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Influence of cattle breed and country of origin on milk yield and milk composition in dairy cows

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Abstract: *Influence of cattle breed and country of origin on milk yield and milk composition in dairy cows*. Dairy cattle breeding and milk industry are still significant part of Polish agriculture industry. Polish farmers have valid positions in Europe and other parts of the world and cattle is their main source of income but also main species using grasslands in Poland. The main objective of the study was to determine the effect of: race, herd, country of origin and number of calving on milk production and milk composition of three dairy cattle breeds: Polish Holstein-Friesian, Polish Black and White, Simmental. Cows were kept on farms with milk performance recording system. Importance of each factor was assessed using one-way analysis of variance. Polish Holstein-Friesian breed achieved the highest daily milk yield ($P < 0.01$). The highest milk yield cows reached during the 3rd lactation. However, cattle imported from the Netherlands had higher ($P < 0.01$) milk yield, protein content and somatic cell count level comparing to cows from other countries. Presented data may suggest that breeders in the Netherland remove from herds cow more susceptible to mastitis. Farmers in Poland should consider breeds different than PHF e.g., SM if having large grasslands.

Key words: cattle, breed, origin, milk production

INTRODUCTION

Milk and dairy products are one of the most important parts of balanced human diet. Dairy industry and cattle breeding are still significant part of Polish agriculture industry that ensure our milk producers valid positions in Europe and other parts of the world. Cattle is the source of income for farmers but also main species using grasslands in Poland. Moreover, milk industry is about 18–20% of commodity production (Litwińczuk and Grodzki 2014).

In general, one of the biggest issue in milk production is short time of dairy cows utilization. Cow culling after 2nd or 3rd lactation is unfavorable for milk producers, because cows reach their production peak between 2nd and 4th lactation (Grodzki et al. 1998, Sawicka-Zugaj 2010, Frejlach et al. 2015). In 2016 average production lengths for Polish Holstein-Friesian (PHF), Simmental (SM) and Polish Black and White (ZB) breeds were 3.05, 3.31, 5.09, respectively and average time of utilization of cows in 2016 was 3.03 (www.pfhb.pl).

The process of cattle breeding has begun in Poland in XVI century and had impact on present population. Different selection strategies resulted in presence of breeds with different genetic merit. High yielding PHF require balanced nutrition and good environmental conditions, Simmental breed is mainly used in semi-intensive systems and native breeds (ZB or Polish Red) generally maintained

in small, agritourism farms (Litwińczuk and Grodzki 2014).

The aim of the study was to estimate the influence of cattle breed and country of origin on production traits of three breeds with different genetic merit (PHF, ZB, SM) that are present in Polish dairy farms.

MATERIAL AND METHODS

Dairy cows originated from Poland (PL), Netherlands (NE), Denmark (DE) or Austria (AT) and were maintained in Polish farms that participate in dairy cattle evaluation system provided by Polish Federation of Cattle Breeders and Dairy Farmers. Analysis contained milk recording data of 325 SM, 394 ZB and 1388 PHF cows. SM cows originated mainly from AT, PHF cows originated from DE and NE and ZB breed originated from PL. In each farm were maintained PHF cows and SM or ZB cows. Samples for milk performance recording were collected using AT4 or A4 methods (www.pfhb.pl).

Results from SYMLEK database containing information connected with daily milk yield, fat content, protein content, lactose content, dry matter, urea content and somatic cell count (SCC) were analyzed. Average daily milk yield and average milk compositions were calculated for each breed. Data were elaborated separately according to selected factors: breed, country of origin and number of lactation.

Statistical analysis were calculated using IBM SPSS Statistics 22.1. The influence of selected factors on milk production and milk composition was estimated with multi-factor analysis of variance (Multi-factor ANOVA). Preliminary analysis did not reviled significant interactions between studied factors.

