THE INFLUENCE OF ECO-GENETIC VARIETIES OF THE MANGALIȚA BREED ON THE CHEMICAL COMPOSITION OF THE MEAT AND THE PROFILE OF FATTY ACIDS IN THE MEAT

B. Păsărin[1*], G.V. Hoha[1], C.E. Nistor[1], C. Simeanu[1]

[1]*Faculty of Food and Animal Sciences, "Ion Ionescu de la Brad" Iasi University of Life Sciences, 8 Mihail Sadoveanu Alley, 700489 Iasi, Romania*

Abstract

The growing number of consumers of meat and products derived from meat obtained from the Balkan breed of Mangalita pigs, shows a definite concern about the nutritional and healthological quality of food products derived from some breeds of pigs. This is also the reason why, for a certain period of time, the Mangalița breed has started to re-enter the attention and concerns of breeders in Romania, becoming a biological material for the export of live animals.

Within the present research protocol, the aim was to investigate the possible influences of the eco-genetic varieties belonging to Mangalița pigs (blonde, black and red-brick varieties) on the chemical composition of the meat and the profile of fatty acids, analyzes carried out at the level of the Gluteus medius muscle.

Following the research and observations undertaken, it can be stated that, although raised in the same system, fed with the same category of feed and having similar ages and body masses, the quality characteristics of the meat varied between individuals, corresponding to the eco-genetic type.

Regarding fat composition, a higher proportion of n-3 and n-6 polyunsaturated fatty acids (PUFA) was identified in pigs belonging to the red-brick variety, while the ratio between them was significantly more balanced, compared to the others varieties.

The ratio of polyunsaturated fatty acids to saturated fatty acids (PUFA/SFA) was not significantly different between groups, while the ratio of monounsaturated fatty acids to saturated fatty acids (MUFA/SFA) was significantly lower in pigs brick-red.

In conclusion, we can state that within the Mangalița breed, there are certain chemical characteristics of the meat, which vary according to the eco-genetic type, a fact that increases the importance of exploiting this breed in different technological systems.

Key words*: eco-genetic varieties, Mangalița, meat quality, color*

INTRODUCTION

One of the current trends in the food market, with strict reference to the pork market, refers to the increase and strengthening of the buyer's selectivity on the health properties of the raw material and meat derivatives. In other words, the new trend of consumers is to choose food products not only according to the external appearance and affordable price, but also taking into account their nutritional value, consistent with the ethical qualities of its production, with special reference to the welfare conditions of farm animals and the degree of impact of obtaining productions on the natural environment. Another motivation for choosing meat from the traditional pig farming system is the belief that the taste and nutritional-health values

*Corresponding author: benone.pasarin@iuls.ro
The manuscript was received: 31.10.2024
Accepted for publication: 12.11.2024

of this category of meat are superior to those of conventionally produced meat.

In this context, starting from 1990, the Mangalița Balkan breed of pigs and its eco-genetic varieties began to come back to the attention and concerns of breeders in Romania, as well as local pork consumers, a fact also due to the publication of specialized research, which highlighted certain particular aspects, of an organoleptic and physico-chemical nature, possessed by the meat and fat of this breed.

Through this research protocol, the aim was to investigate the possible differences in the physico-chemical properties and the fatty acid profile of the meat obtained from three different genetic ecotypes of the Mangalița breed, namely the red-brick variety (L1), the white (or blond) variety (L2) and the black variety (L3), raised under similar housing and feeding conditions. The slaughter weight of the specimens was close (over 120 kg), and the analyzes performed concerned the rump muscles, respectively the *Gluteus medius muscle*.

2. MATERIAL AND METHOD

2.1. Biological material and experimental samples

In order to establish the possible differences in the properties of pork, due to obtaining carcasses from different eco-genetic varieties of the Mangalița breed, work was carried out on a number of 15 carcasses, obtained from castrated males, belonging to the red-brick, white and black varieties, with body weights at slaughter relatively identical, around 120 kg.

The research was carried out on 3 experimental groups (L1-L3), corresponding to the 3 different eco-genetic types of the Mangalița breed, each lot containing 5 thawed carcasses.

The average body weight at slaughter was 125.34±3.12 kg in individuals belonging to group L1, 123.08±4.65 kg in individuals from group L2, respectively 122.12±4.12 kg in individuals from group L3, the experimental samples of non-degreased muscle being taken from the muscles of the rump, respectively from the area of the *Gluteus medius muscle*.

