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Effect of the brown coat-coding gene (*TYRP-1*) on wool and skin color of Żelaźnieńska and Wrzosówka sheep

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Abstract: *Effect of the brown coat-coding gene (*TYRP-1*) on wool and skin color of Żelaźnieńska and Wrzosówka sheep.* The study was conducted on randomly chosen ewes (Żelaźnieńska sheep – 93; Wrzosówka sheep – 133) during the shearing. Color of wool and skin was examined using device Chroma Mater CR-400 (Konica Minolta Sensing Inc., 2011). Taking into account the results of genotyping in order to the brown coat-coding gene (*TYRP-1*), 66 Żelaźnieńska ewes and 74 Wrzosówka ewes were chosen to next stage of study where effect of the brown coat-coding gene (*TYRP-1*) on wool and skin color was assessed within breed and between breeds. Based on the results significant and highly significant differences in all color measurements of wool and skin between tested breeds were found, which should be connected with different wool color in each breed. However, there is striking difference in color of wool and skin regarding to a* color parameter, which were exactly opposite. It probably means that proportion of red or green color in skin is different than in wool. Differences in color values of wool depending on *TYRP-1* gene genotypes were observed only for Wrzosówka sheep. The measurement of L* color parameter made on wool was highly significantly higher in the case of CC and CT genotypes in comparison to TT genotype. However, in the measurement of a* color parameter, the situation is opposite and homozygote TT had higher values compared to the others genotypes. No differences between wool and skin color of Żelaźnieńska sheep and no differences in skin color of Wrzosówka sheep were found. The results of studies on wool color, depending on genotype of the *TYRP-1* gene in Wrzosówka sheep, make possibilities to conduct breeding work in order to develop standards for coat color for this breed.

Key words: sheep, wool, skin, color of wool and skin

INTRODUCTION

Management of sheep wool in the textile industry depend largely on its color. Colors from white to pale cream are preferred and such assumptions were maintained in most of Polish sheep breeds (www.stat.gov.pl, PZO 2015). In the breeding work a lot of attention is paid for wool color, but assessing it is based on subjective experience of selector. The first attempt to objectify the assessment of wool color was made by Kulesza et al. (2014) using a colorimeter. Studies provided information about possibilities for evaluation of color measurement and using objective methods for that. The color of wool is determined by various factors, among which the genetic factor plays a leading role. Especially by gene encoding the brown coat (*TYRP-1*), which has been known widely in analyzing sheep coat color, mainly in Asia (Deng et al. 2006) and in Europe among the breeds considered as ancestors of modern sheep breeds (Gratten et al. 2007). In Poland frequency of alleles and genotypes of *TYRP-1* gene was examined by Niżnikowski et al. (2013, 2015a, b) and

pointing to the significant differentiation between primitive and cultural sheep breeds (Niżnikowski et al. 2013), and relative low differences among Polish wool-meat sheep breeds (Niżnikowski et al. 2015a, b). Taking into account the results of Kulesza et al. (2014) and Niżnikowski et al. (2015a, b), it was hypothesized that there is a relationship between frequency of alleles and genotypes of brown coat-coding gene (*TYPR-1*) and color of wool and skin measured objectively. In order to better illustrate color differences two breeds where examined: white colored – Żelaźnieńska sheep, and colorful (mostly grey) Wrzosówka sheep.

MATERIAL AND METHODS

The study was conducted on mature ewes (Żelaźnieńska sheep – 93; Wrzosówka sheep – 133) maintained in research farm in Żelazna – WULS-SGGW in 2015. Animals were randomly selected during the shearing. Color of wool and skin was examined using device Chroma Mater CR-400 (Konica Minolta Ltd.). The color was measured using the system CIE L*a*b*. Parameter L* expresses clarity and varies from 0 (black) to 100 (white). Parameter a* varies from –60 to +60: –a* goes from green, +a* goes towards red. Parameter b* varies from –60 to +60: –b* goes towards blue, +b* towards yellow. Device was calibrated on white calibration plate before measurements. Color of wool and skin measurements were done on the right side of sheep at last rib.

