quantitative and qualitative composition of fatty acids of various muscles in pigs (Kouba, Enser, et al., 2003; Puig-Oliveras, Ramayo-Caldas, et al., 2014). In its turn, the amount and composition of subcutaneous and intramuscular fat (IMF) and fatty acids (FA) are important characteristics for the quality indices of processed and fresh meat products (Zappaterra, Gioiosa, et al., 2021).

Correspondence to Olena Kaniuka, Poltava Scientific Research Forensic Center Of The Ministry Of Internal Affairs Of Ukraine, 8 Rybalsky Lane, Poltava, 36004 Ukraine.
E mail: olekanyuka@gmail.com

However, the composition of fatty acids in different groups of animal muscle tissue differs significantly in different species (monogastric, ruminant, poultry) (Smith, Fletcheer et al., 1993; Wood, Enser et al., 2008). For pigs, the fatty acid composition of different muscle tissues has been relatively studied, but the results obtained are very controversial (Zappaterra, Gioiosa et al., 2021). The deposition of lipids in different muscles of pigs is influenced by a whole range of factors, among which the key ones are gender, age, live weight at slaughter (Minelli, Macchioni et al., 2019), feeding and maintenance features (Puig-Oliveras, Ramayo-Caldas et al., 2014), genetic characteristics of breeds and direction of their productivity (Wood, Enser et al., 2008; Piedrafita, Christian et al., 2001).

Thus, the purpose of this study is to clarify the composition of fatty acids in various pig muscles of two breeds – Large White and Landrace – in order to select further strategies for improving carcass meatiness and palatability of meat through selection and correction of diets. Promising fields for further research are the assessment of the negative impact of fatty acid composition of different pig muscle groups on human health when they are consumed, as well as the role of artificial selection of pigs in modifying the structure and biochemical processes in their muscle tissues.

## Materials and Methods

We studied the muscle tissue of pigs of two breeds – Landrace (n = 5) and a Large White breed (n = 5) of English selection (neuter boars). When choosing experimental animals, the rule of pairs of analogues was observed, and fattening pigs were kept in the same conditions (group pens) in accordance with the minimum standards for their protection. Animals were fed with standard complete feeds, taking into account the nutritional and energy requirements for fattening pigs, with the inclusion of premixes from the English company FRANK WRIGHT. Pigs were slaughtered when they reached a live weight of 96–112 kg at the age of 5.5–6 months. Samples of muscle tissues were taken from pair carcasses of pigs at the "Taurian Bacon" slaughterhouse of ZAO "Freedom Farm Bacon", Kherson. All animals were slaughtered in accordance with the technical conditions and instructions approved by the enterprise, followed by veterinary control. Pig muscles studied were *longisimus dorsi, serratus ventralis, pars costalis diafragmatis, rectus abdominis, trapezius, and semimembranosus*.

The study was carried out in accordance with the "Rules for the use and keeping of animals for experiments and other purposes".

To determine the content of fatty acids in muscle tissue, we used the method in our own developed modification. A Crystal 2000M chromatograph was used with an HP FFAP 50 m × 0.32 mm × 0.2 μm capillary column loaded with a phthalates-modified PEG-20M stationary phase. Carrier gas was nitrogen, column temperature was 210°C, detector temperature was 250°C, and evaporator temperature was 220°C. To identify the results obtained, substances with a known fatty acid composition were used, namely butter and coconut oil, sunflower oil and methyl stearate. Quantification was performed using internal normalization.

The sum of all components' peaks in the test sample was taken as 100%. To extract lipids, muscle tissue was crushed and dried to an air-dry state. A sample weighing 0.5 g was taken, 3 mL of hexane was added, thoroughly shaken for 2 minutes, and the mixture was heated to boiling. It was centrifuged for 5 minutes at 2000 rpm. 2 mL of the extract was decanted, 0.5 mL of 10% sodium methoxide was added in methanol and shaken vigorously for 2 minutes. After settling (5 min), a sample of the upper transparent layer with the volume of 3 μL was taken, which was introduced into the chromatograph evaporator for analysis using a microsyringe.

Fatty acids were divided into the following categories: saturated fatty acids (SFA), unsaturated fatty acids (UFA), including monounsaturated fatty acids (MUFA) and polyunsaturated fatty acids (PUFA).

### Statistical analysis

The data were analyzed using one-way analysis of variance (ANOVA) with Excel software. The statistical characteristics of the sample (arithmetic mean – M, standard error – SE) were calculated using the Excel software. Significance was determined at $p < 0.05$ and $p < 0.01$.