2.2. Analytical determinations

After slaughter, the meat and fat samples were vacuum-packed and kept frozen at approximately -20°C for further analysis. The following measurements of the chemical composition of *G. medius muscle* were performed: pH, water content, protein content, total fat, ash, total fatty acid and cholesterol concentrations, and water-to-protein ratio. The chemical composition was determined by the methods defined by the Association of Official Analytical Chemists (AOAC, 1990).

Cholesterol content was determined using HPLC/PDA on a Waters 2695 Separation module HPLC with a Waters 2996 photodiode array detector as defined by the method of Maraschielloet et al. Fatty acids in the form of methyl esters were detected by capillary gas chromatography with a flame ionization detector. A predetermined amount of lipid extracts, obtained by the rapid extraction method, was dissolved in tert-butyl methyl ether. Fatty acids were converted to fatty acid methyl esters (FAME) with trimethylsulfonium hydroxide according to SRPS EN ISO 5509:2007 method. FAMEs were analyzed with Shimadzu 2010 GC-FID (Kyoto, Japan) on cyanopropyl-aryl HP-88 column (column length 100, internal diameter 0.25 mm, film thickness 0.20 µm).

2.3. Statistical analyses

Experimental data were processed and statistically analyzed by ANOVA (Origin 8.5 software, USA) and the least squares method (LSM) by applying the GLM procedure of the SAS 9.1.3 software package (SAS Inst. Inc. 2005-2006).

Eco-genetic type and slaughter weight were entered into the model as independent variables, and when means were significantly different, Tukey's test was applied to compare sample means.

The model used for the analysis of meat and fat properties, post-sacrifice, included the eco-genetic differences of the Mangalița breed as the basic analysis, and the live weight at slaughter as a covariate.

RESULTS OBTAINED, INTERPRETATIONS AND DISCUSSIONS

1. Elements of the physico-chemical structure of meat

According to the specialized literature studied, the eco-genetic varieties lead to the appearance of physico-chemical differences in Mangalița pork (Szabó and Farkas, 2006), differences that manifest in accordance with climatic factors (Edwards, 2015 and Lebret, 2018), the quantity and quality of feed (Holló et al., 2003), as well as with the intensity of the physical effort made by pigs in order to secure feed (Gandemer et al., 1990; Bee et al., 2014).

Comparisons of the results regarding the chemical composition of samples from Mangalița pigs, belonging to different genetic ecotypes and differentiated by the variety of color, part of the eco-genetic type, are presented in tab. 1.

Table 1 Comparative data on Mangalița pork quality according to eco-genetic type

Parameter	L1-Red Mangalița (n[1] = 5)	L2-Blonde Mangalița (n = 5)	L3-Black Mangalița (n = 5)	Significance p
Humidity (%)	66.43 ± 1.12	72.31 ± 1.34	68.17 ± 1.25	**
Protein (%)	19.08 ± 0.17	23.24 ± 0.12	21.05 ± 0.12	*
Total fat (%)	37.21 ± 1.16	34.08 ± 0.10	32.16 ± 0.40	**
Mineral content (%)	0.64 ± 0.22	0.48 ± 0.04	0.61 ± 0.12	*
pH (cold)	5.81 ± 0.40	5.11 ± 0.36	5.40 ± 0.24	ns
Report a/p	3.48	3.09	3.24	ns

Note: n – number of individuals; Cold pH – pH value 24 hours after slaughter; a/p ratio – water-protein ratio; category I – meat with high nutritional value (a/p – 2.5 - 3.5); category 2nd - meat with good nutritional value (a/p – 3.5 - 4.2); ns p >0.05 * p <0.05 ** p <0.01

The data presented in tab. 1 demonstrates the fact that the eco-genetic type of pigs from the Mangalița breed, under identical conditions of feeding and maintenance of the individuals in the groups, as well as a substantially equal body weight at slaughter, generates differences for certain physico-chemical and nutritional constants in the structure of the meat.