The results of the colorimetric measurements was used to compare breeds between wool and skin color. Taking into account the results of the brown coat-coding gene *TYRP-1* described by Niżnikowski et al. (2013, 2015a, b) 66 Żelaźnieńska sheep ewes and 74 Wrzosówka sheep ewes were selected for further analysis, in which the impact of genotype *TYRP-1* gene on wool and skin color within and between breeds was determined. Selected ewes have been already genotyped in order to *TYRP-1* gene. The results were statistically analyzed using the IBM SPSS Statistics 23 software. Regarding to wool and skin color measurements made on all sheep ANOVA system was used, while in the case of animals which had specified *TYRP-1* genotype two-factor analysis of variance was used, reflecting the *TYRP-1* gene genotype and sheep breed and the two-way interaction between these sources of variation. Differences tested features value were evaluated based on the comparison of subclasses interactive. The results of the statistical calculations are presented in tables.

RESULTS AND DISCUSSION

The results of wool and skin color between breed are presented in Table 1. For all color measurements breed had highly significant or significant impact on color parameters. Lightness value L* for wool as well as skin were higher in Żelaźnieńska sheep than in Wrzosówka sheep. Values of a* color parameter were highly significantly higher for wool of Wrzosówka sheep and significantly higher for skin of Żelaźnieńska sheep. Measurements of b* color parameter showed highly significant higher values for wool

TABLE 1. Wool and skin color values according to breed

Specification		Żelaźnieńska sheep	Wrzosówka sheep	Statistical significance
color parameters	n	93	133	
	wool			
L*	*LSM*	75.64	46.09	XX
	SE	3.20	8.83	
a*	*LSM*	0.67	2.33	XX
	SE	1.48	1.40	
b*	*LSM*	16.74	3.10	XX
	SE	5.84	2.75	
×	skin			
L*	*LSM*	70.03	54.26	XX
	SE	4.29	9.22	
a*	*LSM*	4.53	3.98	X
	SE	2.36	1.52	
b*	*LSM*	6.18	3.17	XX
	SE	3.23	1.82	

Statistical significance: XX – $P \leq 0.01$; X – $P \leq 0.05$.

and skin of Żelaźnieńska sheep than in Wrzosówka sheep. The values of these parameters in relation to color of wool in Żelaźnieńska sheep coincide with work published by Kulesza et al. (2014). Differences in color between Wrzosówka and Żelaźnieńska sheeps does not raise doubts due to the fact that both breeds differ significantly in terms of coat color. However, there is striking difference in color of wool and skin regarding to a* color parameter, which were exactly opposite. This means that proportion of red or green color in the skin is different than in the wool. Colors values of wool and skin depending on the interaction of *TYRP-1* genotype and breed are summarized in Table 2. The genotypes distribution of brown coat-coding gene *TYRP-1* within breed was characteristic for foreign sheep breeds (Deng et al. 2006, Gratten et al. 2007) and was also proven in national research (Niżnikowski et al. 2013, 2015a, b). The effect of interaction was highly significant on all color parameters of the wool and on L* and b* color parameters of the skin. After analysis of color measurements on wool and skin of Żelaźnieńska sheep, there was no statistically significant differences between genotypes *TYRP-1*. The situation is different for Wrzosówka sheep. The measurement of L* color parameter made on wool was highly significantly higher in the case of CC and CT genotypes in comparison to TT genotype. However, in the measurement of a* color parameter, a situation is opposite and homozygote TT had higher values compared to the others genotypes. What is interesting, in the case of skin color of Wrzosówka sheep such differences were not found. In general summary, differences in color measurement values of wool were observed

TABLE 2. Wool and skin color values according to genotype

Specification		Żelaźnieńska sheep			Wrzosówka sheep		
		CC (A)	CT (B)	TT (C)	CC (D)	CT (E)	TT (F)
Color parameters	*n*	41	22	3	40	26	9
	wool						
L*	*LSM*	75.56^{DEF}	74.87^{DEF}	72.80^{DEF}	47.25^{ABCF}	48.27^{ABCF}	38.10^{ABCDE}
	SE	0.98	1.33	3.61	0.99	1.23	2.09
a*	*LSM*	0.79^{DEF}	0.78^{DEF}	2.36	2.17^{ABf}	1.92^{AbF}	3.58^{ABdE}
	SE	0.21	0.28	0.77	0.21	0.26	0.45
b*	*LSM*	17.55^{DEF}	16.24^{DEF}	20.55^{DEF}	3.06^{ABC}	3.33^{ABC}	1.35^{ABC}
	SE	0.69	0.94	2.53	0.69	0.86	1.46
×	skin						
L*	*LSM*	69.58^{DEF}	69.22^{DEF}	71.01^{dEf}	55.57^{ABc}	51.92^{ABC}	54.10^{ABc}
	SE	1.26	1.71	4.64	1.27	1.58	2.68
a*	*LSM*	4.91	4.88	3.96	3.65	3.43	4.02
	SE	0.33	0.45	1.21	0.33	0.41	0.70
b*	*LSM*	6.12^{DEF}	6.45^{DEF}	10.57^{DEF}	3.37^{ABC}	2.83^{ABC}	2.35^{ABC}
	SE	0.42	0.57	1.55	0.42	0.52	0.89