The content of fatty acids in various muscles of pigs associated with the formation of cholesterol when consumed by humans was calculated using the atherogenic index (AI) according to the formula (Vesely, Krizova et Al., 2009):

$$AI = \frac{C12 + 4 \times C14 + C16}{\sum UFA}$$

where: UFA – unsaturated fatty acids; C12 – lauric acid; C14 – myristic acid, C16 – palmitic acid.

The mean values of the fatty acids' content were used in the calculations. The ratio of polyunsaturated and saturated (PUFA/SFA), unsaturated and saturated (UFA/SFA) fatty acids was determined for each of the studied pig muscles of both breeds.

The iodine value (IV) of intramuscular fat in each of the studied pig muscles was calculated by the formula (Lo Fiego, Minelli et al., 2016):

$$IV = 85.703 + [C14:0] \times 2.740 - [C16:0] \times \times 1.085 - [C18:0] \times 0.710 + [C18:2] \times 0.986,$$

where C14:0 is myristic acid, C16:0 is palmitic acid, C18:0 is stearic acid, C18:2 is linoleic acid.

## Results

When comparing the results of the analysis on the percentage of fatty acids in various muscles and the value of individual SFA, UFA, MUFA and PUFA in intramuscular fat (IMF) of large white pigs, a significant trend was found (Table 1).Thus,

*Table 1.* Fatty acids content of the different muscles of Large White pig breed (means ± SE, n = 5)

| Fatty acids | *m. longisimus dorsi* | *m. serratus ventralis* | *pars costalis diafragmatis* | *m. rectus abdominis* | *m. trapezius* | *m. semimem-branosus* | Significance |
|---|---|---|---|---|---|---|---|
| C 8:0 | 0.034 ± 0.007 | 0.049 ± 0.001 | 0.087 ± 0.008 | 0.071 ± 0.001 | 0.059 ± 0.001 | 0.094 ± 0.008 | ** |
| C 10:0 | 0.250 ± 0.041 | 0.194 ± 0.001 | 0.221 ± 0.014 | 0.260 ± 0.001 | 0.227 ± 0.002 | 0.357 ± 0.010 | ** |
| C 12:0 | 0.146 ± 0.018 | 0.122 ± 0.001 | 0.129 ± 0.005 | 0.162 ± 0.001 | 0.132 ± 0.001 | 0.381 ± 0.041 | ** |
| C 14:0 | 2.015 ± 0.175 | 1.771 ± 0.002 | 1.723 ± 0.016 | 2.062 ± 0.001 | 1.892 ± 0.002 | 2.596 ± 0.026 | ** |
| C 16:0 | 30.669 ± 1.500 | 27.911 ± 0.057 | 28.868 ± 0.150 | 30.471 ± 0.020 | 28.472 ± 0.029 | 34.892 ± 0.143 | NS |
| C 18:0 | 11.026 ± 1.037 | 13.709 ± 0.011 | 17.061 ± 0.030 | 13.438 ± 0.034 | 12.461 ± 0.017 | 8.861 ± 0.052 | ** |
| C 20:0 | 0.094 ± 0.042 (n = 2) | 0.112 ± 0.007 | 0.115 ± 0.000 (n = 1) | – | 0.095 ±0.005 | – | NS |
| SFA | 44.176 ± 1.412 | 43.868 ± 0.062 | 48.112 ± 0.160 | 46.463 ± 0.035 | 43.337 ± 0.023 | 47.180 ± 0.142 | NS |
| C 16:1 | 5.233 ± 0.540 | 3.444 ± 0.006 | 2.691 ± 0.030 | 3.648 ± 0.020 | 4.167 ± 0.006 | 5.875 ± 0.099 | ** |
| C 18:1 | 46.039 ± 1.114 | 44.085 ± 0.007 | 40.291 ± 0.157 | 41.771 ± 0.030 | 45.649 ± 0.038 | 43.075 ± 0.145 | NS |
| C 18:2 | 4.140 ± 0.388 | 7.530 ± 0.021 | 8.278 ± 0.073 | 7.366 ± 0.010 | 6.078 ± 0.026 | 3.566 ± 0.206 | ** |
| C 18:3 | 0.384 ± 0.087 (n = 3) | 0.500 ± 0.006 | 0.533 ± 0.006 | 0.438 ± 0.0063 | 0.322 ± 0.003 | – | * |
| C 20:1 | 0.452 ± 0.042 (n = 2) | 0.573 ± 0.039 | 0.479 ± 0.000 (n = 1) | 0.313 ± 0.029 | 0.446 ±0.024 | – | ** |
| UFA | 55.824 ± 1.412 | 56.132 ± 0.062 | 51.888 ±0.160 | 53.537 ± 0.035 | 56.663 ± 0.023 | 52.820 ± 0.142 | NS |
| MUFA | 51.724 ± 1.018 | 48.102 ± 2.524 | 46.39 ±1.884 | 45.732 ±1.980 | 50.511 ± 3.545 | 48.950 ± 2.431 | NS |
| PUFA | 4.524 ± 0.472 | 8.030 ± 0.415 | 8.811 ± 0.626 | 7.804 ± 0.698 | 6.400 ± 0.557 | 3.566 ± 0.206 | ** |
| UFA/SFA | 1.263 | 1.280 | 1.078 | 1.152 | 1.307 | 1.120 | |
| PUFA/SFA | 0.102 | 0.183 | 0.183 | 0.168 | 0.148 | 0.076 | |
| IV | 54 | 58 | 55 | 56 | 57 | 52 | |
| AI | 0.70 | 0.63 | 0.70 | 0.73 | 0.64 | 0.86 | |