Regarding the proportions of water and fat, the statistical analysis reveals very significant differences between the groups ($p < 0.01$), the minimum value of water being 66.43 ± 1.12% in individuals from group L1, and the maximum of 72.31 ± 1.34%, in group L2, and the proportion of fat is between 32.16 ± 0.40% in group L3 and 37.21 ± 1.16% in group L1. As is well known (Holló et al., 2004; Păsărin et al., 2023), the amount of water and protein varies in an inverse ratio, compared to the percentage of fat. Thus, the proportions of protein and mineral content showed significant differences statistically ($p < 0.05$), the minimum value, for proteins, being between a maximum of 23.24 ± 0.12% (L2) and a minimum of 19.08 ± 0.17% (L1), and for minerals content, the values were between 0.48 ± 0.04 % (L2) and 0.64 ± 0.22% (L1). The pH reaction and the a/p ratio were located at the p value >0.05, which ensured statistically insignificant differences.

2. Fat composition

The composition of saturated and unsaturated fatty acids, the ratio between them as well as the cholesterol content of the

G. medius muscle from the pigs examined by genetic varieties, belonging to the 3 experimental groups, are presented in tab. 2.

Table 2 Comparative data on total fatty acids and their different ratios

Parameter	L1-Red Mangalița (n[1] = 5)	L2-Blonde Mangalița (n = 5)	L3-Black Mangalița (n = 5)	Significance p
SFA	33,90 ± 0,34 c	32,76 ± 0,53 b	41,27 ± 0,56 a	**
MUFA	56,14 ± 0,62 b	57,96 ± 441,01 a	51,18 ± 1,06 c	**
PUFA	5,93± 0,45	6,21 ± 0,77	5,13 ± 0,81	ns
PUFA/SFA	0.17 ± 0,01 b	0,18 ± 0,31 b	0,12 ± 0,22 a	*
MUFA/SFA	1.66 ± 0.04 c	1.77 ± 0,35 b	1.24± 0,13 a	**
Total n-3 PUFA	0,49± 0,35 c	0,37 ± 0,12 b	0,57 ± 0,05 a	**
Total n-6 PUFA	6.23 ± 0.51 c	7.63 ± 0.54 b	5,80 ± 0,12 a	**
n-6/n-3 PUFA	12.71 ± 1,16 b	20.62 ± 2,20 a	10.17 ± 2,05 a	***
Cholesterol (mg/100g)	64.30 ± 1.14 b	63.50 ± 3.41 b	74.20 ± 1.02 a	**

[1] n = number of samples; [2] NS - not significant (p ≥0.05); *: Statistical significance at the p <0.05 level; **: Statistical significance at the p<0.01 level; ***: Statistical significance at the p<0.001 level; Content of SFA, MUFA, PUFA; a-c Means in a row with different superscripts differ (p<0.05).

In the study carried out, according to tab.2, the highest proportion of saturated fatty acids was found in individuals of group L3 (41.27 ± 0.56%), and the lowest in group L2 (32.76 ± 0.53%), the differences between the groups being highly statistically significant (p<0.01). According to specialized literature (Szabó et Farkas, 2006; Păsărin and all., 2023), in the fat content of the Mangalița breed, there are 12-16% less saturated fatty acids and 8-10% more unsaturated fatty acids (of type n-3 and n-6) than in improved breeds of pigs and their hybrids.

Regarding the content of meat and fat in PUFA, the highest proportion was recorded in individuals of group L2 (6.21 ± 0.77% - 100%), group L1 registering a value of 5.93 ± 0.45% - 95.5%, and L3 recording the lowest value (5.13 ± 0.81% - 82.6%)

Analyzing the ratio between polyunsaturated fatty acids (PUFA) and saturated fatty acids (SFA), by varieties and groups, it can be concluded that the ratio belonging to Mangalita blonde (group L2 - 0.18 ± 0.31%) was the highest, followed by Mangalița red (group L1 - 0.17 ± 0.01%) and Mangalița black (group L3 - 0.12 ± 0.22%), the differences between the groups being statistically significant (p < 0.05). It is well known that a lower content of saturated fatty acids and a higher proportion of unsaturated fatty acids are beneficial for human health.

Regarding the ratio between omega 6 and omega 3 unsaturated fatty acids, the results showed that the most balanced ratio was recorded by group L3 (10.17 ± 2.203%), compared to group L1 (12.71 ± 1.16%) and by L2 (20.62 ± 2.203%), the differences between the groups being distinctly significant (p < 0.001).