Statistical significance: A... F – $P \leq 0.01$; a... f – $P \leq 0.05$.

only for Wrzosówka sheep. The lowest value of L* and a* color parameters of Wrzosówka sheep with the genotype TT compared to not dissimilar CC and CT was found. It could be state that for this breed that values of color measurements of heterozygote CT were similar to homozygote CC. The analysis indicates that the genotype of *TYRP-1* gene influenced only on measurements of wool color for Wrzosówka sheep – breed with colorful wool. It is difficult to relate the results of other research. However, in a practical sense, developing criteria of color distribution depending on the genotype could be used in breeding work to achieve patterns of coat color for this breed.

CONCLUSIONS

The obtained results led up to following statements and conclusions:

1. Significant or highly significant differences between assessed sheep breeds in all color measurements of wool and skin, which should be associated with different coat color in both breeds. Striking is the fact of the differences in the color of wool and skin in relation to the a* value, which are arranged exactly the opposite in both cases. This means that proportion of red or green color in skin is different as wool.

2. Differences in color measurement values of wool depending on *TYRP-1* gene genotypes were observed only for Wrzosówka sheep. The measurement of L* color parameter made on wool was highly significantly higher in the case of CC and CT genotypes in comparison to TT genotype. However, in the measurement of a* color parameter situation is opposite and homozygote TT was higher values compared to the other genotypes.
3. No differences between wool and skin color of Żelaźnieńska sheep and no differences in skin color of Wrzosówka sheep.
4. The results of studies on the distribution of measurements of color wool, depending on the *TYRP-1* gene genotype of Wrzosówka sheep, make possibilities to conduct breeding work in this field, which could be used in breeding practice to develop standards of coat color for this breed.

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Streszczenie: *Wpływ rasy oraz genu kodującego brązowe umaszczenie (*TYRP-1*) na barwę wełny i skóry u ras owcy żelaźnieńskiej i wrzosówki polskiej*. Badania przeprowadzono na maciorkach dorosłych, losowo wybranych w trakcie strzyży maciorek rasy żelaźnieńskiej (93) i wrzosówki (133). Wykonano pomiary wełny i skóry przy użyciu urządzenia Chroma Meter CR-400 (Konica Minolta Sensing Inc., 2011). Uwzględniając wyniki określania genotypu genu kodującego brązowe umaszczenie *TYRP-1*, wybrano do dalszych analiz 66 maciorek żelaźnieńskich i 74 rasy wrzosówka, na których oceniono wpływ genotypu *TYRP-1* na cech barwy wełny i skóry w obrębie rasy i pomiędzy nimi. Na podstawie przeprowadzonych badań stwierdzono bądź wysoko istotne statystycznie różnice pomiędzy ocenianymi rasami owiec w zakresie wszystkich pomiarów barwy wełny i skóry, co należy wiązać z umaszczeniem u obu ras. Zasta-

nawiający jest jednak fakt innego układu różnic w barwie wełny i skóry w odniesieniu do wartości pomiarów udziału barwy czerwonej a*, które układały się dokładnie na odwrót w obu przypadkach. Oznacza to, że udział barwy czerwonej bądź zielonej w skórze jest inny niż w wełnie. Pomiar jasności barwy L* wykonany na wełnie wykazał wysoko istotne statystycznie większe wartości w przypadku genotypów CC i CT w porównaniu do TT. W przypadku pomiaru a* sytuacja kształtowała się odwrotnie i to u osobników homozygotycznych TT osiągnęła większe wartości tej cechy w porównaniu do pozostałych. Nie wykazano zróżnicowania pomiarów barwy wełny i skóry u owcy żelaźnieńskiej oraz skóry u wrzosówki. Wyniki badań dotyczących rozkładu pomiarów barwy wełny w zależności od genotypu *TYRP-1* u wrzosówki, stwarzają możliwość prowadzenia pracy hodowlanej w tym zakresie, co w konsekwencji może być wykorzystane w praktyce hodowlanej przy dążeniu do wypracowania skonsolidowanych standardów umaszczenia dla tej rasy.

*Słowa kluczowe***:** owce, wełna, skóra, barwa wełny i skóry

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