NS: non-significant differences ($p > 0.05$).
* Mean value in rows differ at $p \leqslant 0.05$.
** Mean value in rows differ at $p \leqslant 0.01$.

for saturated fatty acids (SFA) within the compared muscles, the difference was statistically significant ($p \leqslant 0.01$), with the exception of palmitic acid, the value of which ranged from 27.911% in *m. serratus ventralis* up to 34.892% in *m. semimembranosus*. In animals of the Large White breed, no significant ($p > 0.05$) differences were found in the content of C20:0, C18:1, SFA, UFA and MUFA in the studied muscles. The results showed a statistically significant difference between the content of other fatty acids in the studied muscle groups ($p < 0.05$). The highest content of saturated fatty acids (C8:0, C10:0, C12:0, C14:0) was observed in *m. semimembranosus* and was statistically significantly different from other muscles ($p < 0.01$). The largest amount of stearic acid (C18:0) was noted in the *pars costalis diafragmatis* at the level of 17.061%, with the minimum value of this parameter in m. *semimembranosus* – 8.861% ($p < 0.05$).

The largest contribution to the value of monounsaturated fatty acids in intramuscular pork fat is made by oleic acid, the values of which for the Large White breed ranged from 40.291% pars *costalis diafragmatis* to the maximum of 46.039% in *m. longisimus dorsi* ($p > 0.05$). For fatty acid 20:1, the differences in values in the muscles of different groups were statistically significant ($p \leqslant 0.01$) and ranged within 0.313–0.573% with the complete absence of its content in *m. semimembranosus*. Statistically significant differences in the concentration of polyunsaturated fatty acids – linoleic (C18:2) and linolenic (C18:3) – were noted within the compared muscle groups ($p \leqslant 0.01$, $p < 0.05$, respectively). We separately note the absence of the important essential linolenic acid in *m. semimembranosus* of Large White pig breed.

The highest concentration of polyunsaturated fatty acids (PUFA) necessary for human health was found in the *pars costalis diafragmatis* – 8.811%, while the most optimal values of PUFA/SFA and AI were found in *m. serratus ventralis* – 0.183% and 0.626%, respectively. It should be noted that intramuscular fat m was characterized by the highest absolute value of the atherogenicity index in *m. semimembranosus*, i.e. 0.864, with the lowest iodine value among the studied muscle groups being 52.183.

Table 2 shows the percentage of fatty acids in various muscles and the proportions of individual SFA, UFA, MUFA and PUFA in intramuscular fat (IMF) of Landrace pigs.

As a result of the analysis of the results obtained, in most cases, similar patterns were observed in the absence of significant ($p > 0.05$) differences in the content of C16:0, C20:0, C18:1, SFA, UFA and MUFA in the studied muscles of Landrace pigs. The highest content of saturated fatty acids (C8:0, C10:0, C14:0 at $p < 0.01$, C12:0 at $p < 0.05$) was observed in *m. semimembranosus*. The maximum C18:0 values were also found for *pars costalis diafragmatis* at the concentration similar to that of the Large White muscle, 17.119%.