As I reported previously, in Subchapter 3.1., between groups and varieties of the Mangalița breed there were statistically very significant differences regarding the proportion of fat in the muscles. Compared to the amount of total fat found in different portions in lean meat, it can be seen that, although the Mangalița is a specialized breed for fat, the cholesterol content in the meat is below the recommended daily dose for an individual, that of 300 mg/day.

In the case of saturated fatty acids from *G. medius muscle*, according to tab. 3, regardless of race variety and batch, palmitic acid (C16:0) was the most abundant acid in the SFA category (20.55 ±

0.19% in L1; 23.30 ± 0.21% in L2 and 21.10 ± 0.43% in L3), the differences statistics being significant between groups ($p < 0.05$). Oleic acid (C18:1) was the most abundant of the MUFA fatty acids (43.67 ± 0.22% in L1; 43.24 ± 0.24% in L2 and 47.08 ± 0.43% in L3), the statistical differences being highly significant between groups, and linoleic acid (C18:2) was the most abundant PUFA fatty acid (4.86 ± 0.17% in group L1; 5.40 ± 0.32% in group L2, respectively 4.78 ± 0.38% in group L3, the differences between groups being statistically significant ($p < 0.05$).

Regarding the ω-6/ω-3 ratio, significantly higher compared to the norms recommended by the profile forums (British Foundation of Nutrition, 2014), it was distinctly significant between groups ($p < 0.001$), varying between a maximum of 20.62 ± 2.20, in Group L2 and a minimum of 10.17 ± 2.05, in Group L3. We remind you that at the European level, the ratio considered optimal between ω-6 and ω-3 is 5/1, but the ideal is 3/1. In reality, following many tests performed both on the Mangalița breed and on its various crossbreeds with various improved breeds, this ratio also reaches values of over 60/1 (Păsărin et al., 2022).

The imbalance of the Omega-6/Omega-3 ratio, through a high consumption of Omega 6 fatty acids, can cause inflammation in the body, immune imbalances, cardiovascular risks, as well as impaired memory and ability to concentrate.

Table 3 Dynamics of fat composition in fatty acids in different varieties of Mangaliţa

Fatty acids	L1-Red Mangalița (n[1] = 5)	L2-Blonde Mangalița (n = 5)	L3-Black Mangalița (n = 5)	Significance p
Lauric ac. C12:0	0.57 ± 0.21	0.54 ± 0.01	0.52 ± 0.16	ns
Myristic ac. C14:0	0.95 ± 0.03	1.08 ± 0.21	1.22 ± 0.11	*
Palmitic ac. C16:0	20.55 ± 0.19	23.30 ± 0.21	21.10 ± 0.43	*
Margaric ac. C17:1	0.25 ± 0.07	0.23 ± 0.51	0,24± 0.18	ns
Palmitoleic ac. C16:1	3.58 ± 0.16	4.15 ± 0.18	4.60 ± 0.51	*
Stearic ac . C18:0	10.31 ± 0.31	12.51 ± 0.42	12.30 ± 0.31	*
Oleic ac. C18:1	43.67 ± 0.22	43.24 ± 0.24	47.08 ± 0.43	**
Linoleic ac. C18:2	4.86 ± 0.17	5.40± 0.32	4.78 ± 0.38	*
α linolenic ac. C18:3 n-3	0.21 ± 0.21	0.57 ± 0.13	0.36 ± 0.18	**
Eicosatrienoic ac C20:3	0.23 ± 0.02	0.27± 0.12	0.43 ± 0.62	**
Arahidonic ac . C20:4	0.15 ± 0.05	0.17 ± 0.02	0.17 ± 0.01	ns
DPA ac. C22:5 n-3	0.107 ± 0.02	0.105 ± 0.41	0.102 ± 0.62	ns
DHA ac. C22:6 n-3	traces	traces	traces	ns
h/H	1.85	1.68	2.03	ns
IA	2.85	2.68	2.93	ns
IT	1.12	1.08	1.23	ns

Note: IA = [(C12: 0 + (4 × C14: 0) + C16: 0)]/(MUFA + n−6 PUFA + n−3 PUFA)
IT = (C14: 0 + C16: 0 + C18: 0)/[(0.5 × MUFA) + (0.5 × n−6 PUFA) + (3 × n−3 PUFA) + (n−3PUFA/n−6 PUFA)]
h/H = (C18: 1n−9 + C18: 2n−6 + C20: 4n−6 + C18: 3n−3 + C20: 5n−3 + C22: 5n−3 + C22: 6n−3)/(C14 : 0 + C16: 0)

The values of the fatty acid eicosapentaenoic-EPA (0.23 ± 0.02mg/100g, in group L1, compared to 0.27± 0.12 mg/100g, in group L2 and 0.43 ± 0.62mg/100g, in group L3), generated very significant differences between the groups), and docosapentaenoic acid-DPA registered statistically insignificant differences (0.107 ± 0.02mg/100g in group L1, 0.105 ± 0.41mg/100g in group L2 and and 0.102 ± 0.62mg/100 g, in group L3).

