Ann. Anim. Sci., Vol. 15, No. 1 (2015) 247–261 *DOI: 10.2478/aoas-2014-0082*

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EFFECT OF BREED AND PRODUCTION SYSTEM ON PHYSICOCHEMICAL CHARACTERISTICS OF MEAT FROM MULTI-PURPOSE HENS*

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Abstract

The objective of the study was to determine the effect of breed (A) and free-range production system (B) on quality of meat from hens of two breeds, Greenleg Partridge (Z-11) and Rhode Island Red (R-11), which are under the biodiversity conservation programme in Poland. Subjects were 120 hens of each breed, which were assigned to two treatment groups differing in the housing system: 60 layers were kept on litter without outdoor access (C) and 60 layers were raised on litter with access to free range (FR). At 56 weeks of age, 8 hens were randomly chosen from each group, slaughtered, and subjected to slaughter analysis. It was found from the study that carcasses from 56-week-old multi-purpose hens are characterized by poor muscle development and considerable fat content. After the first year of egg production, the meat of hens was characterized by low tenderness, high water holding capacity, and a fatty acid profile that was desirable from the viewpoint of human nutrition. In the meat of hens that completed their first year of egg production, the profile of fatty acids was beneficial from the standpoint of human nutrition. The free-range production system reduced carcass fatness, enhanced carcass and meat yellowness, and increased the proportion of polyunsaturated fatty acids (both *n-6* and *n-3*) in breast and leg muscles while causing no significant changes in the content of saturated fatty acids. The meat of the native Z-11 breed was found to contain less saturated and more unsaturated fatty acids compared to the meat of R-11 hens. There was no statistically significant effect of the production system on the sensory evaluation of cooked meat and broth.

Key words: hens, biodiversity, free range, meat quality, fatty acid

Today's consumers of poultry products expect meat to be tender and juicy, have good flavour and aroma, be high in protein and low in cholesterol, and show a favourable fatty acid profile. Every poultry meat quality trait is determined by many factors such as bird genotype, nutrition, and housing system.

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*Work financed from multiannual programme no. 08-1.31.9.

The most efficient way of increasing the proportion of unsaturated fatty acids in meat is to feed the birds with compound feeds supplemented with vegetable oils and fish oils (Grashorn, 2007; Szymczyk and Frys-Żurek, 2011; Zduńczyk and Jankowski, 2013).

Poultry production system (Castellini et al., 2002 a, b; Gornowicz and Lewko, 2010; Michalczuk et al., 2014) and duration of the rearing period (Połtowicz and Doktor, 2012) not only have an effect on carcass size and carcass weight, but also contribute to meat quality. Carcasses from slow-growing chickens whose growth period was extended to 12–15 weeks are characterized by a greater proportion of breast muscle, a smaller proportion of leg muscles and abdominal fat, and a favourable fatty acid profile (Berri et al., 2005; Fanatico et al., 2005 a, b; Mikulski et al., 2011; Dal Bosco et al., 2012).

In the extensive production systems, in which birds have access to the free range, the meat obtained is low in fat and has a healthy *n-3:n-6* PUFA ratio (Castellini et al., 2002 a, b; Berri, 2007; Dal Bosco et al., 2012; Sun et al., 2013; Michalczuk et al., 2014). Increased physical activity of birds on the free range makes them lighter and less fat, because, as observed by Skomorucha et al. (2007), pastured birds more often peck grass than ingest feed, and rest less frequently than birds without outdoor access.

Of interest, in light of the above, are the physicochemical characteristics of meat from conserved populations of multi-purpose hens that are raised under backyard conditions with access to the free range. The use of indigenous poultry breeds encourages the conservation of biodiversity and broadens the range of poultry products introduced to the market.

The objective of this study was to determine the effect of breed (A) and free-range production system (B) on quality of meat from hens of two breeds undergoing conservation in Poland.

Material and methods

The study involved two breeds of hens: Greenleg Partridge (Z-11) and Rhode Island Red (R-11), which are under the biodiversity conservation programme in Poland, and had previously been used for both egg and meat production.