The nature of the distribution of monounsaturated fatty acids in different muscle groups of Landrace animals was somewhat different in the absence of statistically significant patterns: the maximum value of oleic acid (C18:1) was found in *m. serratus ventralis* (45.086%) with the minimum of this index for *m. semimembranosus* – 41.228%. By analogy with the Large White breed, in *m. semimembranosus* landrace C20:1 was not found.

It should be noted that within the compared muscles, the content of the essential polyunsaturated fatty acid C18:3 differed statistically significantly ($p < 0.01$), and its highest concentration, 0.795%, was recorded in *m. semimembranosus* of Landrace pigs in the absence of this fatty acid in the similar muscle in individuals of the Large White breed ($p > 0.05$).

When comparing the calculated UFA/SFA, PUFA/SFA, AI indices for different muscles in representatives of the Large White and Landrace breeds (Fig. 1), similar

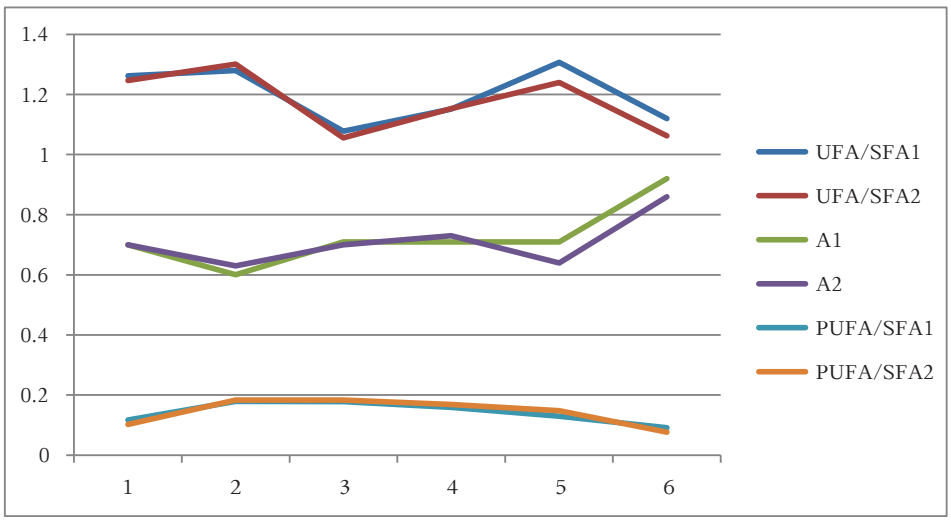


*Fig. 1.* Comparative characteristics of the values in the indices UFAs/SFA, PUFAs/SFA, AI in various muscles of the Large White (1) and Landrace (2) animals. Along the abscissa: 1. *m. longisimus dorsi*; 2. *m. serratus ventralis*; 3. *pars costalis diafragmatis*, 4. *m. rectus abdominis; 5. m. trapezius*; 6. *semimembranosus*.

*Table 2.* Fatty acids content in different muscles of Landrace pig breed (means ± SE, n = 5)