The role of EPA and DHA in alleviating the symptoms of a number of diseases, including coronary heart disease, is well recognized and appreciated (British Nutrition Foundation, 2014). An increasing content of EPA and DHA and a decrease in the ω-6/ω-3 ratio, together with high levels of MUFA fatty acids, indicate a potentially beneficial effect and support a healthier image of organic pork.

In the same way of interpretation, the IA, IT and h/H indices of fat are sufficiently suggestive, indicating the functional effects of fatty acids on human health.

As is known, high atherogenic index (IA) (values above 5) as well as increased values of thrombogenicity (IT<0.7) are responsible for atheroma formation and stimulate platelet aggregation in the human cardiovascular system. Therefore, the lower values of these indices are desirable, being a guarantor for the prevention of cardiovascular disorders.

In this context, the meat and fat of the Mangalița breed, regardless of the genetic variant, were at low values, with statistically insignificant differences between groups, and can be considered functional and healthy foods for human consumption (Fig. 1).

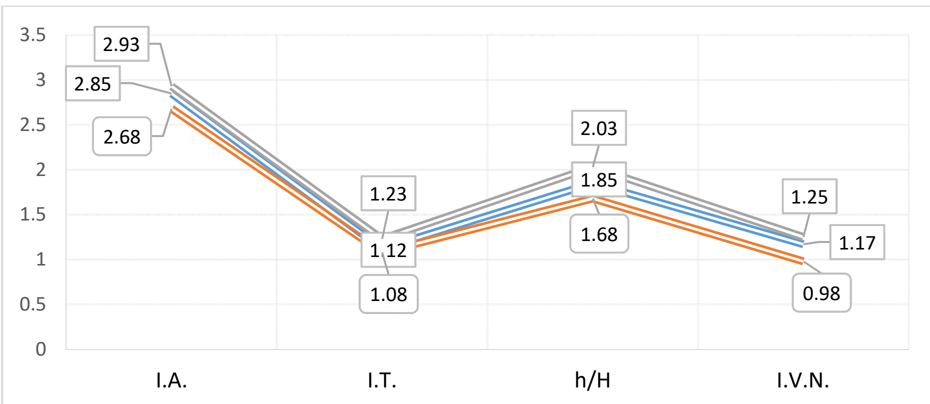

Figure 1 Nutritional quality indices of lipid

CONCLUSIONS

The results of the research carried out in practical conditions, of a production farm, have shown us the existence of some statistical differences between the genotypes of the Mangalița pig breed, regarding the physico-chemical and sanological quality of their meat and fat.

Thus, very statistically significant differences were recorded between the water and fat content, although the experimental groups were reared and fed under identical conditions, and the body weight at slaughter was substantially equal.

Regarding the amount of cholesterol, it varied between the groups of individuals (very significant statistical differences), but they were below the values of the improved breeds of pigs, according to the specialized literature. The fatty acid content of *G. medius muscle* was different between groups, and the content of saturated and unsaturated fatty acids was distinctly expressed, with very significant differences being recorded between oleic, α linolenic and eicosatrienoic acids. A higher percentage of fatty acids unsaturated, which are supposed to be less harmful to human health, was measured in the varieties Blonde Mangalița (group L2) and Red Mangalița (group L1), while the percentage of saturated fatty acids was found to be significantly higher in Mangalița Black (group L3).

In full accordance with the results of the research carried out, we recommend the production and consumption of meat and fat belonging to the Mangalița breed, regardless of the eco-genetic variety, in accordance with the obvious health benefits that these products bring, compared to other sources of meat.