The laying hens of both breeds were maintained in an experimental farm from September 2011 to June 2012, i.e. from 20 to 56 weeks of age. The study involved 120 hens of each breed, which were assigned to two treatment groups (C and FR) differing in the housing system. Group C consisted of 60 layers that were kept on litter without outdoor access (stocking density of 5.5 birds/m^2) and group FR included 60 layers that were raised on litter with access to the free range (FR) (around 1 bird/4 m^2). Throughout the production period, temperature inside the building ranged from 16 to 20ºC with humidity of 60–70%. During the egg production period, all hens were fed a complete layer diet containing 16.1% crude protein and 11.3 MJ ME/kg. Hens supplemented their diets with free-range vegetation (mixed meadow grasses).

At 56 weeks of age, 8 hens were randomly chosen from each group and individually weighed. Following a 12-hour feed withdrawal (with free access to water), they were slaughtered and eviscerated. After 24-hour chilling, the carcasses were subjected to slaughter analysis and samples of breast and leg muscles were collected to determine the fatty acid profile. Muscle pH was determined 15 min postmortem (pH_{15min}) and after 24-hour chilling of carcasses (pH_{24h}) with a CyberScan10 pH meter (Singapore), and the colour of carcasses, breast muscles and leg muscles was measured after 24-hour chilling of carcasses (Minolta CR 310 reflectance spectrophotometer, Japan) in the L*a*b* colour space (CIE 1976), where L* is lightness, a* is redness, and b* is yellowness. Water holding capacity (WHC) of breast and thigh muscles was determined according to Grau and Hamm (1953). Thermal loss was determined based on muscle weight loss during cooking. Samples of 80 g were placed in plastic bags, and muscles were cooked at 80ºC for 14 min (breast muscles) and 16 min (thigh muscles). After cooking, the samples were cooled for 30 min at room temperature, and refrigerated for 45 min at 4ºC. The samples were weighed and thermal loss was calculated according to the formula:

$$\textit{thermal loss (\%)} = \frac{\textit{sample weight before cooking (g)} - \textit{sample weight after cooking (g)}}{\textit{sample weight before cooking (g)}} \times 100$$

Drip loss was determined after 24-hour storage of the breast and thigh muscle samples at +4ºC. To this end, 80 g samples of meat were collected from the right thigh and breast muscle, placed in airtight containers and stored in a refrigerator. Drip loss was calculated using the formula:

$$\textit{drip loss (\%)} = \frac{\textit{sample weight before cooling (g)} - \textit{sample weight after cooling (g)}}{\textit{sample weight before cooling (g)}} \times 100$$

Meat tenderness was measured using a Stable Micro Systems texture analyser. Fatty acid content was determined by gas chromatography (VARIAN 3400 CX) using helium as a carrier gas, and column Rtx 2330 (105 m). Injector temperature was 200ºC, detector temperature 240ºC. The samples were prepared by the method of Folch et al. (1957) using BF3/methanol methylation. In addition, sensory evaluation of cooked meat was performed on a 5-point scale.

The results were statistically analysed with two-way analysis of variance genotype × housing system). Significant differences between the means in the groups were estimated using Duncan's test (Statistica 6.0). The experiment was conducted with approval (no. 2/2010) of the Local Ethics Committee for Animal Experimentation.

Results

The present study showed that breed and housing system have an effect on hens' body weight before slaughter (P≤0.01) (Table 1). Z-11 hens had 5.2 percentage points lower carcass yield with giblets compared to R-11 hens ($P \leq 0.01$). Housing system had no influence on this trait. There were no statistically significant differences in breast and leg muscle percentage, neither between the breeds nor between the housing systems. Giblets percentage was considerably lower in R-11 compared to Z-11 hens ($P \leq 0.01$). In hens of both breeds, giblets percentage was lower ($P \leq 0.05$) for birds kept without outdoor access compared to free-range hens. Regardless of the breed, the carcasses of confined hens had a higher content of abdominal fat compared to free-range birds ($P \leq 0.05$). The effect of the breed on carcass colour was observed for lightness, with carcasses from R-11 hens being lighter than those from Z-11 hens ($P \leq 0.05$). The carcasses of hens from the free-range system had lower ($P \leq 0.05$) redness (a*) and higher ($P \leq 0.01$) yellowness (b*) values.

As is clear from Tables 2 and 3, neither the production system nor the breeds of hens had a statistically significant effect on the pH_{15}, WHC and tenderness of breast and leg muscles. The pH_{24} of breast muscles was significantly higher in Z-11 than in R-11 hens ($P \leq 0.05$). Thermal loss was higher by 2.1 percentage points in the breast muscles of hens raised with outdoor access ($P \leq 0.05$). The leg muscles of confined hens were characterized by significantly lower drip loss after 24 h. The outdoor production system contributed significantly to muscle yellowness (b*) and to leg muscle redness (a*) ($P \leq 0.01$), while bird genotype had a significant effect on colour lightness (L*) of breast and leg muscles ($P \leq 0.01$).