| Fatty acids | *m. longisimus dorsi* | *m. serratus ventralis* | *pars costalis diafragmatis* | *m. rectus abdominis* | *m. trapezius* | *m. semimem-branosus* | Significance |
|---|---|---|---|---|---|---|---|
| C 8:0 | 0.041 ± 0.014 | 0.051 ± 0.001 | 0.055 ± 0.001 | 0.053 ± 0.001 | 0.081 ± 0.001 | 0.100 ± 0.002 | ** |
| C 10:0 | 0.248 ± 0.061 | 0.167 ± 0.001 | 0.169 ± 0.001 | 0.213 ± 0.002 | 0.260 ± 0.002 | 0.458 ± 0.007 | ** |
| C 12:0 | 0.166 ± 0.046 | 0.106 ± 0.001 | 0.108 ± 0.001 | 0.130 ± 0.001 | 0.145 ± 0.001 | 0.223 ± 0.033 | * |
| C 14:0 | 2.087 ± 0.204 | 1.594 ± 0.002 | 1.655 ± 0.003 | 1.935 ± 0.002 | 1.961 ± 0.006 | 2.704 ± 0.030 | ** |
| C 16:0 | 30.479 ± 1.390 | 27.535 ± 0.022 | 29.469 ± 0.022 | 30.299 ±0.022 | 30.379 ± 0.037 | 36.254 ± 0.285 | NS |
| C 18:0 | 11.427 ± 1.368 | 13.851 ± 0.010 | 17.119 ± 0.009 | 13.812 ± 0102 | 11.821 ± 0.020 | 8.924 ± 0.146 | ** |
| C 20:0 | 0.158 ± 0.047 (n = 2) | 0.149 ± 0.006 | 0.119 ± 0.009 (n = 3) | – | – | – | NS |
| SFA | 44.511 ± 0.795 | 43.452 ± 0.023 | 48.647 ± 0.015 | 46.442 ± 0.032 | 44.647 ± 0.041 | 48.663 ± 0.411 | NS |
| C 16:1 | 5.148 ± 0603 | 3.115 ± 0.014 | 2.553 ± 0.007 | 3.483 ± 0.023 | 4.301 ± 0.006 | 5.670 ± 0.049 | ** |
| C 18:1 | 44.982 ± 0.535 | 45.086 ± 0.017 | 39.735 ± 0.050 | 42.320 ± 0.034 | 44.995 ± 0.052 | 41.228 ± 0.376 | NS |
| C 18:2 | 4.869 ± 0.701 | 7.345 ± 0.011 | 8.131 ± 0.005 | 6.983 ± 0.020 | 5.418 ± 0.025 | 3.645 ± 0.094 | ** |
| C 18:3 | 0.347 ± 0.080 (n = 4) | 0.441 ± 0.009 | 0.507 ± 0.008 | 0.408 ± 0.013 | 0.342 ± 0.009 | 0.795 ± 0.070 | ** |
| C 20:1 | 0.530 ± 0.138 (n = 2) | 0.561 ± 0.048 | 0.427 ± 0.038 | 0.363 ± 0.011 | 0.296 ± 0.032 | – | ** |
| UFA | 55.489 ± 0.795 | 56.548 ± 0.023 | 51.353 ± 0.015 | 53.558 ± 0.032 | 55.353 ± 0.041 | 51.676 ± 0.411 | NS |
| MUFA | 50.660 ± 0.457 | 48.762 ± 2.509 | 42.695 ± 2.605 | 46.166 ± 2.050 | 49.592 ± 1.534 | 46.898 ± 1.486 | NS |
| PUFA | 5.216 ± 0.761 | 7.786 ± 0.173 | 8.638 ± 0.688 | 7.391 ± 0.464 | 5.760 ± 0.232 | 4.440 ± 0.435 | ** |
| UFA/ SFA | 1.247 | 1.301 | 1.056 | 1.153 | 1.240 | 1.062 | |
| PUFA/SFA | 0.117 | 0.179 | 0.178 | 0.159 | 0.129 | 0.091 | |
| IV | 55 | 58 | 54 | 55 | 55 | 51 | |
| AI | 0.70 | 0.60 | 0.71 | 0.71 | 0.71 | 0.92 | |

NS: non-significant differences ($p > 0.05$).
* Mean value in rows differ at $p \leqslant 0.05$.
** Mean value in rows differ at $p \leqslant 0.01$.

trends were noted: in terms of the UFA/SFA ratio, the obtained values almost coincided even in absolute mathematical values. Some differences were found only in PUFA/SFA and AI for *m. semimembranosus*, in breeds Large White and Landrace; however, the difference between them was not statistically significant ($p > 0.05$). It should be noted that the atherogenic index had the maximum value for this particular muscle (0.864% and 0.915% for the Large White and Landrace, respectively). The most optimal ratio of PUFA/SFA of the compared muscle groups of two breeds – Large White and Landrace – in terms of the degree of negative impact on the health of consumers was noted by us for *m. serratus ventralis* (0.183% and 0.179%, respectively).

**Discussion and Conclusions**

Animal fat and fatty acids, both in adipose tissue and in muscles, make an important contribution to various aspects of meat quality and play a central role in its nutritional value. A sufficiently proven fact is the established correlation between the content of fatty acids in the diet and the deposition of fat in monogastric animals, which include pigs. Thus, the technological and palatability of meat can be controlled by saturating pig diets with unsaturated vegetable fats and antioxidants (Wood, Enser et al., 2008). The exploration of fatty acids composition in different muscle groups of pigs in this study showed that their distribution is significantly different, especially in SFA, with the exception of the dominant C16:0. The content of fatty acids in *m. longissimus dorsi* was the same ($p > 0.05$) in pigs of the compared breeds. In this study, the concentration of caprylic acid (C8:0) in *m. serratus ventralis* and *m. trapezius*, arachidic acid (C20:0) in *m. serratus ventralis* and capric acid (C10:0) in *m. semimembranosus* ($p < 0.05$) was significantly higher in Landrace pigs than in Large White ones. However, the content of some fatty acids in *m. serratus ventralis* (C12:0, C20:1), *pars costalis diafragmatis* (C8:0, C10:0, C16:1), *m. rectus abdominis* (C8:0, C10:0), *m. trapezius* (C20:1) and *m. semimembranosus* (C12:0) was higher in Large White pigs ($p < 0.05$).

