UNIVERZITET U KRAGUJEVCU
AGRONOMSKI FAKULTET U ČAČKU

UNIVERSITY OF KRAGUJEVAC
FACULTY OF AGRONOMY
ČAČAK

1st INTERNATIONAL SYMPOSIUM ON BIOTECHNOLOGY

17–18 March 2023

Faculty of Agronomy in Čačak, University of Kragujevac, Serbia

- PROCEEDINGS -

1st INTERNATIONAL SYMPOSIUM ON BIOTECHNOLOGY
XXVIII Savetovanje o biotehnologiji sa međunarodnim učešćem

- PROCEEDINGS -

ORGANIZER AND PUBLISHER

University of Kragujevac, Serbia
Faculty of Agronomy in Čačak

Technical editors
Prof. Dr Pavle Mašković; Dr Vesna Milovanović; Dušan Marković, BSc

Print-run: 100

Printed by
Copy Xerox, Cara Dušana 11, 32000 Čačak

ISBN 978-86-87611-88-7

Year of publication: **2023**

DOI: 10.46793/SBT28.189R

THE EFFECT OF THE REARING SYSTEM AND GENOTYPE OF LAYING HENS ON FATTY ACID COMPOSITION OF EGGS

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Abstract: This paper aimed to determine the effect of the rearing system and genotype of laying hens on the fatty acid composition of eggs. Seven times during the one-year production cycle, 15 eggs from all four experimental groups were taken, and fatty acid composition was determined on pooled samples. Based on the obtained results, it can be concluded that the highest content of SFA had organic New Hampshire eggs, MUFA organic Isa Brown eggs and PUFA floor-produced eggs. Regarding the ratio of n-6:n-3 PUFA, it can be noted that the organic eggs had a lower ratio compared to the floor eggs, as well as the New Hampshire breed compared to the Isa Brown hybrid.

Keywords: laying hens, floor system, organic system, breed, hybrid, fatty acid.

Introduction

Omega-3 fatty acids have a wide range of demonstrated health-related benefits. These positive effects include: cardioprotective, anticancer, triglyceride and blood pressure lowering, immune health enhancing and their roles in the growth and maturation of the central nervous system (Cherian and Quezada, 2016), and also prevention of some psychiatric disorders, from stress to depression and dementia (Bourre, 2005). Special attention is paid to the content of omega-3 (n-3) and omega-6 (n-6) fatty acids, as well as their ratio, so Simopoulos (2000) report that the ideal ratio of n-6 to n-3 is 10:1 and lower, and Johansson (2010) 4:1 and lower. Samman et al. (2009) state that people consuming n-3 fatty acids from the so-called "engineered eggs" reduce the risk factors of heart diseases, and Johansson (2010) that the most common diseases in western countries, such as cardiovascular problems, diabetes, cancer, autoimmune diseases, are related to an inappropriate ratio of n-6:n-3 polyunsaturated fatty acids. During the long evolutionary history of *Homo*

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sapiens, an n-6:n-3 fatty acid ratio balance has existed, and it is believed that many genetic changes happened partly because of it (Nyberg, 2017).

For this reason, this paper aimed to determine the effect of the rearing system and genotype of laying hens on the fatty acid composition of eggs.

Materials and methods

The experiment was arranged in a 2 x 2 factorial design with two layer genotypes (Isa Brown hybrid and New Hampshire breed) and two rearing systems (floor and organic). 30 birds per group were housed at 18 weeks of age.

In both rearing systems, stocking density was 2.5 birds/m^2. Organic layers also had about 5 m^2 per bird of available outdoor area covered with grass and bushes, which enabled them to supplement their diets using vegetation and small creatures living outdoors.

Floor-reared laying hens were fed *ad libitum* a standard commercial diet. The diet for organic hens was complete without synthetic amino acids, vitamins and minerals and with more than 80% of organic components.

In order to examine the effect of the rearing system and genotype on the fatty acid composition of eggs, seven times during the one-year production cycle (24, 32, 40, 48, 56, 64 and 72 weeks hen's age), 15 eggs from all four experimental groups were collected, homogenized, and the fatty acid composition (pooled samples) was determined by HPLC. The analysis of the obtained data was performed based on calculated mean values using the computer program Statistica (Stat Soft Inc Statistica for Windows. Version 7.0., 2006).

Results and discussion

Table 1 shows the content of the most important fractions of fatty acids and their ratio.

The highest content of saturated fatty acids (SFA) in eggs during the experimental period in five controls was recorded in the organic New Hampshire group. Regarding the minimum content of SFA in eggs, in five of seven controls it was recorded in the floor experimental groups, three in Isa Brown (at 24, 56 and 72 weeks), and two in the New Hampshire group (in 40 and 64 weeks).