The breast muscles of Z-11 hens were found to contain less saturated fatty acids myristic (C14:0) ($P \leq 0.01$) and palmitic (C16:0) ($P \leq 0.05$) compared to the breast muscles of R-11 hens (Table 4). Compared to the breast muscles of R-11 hens, those of Z-11 hens had a slightly higher content of monounsanturated fatty acids, but the difference was not significant. The content of polyunsaturated fatty acids in the breast muscles of hens of both breeds showed differences, including a significantly lower content of α-linolenic acid in Z-11 compared to R-11 hens ($P \leq 0.01$). The breast muscles of Z-11 hens had less SFA and higher UFA compared to R-11 hens ($P \leq 0.05$). The *n-6:n-3* PUFA ratio, which is important from the standpoint of human nutrition, did not exceed 10 for the breast muscles of all the groups of hens and the differences were not significant for either genotype or production system.

In the breast muscles of hens from the outdoor production system, there was a favourable increase in the content of *n-6* linoleic acid and PUFA, in particular linoleic acid ($P \leq 0.01$). In the hens kept without outdoor access, there were increases in MUFA, in particular oleic acid (C18:1) and also in palmitoleic acid (C16:1) ($P \leq 0.05$).

Greater differences between the breeds were found for the fatty acid content of leg muscles (Table 5). Z-11 hens had a lower proportion of SFA ($P \leq 0.01$), including myristic (C14:0) and palmitic acids (C16:0), and a higher proportion of UFA ($P \leq 0.01$), including MUFA ($P \leq 0.01$), in particular oleic acid (C18:1) and palmitoleic acid (C16:1) ($P \leq 0.05$). Compared to the leg muscles of Z-11 hens, those of R-11 hens contained more polyunsaturated fatty acids γ-linolenic (C18:3) ($P \leq 0.05$) and α-linolenic (C18:3*n-3*) and showed a lower *n-6:n-3* PUFA ratio ($P \leq 0.01$).

Table 1. The body weight, dressing percentage and carcass colour in 56-week-old hens

Item	Breed of hens (A)		Production system (B)		A × B				SEM	Effect of		
	Z-11	R-11	C	FR	Z-11C	Z-11FR	R-11C	R-11FR		A	B	A x B
Preslaughter weight (g)	1793	2562	2287	2069	1834	1752	2740	2385	75.54	**	**	**
Dressing percentage with giblets (%)	65.5	70.7	67.6	68.6	65.2	65.9	70.1	71.3	0.65	**	NS	NS
Breast muscles (%)	15.9	15.8	15.6	16.1	15.6	16.1	15.5	15.9	0.29	NS	NS	NS
Leg muscles (%)	16.8	18.9	18.4	17.3	17.8	15.8	19.0	18.8	0.57	NS	NS	NS
Giblets (%)	5.62	4.40	4.75	5.27	5.44	5.79	4.06	4.75	0.16	**	*	NS
Abdominal fat (%)	5.97	6.79	6.99	5.77	6.84	5.09	7.14	6.44	0.27	NS	*	NS
Carcass colour:												
L*	70.15	71.68	71.15	70.68	70.10	70.20	72.20	71.16	0.27	**	NS	NS
a*	2.63	3.06	3.04	2.65	3.17	2.08	2.90	3.21	0.13	NS	NS	**
b*	12.67	13.85	11.96	14.55	11.23	16.46	12.68	12.65	0.54	NS	**	**

Notes: C – raised on litter without outdoor access, FR – raised on litter with outdoor access; Z-11 – Greenleg Partridge, R-11 – Rhode Island Red;
Significance of differences: NS – non-significant, *significant ($P \leq 0.05$), **highly significant ($P \leq 0.01$): A – effect of breed, B – effect of production system.