The qualitative composition of fatty acids in some muscles of Landrace pigs differed from their distribution in Large White pigs. Arachidic acid (C20:0) and gondoic acid (C20:1) in *pars costalis diafragmatis* have been found in Landrace pigs. But arachidonic acid (20:0) was found in *m. trapezius* in Large White pigs only.

Of greatest interest was a comparative study on the distribution of polyunsaturated fatty acids in the intramuscular fat of Large White pigs and Landrace – linoleic and linolenic. As for C18:2, its content in the muscle tissue of most farm animals is insignificant, and a distinctive species feature of pigs is that this acid is obtained exclusively from the diet with subsequent deposition in subcutaneous and intramuscular fat, and as a result of our own research, its higher content is in *pars costalis diafragmatis* compared with other muscles.

**α**-Linolenic acid (18:3n-3) is an important essential fatty acid. Due to the low possibility of inclusion into the structure of phospholipids, its content in the muscle tissue of pigs is small and can differ significantly in different types of muscles (Wood, Enser et al., 2008). Note that the highest concentration of linolenic acid was found in the *pars costalis diafragmatis* of the Large White breed (0.533%), with its complete absence in *m. semimembranosus*, while in Landraces it was in this muscle that the maximum concentration of C18:3 was recorded – 0.795% ($p > 0.05$)

It is known that PUFA more often cause oxidative effects in muscles (Zappaterra, Gioiosa et al., 2021). Our study has shown that *m. rectus abdominis* is the most sensitive to oxidative processes in pigs of both breeds, and *m. semimembranosus* is half less susceptible to them. Thus, the uneven distribution of fatty acids that we found in various muscles of pigs can be explained from the standpoint of the metabolic hypothesis (red and white muscles). Muscles of the oxidative type (red) contain more phospholipids and cholesterol, and, accordingly, biochemical metabolism differs in different types of muscle fibers (Alasnier, Re'mignon et al., 1996).

Differences in the lipid metabolism of pig intramuscular fat can also be associated with the fact that PUFA are deposited mainly in the outer layer of the subcutaneous adipose tissue (Alasnier, Re'mignon et al., 1996; González-Domínguez, Sayago et al., 2020). It should be noted that in connection with breeding for meat, in most specialized pig breeds (Duroc, Landrace, Pietrain), there was a change in the structure of muscle fibers to their hypertrophy (changes in red fibers to white ones). At the same time, there is a change in the nature of the course of oxidative processes, especially in the muscles of the lumbar region, limbs and chest (Chizzolini, Zanardi et al., 1991). Apparently, this can explain the most significant difference in the distribution of fatty acids between the Large White and Landrace breeds in *m. semimembranosus*.

The differences in the distribution of fatty acids in different muscles of pigs of the two breeds that we noted in the course of our studies had minor differences that were not statistically significant. This phenomenon can be explained by the fact that, in the historical aspect, the Large White breed and Landrace are genealogically related, since Large White pigs were used as the mother breed in the creation of Landrace (Zeven, 1998). On the other hand, due to the intensive selection of both these breeds to reduce the lard content of carcasses, increase meatiness, growth intensity and multifetation of sows, the selection vector for the main complex of genes for quantitative traits was similar, which led to an analogy in the passage of the main biochemical processes in muscle tissues.

The quality of the adipose tissue is one of the components of quality indices of meat. One of the technological parameters of fat quality is the iodine number, which reflects the degree of its saturation with polyunsaturated fatty acids, and for most meat processing plants in the leading countries of the world, its boundary value is 70–73. Significant negative correlations were established between the iodine value and the visual color, elasticity and marbling of meat. Thus, according to the iodine value calculated in various muscles of pigs, one can judge the potential palatability of meat and the products obtained from them (Minelli, Macchioni et al., 2019).