REFERENCES

1. Alonso V., Campo Maria del Mar, Provincial L, Roncalés P., Beltrán J.A., 2010 - Effect of protein level in commercial diets on pork meat quality. Meat Science 85:7–14.
2. Andersson, K., Andersson, I. & Essén-Gustavsson, B., 1990 - Indoor or outdoor management of pigs? (Grisarna inne elle ute?). Fakta – Sveriges Landtbruksuniversitet, Husdjur, 12, 4.
3. Bee G., Guex G., Herzog W., 2004 - Free-range rearing of pigs during the winter: adaptations in muscle fiber characteristics and effects on adipose tissue composition and meat quality traits. J Anim Sci 82:1206-1218.
4. Bohac, C.E. & Rhee, K.S., 1988 - Influence of animal diet and muscle location on cholesterol content of beef and pork muscles. Meat Sci. 23, 71-75.
5. Csapó, J., Vargá-Visi, É., Csapó-Kiss, Z.S. & Csokona, É., 2002 - Fatty acid composition and cholesterol content of the fat of pigs of various genotypes. Acta Agraria Kaposvariensis 6 (2), 107-113.
6. Danielsen V., Hansen L.L., Moller F., Bejerholm C., Nielsen S., Hermansen J.E. 2000 - Ecological animal husbandry in the Nordic countries. In: Proc NJF-seminar 303, Horsens, Denmark, 16-17 September 1999, 79-86.
7. Daza, A., Menoyo, D., Olivares, A., Cordero, G. & López-Bote, C.J., 2007 - Effect of Iberian pig feeding system on tissue fatty-acid composition and backfat rheological properties. J. Anim. Feed Sci. 16, 408-419
8. Edwards, S.A., 2005 - Product quality attributes associated with outdoor pig production. Livest. Prod. Sci. 94, 5-14.
9. Gentry J.G., McGlone J.J., Blanton J.R., Miller M.F., 2002 - Impact of spontaneous exercise on performance, meat quality, and muscle fiber characteristics of growing/ finishing pigs. J Anim Sci 80:2833-2839.
10. Holló G.J., Seregi K., Ender K., Nürnberg J., Wegner J., Seeger I., Holló I., Repa 2003 - Examination of meat quality and fatty acid composition of Mangalitsa. Acta Agraria Kaposvariensis 7(2):19- 32.
11. Incze K., Zukál E., Szerdahelyi K., Erdős Z., 1998 - Az alapanyag-feldolgozás és a piacra jutás folyamatainak minıségi ugrópontjai a húsipari termékeknél” Agro-21 Füzetek 5-31.
12. Kovács, Á., Zsarnóczay, G., 2003 - Development of traditional pork (Mangalitza) production value chain, Hungarian Meat Research Institute, Budapest.
13. Nistor E., Bampidis V., Pentea M., Prundeanu H., Ciolac V., 2012 - Nutritional Quality of Pork Produced by Mangalitsa Breed. Animal Science and Biotechnologies 45(2) USAMV B Timișoara.
14. Păsărin B., Hoha G.V., Nistor C.E., Simeanu Cristina, 2022 - The influence of the type of maintenance of Mangalița pigs on the chemical composition of the meat, the fatty acid profile and the cholesterol content of the meat, Journal of Animal Science, FIRAA, Iași
15. Păsărin B., Hoha G.V., Nistor C.E., Simeanu Cristina, 2022 - Elements regarding the lipolysis and proteolysis of refrigerated meats from the Mangalita breed, Journal of Animal Science, FIRAA, Iași
16. Păsărin B., Hoha G.V., Nistor C.E., Simeanu Cristina, 2021 - Elements regarding the lipolysis and proteolysis of frozen meats from the Mangalita breed, Journal of Animal Science, FIRAA, Iași
17. Seenger J.K., 2007 - The effect of slaughter weigth and genotype on the fatty acid composition of intramuscular and subcutaneous fat in pigs. Theses of Ph.D. Dissertation, Szent István University, Gödöllő, Faculty of Agicultural and Environmental Sciences, 1-22.
18. Szabo P. 2006 - Fatty acid composition of the tissues of Mangalica and other pig genotypes. Hungarian J Anim Prod 55:293-311.
19. Zăhan M., Raica P., Miclea V., Miclea Ileana, Renaville R., Duterme O., Mihăilescu M., Nagy Al., 2009 – Rezultate privind caracterizarea genetică a rasei Mangaliţa pe baza markerilor microsateliţi. Lucrări Ştiinţifice Zootehnie şi Biotehnologii, Ed. Agroprint, Timişoara, 42 (1), 136-140.