Table 2. The physical characteristics of breast muscles in 56-week-old hens

Item	Breed of hens (A)		Production system (B)		A × B				SEM	Effect of		
	Z-11	R-11	C	FR	Z-11C	Z-11FR	R-11C	R-11FR		A	B	A × B
pH_{15}	6.32	6.29	6.31	6.30	6.32	6.31	6.31	6.28	0.02	NS	NS	NS
pH_{24}	5.56	5.44	5.47	5.53	5.52	5.60	5.41	5.47	0.02	*	NS	NS
Drip loss (%)	0.38	0.45	0.41	0.42	0.41	0.34	0.41	0.50	0.03	NS	NS	NS
Cooking loss (%)	31.8	31.2	30.5	32.6	30.6	33.1	30.5	32.0	0.43	NS	*	NS
WHC (%)	16.22	17.85	17.29	16.78	16.03	16.42	18.55	17.15	0.36	NS	NS	NS
Shear force (N)	12.00	12.78	12.37	12.42	11.96	12.05	12.78	12.78	0.37	NS	NS	NS
Colour:												
L*	53.93	57.95	56.14	55.74	54.23	53.63	58.05	57.85	2.67	**	NS	NS
a*	11.16	10.45	10.34	11.26	10.18	12.14	10.50	10.39	1.63	NS	NS	NS
b*	7.39	7.20	6.73	7.85	6.60	8.17	6.86	7.53	0.95	NS	**	NS

For notes, see Table 1.

Table 3. The physical characteristics of leg muscles in 56-week-old hens

Item	Breed of hens (A)		Production system (B)		A × B				SEM	Effect of		
	Z-11	R-11	C	FR	Z-11C	Z-11FR	R-11C	R-11FR		A	B	A × B
pH_{15}	6.64	6.59	6.58	6.65	6.64	6.64	6.52	6.66	0.27	NS	NS	NS
pH_{24}	5.99	6.08	5.91	6.16	6.01	5.96	5.81	6.36	0.17	NS	NS	NS
Drip loss (%)	0.35	0.31	0.27	0.39	0.27	0.42	0.26	0.36	0.27	NS	*	NS
Cooking loss (%)	41.2	40.6	41.05	40.8	41.1	41.3	40.9	40.3	0.34	NS	NS	NS
WHC (%)	13.44	15.56	14.93	14.07	13.18	13.70	16.69	14.43	0.64	NS	NS	NS
Shear force (N)	31.16	32.75	30.91	33.00	29.37	32.95	32.44	33.05	0.64	NS	NS	NS
Colour:												
L*	41.98	45.83	44.81	43.00	41.13	42.83	48.49	43.17	0.67	**	NS	**
a*	18.19	17.09	16.86	18.42	17.84	18.55	15.88	18.30	0.26	**	**	**
b*	6.58	6.64	6.12	7.09	5.67	7.50	6.58	6.69	0.23	NS	**	NS

For notes, see Table 1.

Table 4. The fatty acid profile of breast muscles in 56-week-old hens (g/100 g)

Fatty acids	Breed of hens (A)		Production system (B)		A × B				SEM	Effect of		
	Z-11	R-11	C	FR	Z-11C	Z-11FR	R-11C	R-11 FR		A	B	A × B
C14:0	0.510	0.663	0.618	0.556	0.503	0.518	0.733	0.594	0.026	**	NS	*
C16:0	22.1	24.1	23.3	22.9	21.3	22.8	25.2	23.1	0.472	*	NS	*
C18:0	6.60	6.64	6.35	6.89	6.31	6.89	6.39	6.88	0.184	NS	NS	NS
C16:1	2.97	2.71	3.25	2.43	3.36	2.58	3.14	2.28	0.178	NS	*	NS
C18:1	41.4	39.8	41.8	39.3	43.7	39.0	39.9	39.6	0.673	NS	*	NS
C18:2*n-6*	17.6	18.3	16.9	18.9	16.3	18.9	17.6	19.0	0.364	NS	**	NS
C18:3*n-6*	0.097	0.127	0.126	0.098	0.111	0.082	0.141	0.114	0.008	NS	NS	NS
C20:0	0.092	0.106	0.097	0.100	0.078	0.106	0.117	0.095	0.005	NS	NS	*
C18:3*n-3*	1.20	1.47	1.29	1.38	1.12	1.28	1.46	1.49	0.048	**	NS	NS
C20:4*n-6*	5.59	4.35	4.54	5.40	5.32	5.87	3.77	4.94	0.352	NS	NS	NS
C20:6*n-3*	1.19	0.99	10.3	1.16	1.20	1.19	0.86	1.13	0.097	NS	NS	NS
∑ SFA	29.4	31.6	30.4	30.6	28.3	30.5	32.5	30.7	0.544	*	NS	*
∑ UFA	70.6	68.4	69.6	69.4	71.7	69.5	67.5	69.3	0.543	*	NS	*
∑ MUFA	44.3	42.5	45.1	41.8	47.1	41.6	43.0	42.0	0.798	NS	*	NS
∑ PUFA	26.3	25.9	24.5	27.6	24.6	27.9	24.5	27.3	0.591	NS	**	NS
∑ PUFA*n-6*	23.3	22.8	21.6	24.4	21.7	24.8	21.5	24.1	0.522	NS	**	NS
∑ PUFA*n-3*	2.42	2.49	2.34	2.57	2.34	2.49	2.34	2.65	0.093	NS	NS	NS
PUFA*n-6/n-3*	9.73	9.32	9.43	9.62	9.46	10.0	9.40	9.24	0.281	NS	NS	NS