As a result of our research, the iodine number, calculated from the ratio of fatty acids of different muscles, ranged within 52–58 for the Large White and 51–58 for the Landrace breed. At the same time, maximum IV at the most negative PUFA/SFA ratio was noted by us for *m. serratus ventralis* for pigs of both breeds. Thus, IV for the muscles of both pig breeds was significantly lower than the limiting technological value, which indicates the absence of possible defects in the quality of meat and its high ability to heat treatment without loss of taste.

In recent years, there has been a steady trend to limit the consumption of the products that can have a potentially negative impact on health. Such products, due to their high fat content, include, first of all, beef, lamb and pork. Since the most dangerous for the state of the human cardiovascular system is the consumption of products that increase the concentration of cholesterol in the blood, the negative impact of animal fats on the health of consumers can be controlled using the atherogenic index (Vesely, Krizova et al., 2009).

On average, the atherogenic index for pork is estimated at 0.6, while this index can vary significantly both in different muscle groups and in representatives of different breeds. As a result of our own study, we showed AI variation within 0.63–0.87 and 0.60–0.92 for muscles of different groups in Large White and Landrace pigs, respectively. At the same time, fat in *m. semimembranosus* and the most optimal value of the atherogenic index were calculated for *m. serratus ventralis*.

In accordance with the recommendations of nutritionists, the prevention of excess unsaturated fatty acids in food, associated with an increase in plasma cholesterol, reflects the ratio of PUFA/SFA with values of more than 0.4–0.5 (Ansorena & Astiasaran, 2004). Only pars *costalis diafragmatis* and *m. serratus ventralis* in pigs of both breeds had maximum values of PUFA/SFA in our experiment, but they were almost by 2 times lower than the recommended threshold value.

In conclusion, it is important to note that due to the increase in pork prices, for the population of most European countries, including Ukraine, the share of this meat product consumption in the diet is decreasing. Thus, the prevention of cardiovascular diseases should be aimed at balancing the diet, saturating it with fiber and antioxidants, and changing lifestyle towards increasing physical activity.

The prospect of research in the field of fat deposits control lies in the field of breeding genetics aimed at reducing the subcutaneous and visceral fat of pigs while regulating intramuscular fat to an optimal level corresponding to quality and nutritional requirements. To overcome negative genetic correlations and increase the heritability coefficient of such an important selection index as intramuscular fat, it is important to understand gene interactions at the level of biochemical metabolism of their products, primarily fatty acids.

It can be concluded that the fatty acid composition in the muscles of the Large White and Landrace pig breeds is similar to each other, especially in *m. longisimus dorsi*. The greatest differences in fatty acid composition at the interbreed level were only noted for *m. semimembranosus*.

The observed trends in the uneven distribution of individual fatty acids in different muscles of the Landrace and Large White breeds were not statistically significant, which can be explained by the insufficient number of animals in the sample, as well as the genetic relationship of the selected breeds. The largest, statistically significant differences were found in the content of fatty acids in the muscles of different groups, which is associated with the peculiarities of their structure and metabolism. Breeding for meat of Large White and Landrace pigs and the technology of their fattening at ZAO "Freedom Farm Bacon" in this experiment did not show a technological decrease in the quality of meat according to the calculated iodine value indices, but from the point of view of the consumer, it led to an unfavorable ratio of PUFA/SFA in muscle tissues and overestimated indices of the atherogenic index. The prospect of further research may be to find the best ways to improve the quality of meat, both by correcting diets and by methods of breeding improvement in pigs of specialized meat breeds.

## References


1. Alasnier C., Re´mignon H., Gandemer G. Lipid Characteristics Associated with Oxidative and Glycolytic Fibres in Rabbit Muscles. Meat Science. 1996. V. 43. P. 213–224.
2. Ansorena D, Astiasaran I. The use of linseed oil improves nutritional quality of the lipid fraction of dry-fermented sausages. Food Chemistry. 2004. V. 87(1). P. 69–78.
3. Bryhni E. A., Kjos N. P., Ofstad R., Hunt M. Polyunsaturated fat and ish oil in diets or growing-finishing pigs: Effects on fatty acid composition and meat, fat, and sausage quality. Meat Science. 2002. V.62. P. 1–8.
4. Chizzolini R.,. Zanardi E., Dorigoni V, Ghidini S. Calorific value and cholesterol content of normal and low-fat meat and meat products. Trends in Food Science and Technology. 1999. V.10. P. 119–128.
5. Coates W., Ayerza R. Chia (Salvia hispanica L.) seed as an n-3 fatty acid source for finishing pigs: Effects on fatty acid com-