Table 1. Fatty acid composition of eggs by experimental groups

Treatment	Fatty acid	Hen's age						
		24	32	40	48	56	64	72
		Fatty acid content (%) of total fatty acids						
Isa Brown floor	SFA	32.64	32.94	33.10	34.11	32.45	32.88	32.76
	MUFA	45.45	44.89	49.06	45.25	40.38	42.64	44.21
	PUFA	20.25	20.58	16.57	19.17	25.73	22.96	21.71
	n-3	1.12	1.24	0.79	0.97	1.68	1.70	1.25
	n-6	19.13	19.33	15.78	18.20	24.05	21.26	20.45
	n-6/n-3	17.05	15.53	20.04	18.78	14.31	12.51	16.31
New Hampshire floor	SFA	34.06	33.34	32.99	33.74	32.34	32.77	32.90
	MUFA	42.26	42.89	42.31	46.54	45.32	42.32	41.52
	PUFA	22.13	22.20	23.06	18.43	20.85	23.30	23.98
	n-3	0.88	1.62	1.87	0.68	1.30	2.22	2.15
	n-6	21.25	20.58	21.19	17.75	19.55	21.08	21.82
	n-6/n-3	24.14	12.74	11.33	26.04	15.05	9.48	10.14
Isa Brown organic	SFA	34.97	30.91	33.48	32.86	36.29	32.84	32.89
	MUFA	48.60	50.12	50.05	48.80	40.53	43.09	44.79
	PUFA	14.49	18.09	14.56	16.88	21.08	22.37	20.41
	n-3	1.01	1.09	0.71	1.02	1.81	1.70	1.71
	n-6	13.48	17.00	13.86	15.86	19.27	20.67	18.70
	n-6/n-3	13.36	15.60	19.65	15.59	10.66	12.17	10.94
New Hampshire organic	SFA	34.26	36.11	34.94	34.36	34.11	33.52	34.08
	MUFA	45.27	42.99	42.90	46.34	42.44	43.04	43.38
	PUFA	18.29	18.98	20.55	17.37	21.59	21.57	20.95
	n-3	1.41	1.41	1.77	1.38	1.51	1.86	1.59
	n-6	16.88	17.57	18.77	15.98	20.08	19.71	19.35
	n-6/n-3	11.94	12.48	10.59	11.56	13.28	10.60	12.17

SFA - Saturated fatty acids; MUFA - monounsaturated fatty acids; PUFA - polyunsaturated fatty acids;
n-3 - omega-3 fatty acids; n-6 - omega-6 fatty acids.

Regarding the content of monounsaturated fatty acids (MUFA) in eggs, in six out of seven controls, the highest content of this fraction was recorded in the organic Isa Brown group. On the other hand, the lowest MUFA content in eggs was recorded in the floor experimental groups, at 24, 32, 40, 64 and 72 weeks in New Hampshire, and 48 and 56 weeks in Isa Brown.

The highest content of polyunsaturated fatty acids (PUFA) in eggs was recorded in the floor experimental groups - in the 24, 32, 40, 64 and 72 weeks in the New Hampshire breed, and the 48 and 56 weeks in the Isa Brown hybrid. The lowest content of PUFA in eggs was recorded in six controls in the organic groups, in 24, 32, 40, 48 and 72 weeks in the Isa Brown and the 64 weeks in the New Hampshire.

The results on the ratio of SFA, MUFA and PUFA from our research are in accordance with the results reported by Cerolini et al. (2005), who also determined a significantly higher SFA content in eggs in floor compared to organic layers, so the PUFA:SFA ratio in floor produced eggs was 0.92 and in organic eggs only 0.66. And Samman et al. (2009) found a higher SFA content in organic eggs (34.6%) compared to conventional eggs (33.8%), while MUFA and PUFA levels did not differ significantly. On the other hand, Nyberg (2017) found no significant effect of the rearing system on the SFA content in eggs, while there was a significant effect on the content of MUFA and PUFA. Pavlovski et al. (2011), Simčić et al. (2011) and Terčić et al. (2012) did not find a significant effect of the rearing system on the SFA:MUFA:PUFA ratio in eggs.

Regarding the ratio of n-6:n-3 PUFA, it can be noted that the organic experimental groups had a lower ratio compared to the floor experimental groups. The same can be said for the New Hampshire genotype compared to the Isa Brown hybrid. The lower n-6:n-3 ratio in eggs was recorded in the first four controls in organic New Hampshire layers, in the 56th week in the organic Isa Brown hens, and in the 64 and 72 weeks in the floor New Hampshire layers. The higher ratio of n-6:n-3 fatty acids in eggs was found in six out of seven controls in the floor experimental groups, in the Issa Brown at 40, 64 and 72 weeks, while in New Hampshire at 24, 48 and 56 weeks.

The lower n-6:n-3 fatty acids ratio in the organic compared to floor eggs in our research is in agreement with the results of numerous authors who found that access to and feeding on the outlet leads to an increase in the content of n-3, and a decrease in the content of n-6 fatty acids. Thus, Pavlovski et al. (2011) found that the ratio of n-6:n-3 was significantly different - 8.64:13.25, and more favourable in free range compared to cage-produced eggs. A more favourable fatty acid composition of eggs in the rearing system with outlet was also established by Simčić et al. (2011), who determined the lower n-6:n-3 ratio in free-range (6.27) compared to cage-reared hens (10.37) on the Styrian breed.