Notes: UFA – unsaturated fatty acids, MUFA – monounsaturated fatty acids, PUFA – polyunsaturated fatty acids, SFA – saturated fatty acids; for others, see Table 1.

Table 5. The fatty acid profile of leg muscles in 56-week-old hens (g/100 g)

Fatty acids	Breed of hens (A)		Production system (B)		A × B				SEM	Effect of		
	Z-11	R-11	C	FR	Z-11C	Z-11FR	R-11C	R-11FR		A	B	A × B
C14:0	0.546	0.664	0.616	0.594	0.517	0.575	0.714	0.613	0.024	**	NS	NS
C16:0	19.79	21.74	21.07	20.46	19.64	19.94	22.50	20.99	0.433	*	NS	NS
C18:0	4.99	5.47	5.10	5.36	4.67	5.32	5.53	5.41	0.121	*	NS	NS
C16:1	4.10	3.34	4.19	3.25	4.71	3.49	3.68	3.01	0.212	*	*	NS
C18:1	46.4	44.1	46.2	44.3	48.7	44.1	43.8	44.5	0.639	*	NS	*
C18:2*n-6*	19.8	20.3	18.7	21.4	17.9	21.6	19.4	21.1	0.437	NS	**	NS
C18:3*n-6*	0.110	0.143	0.137	0.116	0.112	0.098	0.015	0.135	0.008	*	NS	NS
C18:3*n-3*	1.45	1.71	1.46	1.70	1.31	1.59	1.62	1.80	0.055	**	*	NS
C20:4*n-6*	1.58	1.41	1.38	1.61	1.27	1.89	1.49	1.33	0.088	NS	NS	*
C20*:6n-3*(DHA)	0.26	0.25	0.25	0.27	0.22	0.32	0.28	0.22	0.022	NS	NS	NS
∑ SFA	25.5	28.0	26.9	26.6	24.9	26.1	28.9	27.2	0.515	**	NS	NS
∑ UFA	74.5	72.0	73.1	73.4	75.1	73.9	71.1	72.8	0.051	**	NS	NS
∑ MUFA	50.5	47.5	50.4	47.6	53.4	47.6	47.5	47.5	0.711	**	**	**
∑ PUFA	23.9	24.5	22.7	25.8	21.7	26.3	23.6	25.3	0.541	NS	**	NS
∑ PUFA*n-6*	21.5	21.8	20.2	23.13	19.3	23.6	21.1	22.6	0.481	NS	**	NS
∑ PUFA*n-3*	1.73	1.98	1.73	1.98	1.53	1.92	1.92	2.04	0.061	*	*	NS
PUFA*n-6/n-3*	12.5	11.1	11.9	11.7	12.6	12.3	11.1	11.1	0.241	**	NS	NS

For notes, see Tables 1 and 4.

In the outdoor production system, the leg muscles of hens had an increased content of PUFA (both *n-6* and *n-3*), in particular α-linolenic acid (C18:3*n-3*) ($P \leq 0.01$), which was paralleled by a decreased MUFA content ($P \leq 0.01$), with no significant differences in the proportion of SFA. The aroma, appearance and flavour of cooked meat and broth were evaluated during the sensory assessment. The taste panel rated the meat and broth from heavier hens (R-11) with genetically determined yellow carcass colour as the best ($P \leq 0.05$), whereas differences in the other categories (including the production system) were small and not significant.

Discussion

Poultry meat production, which is playing an increasing role in the food economy, is now based on raising high-yielding commercial strains of broilers characterized, under controlled environmental conditions, by a rapid growth rate, high dressing percentage, and heavy breast and thigh muscling. The contribution of diet and genetic and environmental factors to the quality of broiler carcasses and meat has been the subject of many studies and is now well understood (Grashorn, 2007; Zduńczyk and Jankowski, 2013).