position and fat stability of the meat and internal fat, growth performance, and meat sensory characteristics. Journal Animal Science. 2009. V.87. P. 3798–3804.
6. González-Domínguez R.; Sayago A.; Fernández-Recamales A. Fatty Acid Profiling for the Authentication of Iberian Hams According to the Feeding Regime. Foods 2020. V.9. P 149–153.
7. Kouba M., Enser M., Whittington F. M., Nute G. R., Wood, J. D. Effect of a high-linolenic acid diet on lipogenic enzyme activities, fatty acid composition and meat quality in the growing pig. Journal of Animal Science. 2003. V. 81. P. 1967–1979.
8. Lo Fiego D.P., Minelli G., Volpelli L.A., Ulrici A. and Macchioni P. Calculating the iodine value for Italian heavy pig subcutaneous adipose tissue from fatty acid methyl ester profiles. Meat Science. 2016. V. 122. P.132–138.
9. Minelli G., Macchioni P., Mezetti F., Belmonte A.M., Volpellia L.A, Faeti V., Lofiego D.P. Characteristics of lipids from immunocastrated medium-heavy pigs fed either a restricted diet or ad libitum. Italian Journal Food Science. 2019. V. 31. P. 98–109.
10. Makedonskyi A.V., Babaiev O.I. Stan ta osnovni napriamy pidvyshchennia rivnia intensyfikatsii vyrobnytstva u svynarstvi. Ekonomika APK. 2009. V.18. P. 30–32.
11. Piedrafita J., Christian L.L., Lonergan S.M. Fatty acid profiles in three stress genotypes of swine and relationship with performance, carcass and meat quality traits. Meat Science. 2001. V. 57. P. 71-77.
12. Picklo M. J., Idso J., Seeger D.R., Aukema H.M., Murphy E.J. Comparative effects of high oleic acid vs high mixed saturated fatty acid obesogenic diets upon PUFA metabolism in mice. Prostaglandins, Leukotrienes Essential Fatty Acid. 2017. V.19. P. 25–37.
13. Puig-Oliveras A., Ramayo-Caldas Y., Corominas J., Estellé J., Pérez-Montarelo D., Hudson N.J., Casellas J., Folch J.M., Ballester M. Differences in muscle transcriptome among pigs phenotypically extreme for fatty acid composition. PLoS One. 2014 V.9 (6). P. 1-11.
14. Rubio B., Martinez B., Garcia-Cachan M.D., Rovira .J, Jaime I. Effect of the packaging method and the storage time on lipid oxidation and colour stability on dry fermented sausage salchichon manufactured with raw material with a high level of mono and polyunsaturated fatty acids. Meat Science. 2008. V.80 (4). P. 1182–1187.
15. Smith D.P., Fletcher D.L., Buhr R.T. Beyer R. S. Pekin Duckling and Broiler Chicken Pectoralis Muscle Structure and Composition. Poultry Science. 1993. V.72. P. 202–208.
16. Stajića S., Živkovića D., Perunovića M., Šobajićb S., Vranić D. Cholesterol content and atherogenicity of fermented sausages made of pork meat from various breeds. Procedia Food Science. 2011. V1. P. 568 – 575.
17. Vesely A., Krizova L., Trinacty J., Hadrova S., Navratilova M., Herzig I., Fisera M. Changes in fatty acid profile and iodine content in milk as influenced by the inclusion of extruded rapeseed cake in the diet of dairy cows. Czech Journal Animal Science. 2009. V.54 (5). P.201–209.
18. Wood J.D., Enser M., Fisher A.V., Nute G.R., Sheard P.R., Richardson R.I., Hughes S.I., Whittington F.M. Fat deposition, fatty acid composition and meat quality: A review. Meat Science 2008. V.78. P. 343–358.
19. Zappaterra M, Gioiosa S, Chillemi G, Zambonelli P, Davoli R. Dissecting the Gene Expression Networks Associated with Variations in the Major Components of the Fatty Acid Semimembranosus Muscle Profile in Large White Heavy Pigs. Animals. 2021; V. 11 (3) P.628–743.
20. Zeven A.C. Landraces: A review of definitions and classifications. Euphytica. 1998. V. 104. P. 127–139.

*Received 19 April 2022*
*Accepted 24 May 2022*