Similar results were reported by Terčić et al. (2012) on Prelux-G, while Mugnai et al. (2013) found a 4.75 n-6:n-3 ratio in organic and 8.88 in cage Ancona layers.

The most favourable ratio of n-6:n-3 fatty acids in the last two controls in floor New Hampshire layers in our experiment is not unexpected, because in that period the organic hens did not have available plants on the outlet, so there was no possibility that their eggs be enriched with an additional level of n-3 fatty acids. This was confirmed by Kucukyilmaz et al. (2012), who found a significantly higher n-6:n-3 ratio in the organic eggs of both investigated hybrids. This ratio was 12.53 in caged Lohmann LSL while organic eggs of the same hybrid had 14.28. Even more drastic differences were found in ATAK-S eggs - conventional 11.95 and organic 15.56. These results clearly show that the genotype significantly affects the n-6:n-3 ratio, which is in agreement with the results of our research, where the eggs of New Hampshire layers had a significantly better fatty acid composition than the eggs of the Isa Brown hybrid. A better n-6:n-3 ratio in the eggs of pure breed compared to hybrid was determined in research by Pavlovski et al. (2011), comparing Banat Naked Neck (5.81) and Hy-Line Brown hybrid (8.64) in a free range system.

Conclusion

Based on the obtained results, it can be concluded that the highest content of SFA had organic New Hampshire eggs, MUFA organic Isa Brown eggs and PUFA the floor produced eggs. Regarding the ratio of n-6:n-3 PUFA, it can be noted that the organic eggs had a lower ratio compared to the floor eggs, as well as the New Hampshire breed compared to the Isa Brown hybrid.

Acknowledgement

This study was funded by the Ministry of Science, Technological Development and Innovation of Republic of Serbia, No. 451-03-47/2023-01/ 200088 and No. 451-03-47/2023-01/ 200022.

References

Bourre J.M. (2005). Where to find omega-3 fatty acids and how feeding animals with diet enriched in omega-3 fatty acids to increase nutritional value of derived products for human: what is actually useful? The Journal of Nutrition, Health & Aging, 9 (4), 232-242.

Cherian G., Quezada N. (2016). Egg quality, fatty acid composition and immunoglobulin Y content in eggs from laying hens fed full fat camelina or flax seed. Journal of Animal Science and Biotechnology, 7, 15.

Cerolini S., Zaniboni L., La Cognata R. (2005). Lipid characteristics in eggs produced in different housing systems. Italian Journal of Animal Science, 4 (suppl.2), 519.

Johansson A. (2010). Effects of genotype, age and feed on the fat components of egg yolk. Master's thesis. Swedish University of Agriculture Sciences (SLU), Uppsala.

Kucukyilmaz K., Bozkurt M., Herken E.N., Cinar M., Cath A.U., Bintas E., Coven F. (2012). Effects of rearing systems on performance, egg characteristics and immune response in two layer hen genotype. Asian - Australasian Journal of Animal Sciences, 25 (4), 559-568.

Mugnai C., Sossidou E.N., Dal Bosco A., Ruggeri S., Mattioli S., Castellini C. (2013). The effects of husbandry system on the grass intake and egg nutritive characteristics of laying hens. Journal of the Science of Food and Agriculture, 94 (3), 459-467.

Nyberg J. (2017). Analysis of Fatty Acids in Egg Yolks of Various Production Systems. Faculty of Natural Resources and Agricultural Sciences Department of Molecular Sciences.

Pavlovski Z., Škrbić Z., Lukić M., Lilić S., Krnjaja V., Staničić N., Petričević V. (2011). Comparative analysis of fatty acid profile and cholesterol content in table eggs from different genotype hens. Biotechnology in Animal Husbandry, 27 (3), 669-677.

Samman S., Kung F.P., Carter L.M, Foster M.J, Ahmad Z.I., Phuyal J.L., Petocz P. (2009). Fatty acid composition of certified organic, conventional and omega-3 eggs. Food Chemistry, 116, 911–914.

Simčić M., Stibilj V., Holcman A. (2011). Fatty acid composition of eggs produced by Slovenian autochthonous Styrian hen. Food Chemistry, 125, 873-877.

Simpoulos A.P. (2000). Role of poultry products in enriching the human diet with n-3 PUFA. Human requirement for n- 3 polyunsaturated fatty acids. Poultry Science, 79, 961–970.

Stat Soft Inc Statistica For Windows, Version 7.0. (2006). Computer program manual Tulsa.

Terčić D., Žlender B., Holcman A. (2012). External, Internal and Sensory Qualities of Table Eggs as Influenced by Two Different Production Systems. Agroznanje, 13 (4), 555-562.