The present study on the quality of poultry meat explored the possibility of obtaining meat from hens that reached the end of their laying lifetime. Thus the hens were not from intensive, but from extensive farming and were used for both egg and meat production. It is necessary to stress that in modern poultry production, dual-purpose production is of marginal significance and obtaining meat from laying hens is no alternative to intensive broiler production, but provides an opportunity to make full use of the conserved breeds in organic or backyard farms. The present study evaluated the effect of hen breed and production system on the physicochemical characteristics of meat and can therefore be a useful criterion in choosing the breeds for dual-purpose production under extensive conditions.

The proportion of breast and leg muscles in the carcasses from both hen breeds was small and much lower than that reported by Berri et al. (2005) and Połtowicz and Doktor (2012) for slow-growing chickens, but comparable to the results obtained with native breeds of hens (Połtowicz and Cywa-Benko, 1999).

The carcasses from hens of the analysed breeds were much fatter (6–7%) than those reported by other studies (less than 3%) (Berri et al., 2005; Połtowicz and Doktor, 2012). Even in broiler chickens whose rearing was extended to 63 days, this value did not exceed 4% (Zhu et al., 2012). The abdominal fat content of carcasses did not exceed 2% in 42-day-old broiler chickens (Kokoszyński et al., 2013) and reached 3% in 48-day-old birds (Polak, 2004). The present study shows that in laying hens that reached sexual maturity (around 20 weeks of age), carcass fatness increased especially in R-11 layers in which higher body weight is genetically conditioned.

Colour is a significant factor in the consumer's perception of the carcass. In traditional Polish cuisine, stewing hens were expected to have yellow carcasses. In the present study, the free-range production system contributed mainly to the yellow colour of the carcasses desired by potential broth consumers. Carcass colour is determined by the colour of subcutaneous fat, which depends on lutein. The intense yellow colour of the carcasses from free-range laying hens was probably due to their ingestion of plants that were a source of xanthophylls deposited in the abdominal fat. Likewise, Fanatico et al. (2005 a) reported skin colour intensity to increase significantly in slow-growing birds with outdoor access.

The measurements of $pH_{15\ min}$ after slaughter were high in all hens (>6.20) and indicated DFD meat (Jakubowska et al., 1999). Likewise, Okruszek et al. (2007) reported similar results of pH_{15min} in ducks of heritage lines and suggested that some muscles of these birds may have the DFD defect due to the long period of rearing. Like in the study of Michalczuk et al. (2014), we observed no effect of the production system on pH value. In contrast, pH values for free-range broiler chickens were found to be significantly higher by Richardson (2004) and lower by Gornowicz and Lewko (2010).

The water holding capacity of the studied hen breeds was small and much lower than in broiler chickens (Połtowicz and Doktor, 2011). We found no effect of the breed and production system on the water holding capacity of breast and thigh muscles, which is in agreement with Michalczuk et al. (2014). In turn, Połtowicz and Doktor (2011) found the WHC of leg muscles from free-range broilers to increase, and Gornowicz and Lewko (2010) and Mikulski et al. (2011) to decrease.

Drip loss of thigh muscle was similar to the findings of Berri et al. (2005) and Połtowicz (2007) reported for broiler chickens raised to 13 weeks of age. The level of these values is indicative of the high water holding capacity of the meat from the hens under study.

In our study, we found cooking loss to be higher in leg muscles than in breast muscles, and our results concur with those obtained for both broiler chickens (Gornowicz, 2008) and slow-growing chickens (Castellini et al., 2002 a, b; Wattanachant et al., 2004; Połtowicz, 2007). The high water holding capacity of thigh muscles was due to the fact that leg muscles contained four or five times as much raw fat as breast muscles.

Shear force, which reflects tenderness of meat, is a trait directly correlated to the age of birds and for this reason our results are much higher than those obtained for the meat of young broiler chickens (Fanatico et al., 2005 b; Połtowicz and Doktor, 2012). Castellini et al. (2002 a) and Michalczuk et al. (2014) found shear force of meat to increase in the organic production system of broiler chickens, and this tendency was also found in our study.

The present study shows that the breed of hens has an effect on colour saturation. The darkest breast and leg muscles as well as highest redness were found in Greenleg Partridge hens (Z-11), which are characteristic features of this native breed, also confirmed by Połtowicz and Cywa-Benko (1999). Both the conformation traits and the dark coloured meat of Greenleg Partridge hens show a resemblance to those of wild partridges. Unrestricted access of the hens to the free-range area caused a significant increase in the yellowness of breast and thigh muscles, which conforms with most of the research results obtained for both young and older broiler chickens kept outdoors (Castellini et al., 2002 a, b; Fanatico et al., 2005 a; Połtowicz and Doktor, 2011).

The fatty acid profile of poultry muscles can be most effectively manipulated through dietary modification (Grashorn, 2007; Szymczyk and Frys-Żurek, 2011; Zduńczyk and Jankowski, 2013), but our study shows that this meat quality trait is also influenced by the production system and hen genotype (breed).

The breast muscles of the native Greenleg Partridge hens (Z-11) contained less saturated and more unsaturated fatty acids compared to Rhode Island Red hens (R-11). The effect of genotype on the fatty acid profile was reported by Franco et al. (2012 b) for hens of two native Spanish breeds. From the point of view of human nutrition, breast muscles have a more beneficial profile of fatty acids compared to leg muscles, which contain less polyunsaturated fatty acids. A similar relationship was observed by Castellini et al. (2002 a) in breast muscles of slow-growing chickens (especially R-11); they were characterized by a nutritionally beneficial low *n-6:n-3* PUFA ratio, which was slightly lower than in young broiler chickens (Žlender et al., 2000), twice as low as in the muscles of hens of the native Spanish breeds (Franco et al., 2012 a), and similar to three varieties of slow- and medium-growing chickens (Dal Bosco et al., 2012). As regards polyunsaturated fatty acids, we found a relatively high proportion of linoleic acid (C18:2*n-6*), being higher than in the native Spanish breeds of hens (Franco et al., 2012 a) but similar to the level obtained for three out of six different varieties of broiler chickens investigated by Dal Bosco et al. (2012).

In the present study, the outdoor production system contributed to an increase in the proportion of both *n-6* and *n-3* PUFA in breast and leg muscles, but decreased MUFA, without causing any significant changes in the content of SFA. Similar results were obtained for Label Rouge chickens by Chartrin et al. (2005) and for slow-growing broiler chickens by Mikulski et al. (2011). In turn, in the muscles of organically raised broiler chickens aged 81 days, Castellini et al. (2002 a and 2002 b) found a concurrent increase in the content of both PUFA and SFA. In our study, the outdoor production system contributed to an increase in the proportion of α–linolenic acid (C18:3*n-3*) in meat, similarly as in 56-day-old broiler chickens studied by Žlender et al. (2000). We found the outdoor production system to exert no significant influence on a nutritionally beneficial decrease in the *n-6:n-3* PUFA ratio, but such a relationship occurs in the meat of young broiler chickens (Žlender et al., 2000; Araújo et al., 2011; Michalczuk et al., 2014). Because poultry meat has a higher content of unsaturated fatty acids, the melting point of poultry fats is lower compared to other animals, which makes them more easily assimilated by the human body.

In the sensory assessment, the taste panel tended to give higher scores to the meat and broth from hens with outdoor access (especially with regard to flavour). These results are in agreement with those of Fanatico et al. (2006), who found no statistically significant differences in the sensory assessment of meat from slow- and fast-growing chickens raised on free range depending on the production system. In the study by Laszczyk-Legendre (1999), consumers gave 1 point higher scores on average to the meat from Label Rouge chickens compared to broiler meat in all assessment categories.

In summing up the present results, it is stated that:

– The carcasses of 56-week-old multi-purpose hens undergoing conservation in Poland are characterized by poor muscle development and considerable fat content.

– After the first year of egg production, the meat of hens was characterized by low tenderness, high water holding capacity, and a fatty acid profile that was desirable from the perspective of human nutrition.

– The outdoor production system contributed to a decrease in carcass fatness and an increase in carcass and meat yellowness, and increased the proportion of both *n-6* and *n-3* PUFA in leg and *n-6* in breast muscles, without causing any significant changes in the content of SFA.

– The outdoor production system has improved meat quality traits in the native Greenleg Partridge hens (Z-11) to a greater extent than in Rhode Island Red hens (R-11).

– There was no statistically significant effect of the production system on the sensory evaluation of cooked meat and broth.

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Received: 8 VII 2014
Accepted: 31 X 2014