RESULTS AND DISCUSSION

Cattle breed and country of origin have significant impact on cow yield and milk composition e.g., fat and protein content, urea content or SCC (Czerniawska-Piątkowska et al. 2009, Sawicka-Zugaj 2010, Gnyp 2012, Litwińczuk et al. 2012, Czaplicka et al. 2013, Barłowska et al. 2014, Balcerak et al. 2015).

Analyzed records revealed that average milk yield for all breeds was 21.49 kg. The highest production was observed in PHF (23.38 kg) and SM and ZB achieved lower yield (20.18 kg and 15.94 kg, respectively) (Table 1). Balcerak et al. (2015) presented average milk yields for PHF and SM were 23.77 kg and 18.02 kg, respectively. Higher results occurred in Litwińczuk et al. (2012) survey and achieved 25.86 kg for PHF and 19.11 kg for SM. In the same study milk yield of ZB was 17.16 kg. According to Barłowska et al. (2014) average SM production is higher than in mentioned references 24.32 kg.

The average dry matter content in milk was 13.24% and statistically significant differences ($P < 0.01$) were observed for this trait between milk of SM (13.33%) and ZB (12.86%). However, cows imported from NE had higher dry matter content (13.53%) in milk ($P < 0.05$) and the highest ($P < 0.01$) dry matter content was observed in 2nd lactation. Sawicka-Zugaj (2010) revealed that ZB and PHF milk contains 12.63% and 12.85% of dry

TABLE 1. Average milk yield and milk composition of dairy cows according to cattle breed

Breed	*N*	Daily milk yield (kg)	Fat content (%)	Protein content (%)	Lactose content (%)	Dry matter (%)	Log SCC (thou./ml)	Urea content (mg/l)	Fat-protein ratio
Simmental	325	20.18^{AB} ±6.56	4.21^{AB} ±0.71	3.57^{A} ±0.38	4.90^{AB} ±0.19	13.33^{A} ±0.90	1.96^{AB} ±0.46	185.23^{AB} ±67.7	1.18
Polish black and white	394	15.94^{AC} ±6.45	4.03^{AC} ±0.75	3.43^{AB} ±0.40	4.67^{AC} ±0.26	12.86^{AB} ±0.90	2.49^{AC} ±0.43	140.88^{AC} ±53.24	1.14
Polish Holstein--Friesian	1388	23.38^{BC} ±7.92	4.37^{BC} ±0.81	3.53^{B} ±0.47	4.73^{BC} ±0.24	13.33^{B} ±1.04	2.34^{BC} ±0.41	175.15^{BC} ±62.41	1.24
Average		21.49 ±8.00	4.28 ±0.79	3.51 ±0.44	4.74 ±0.25	13.24 ±1.01	2.28± 0.50	170.26 ±63.33	1.22

Differences significant at $P < 0.01$ for A, B, C

matter, respectively. According to available references dry matter content in SM milk was 12.73–13.56% (Litwińczuk et al. 2012, Barłowska et al. 2014, Balcerak et al. 2015, Matwiejczuk et al. 2015), for ZB milk 12.63% (Sawicka-Zugaj 2010), and for PHF breed values were 13.02––13.27% (Litwińczuk et al. 2012, Koperska and Litwińczuk 2014, Balcerak et al. 2015).

Obtained results revealed also differences ($P < 0.01$) in fat and protein contents in milk of selected breeds. Fat and protein contents for PHF, SM and ZB were 4.37% and 3.53%, 4.21% and 3.57% and 4.03% and 3.43%, respectively. SM milk contained higher amounts ($P < 0.01$) of lactose and urea in comparison to other breeds. However, the highest average SCC was observed in ZB milk (708.61 tys./ml).

Available references suggest that PHF, SM and ZB milk contains 4.05––4.37%, 3.93–4.35% and 3.98–4.03% fat, respectively (Sawicka-Zugaj 2010, Litwińczuka et al. 2012, Barłowska et al. 2014, Balcerak et al. 2015, Matwiejczuk et al. 2015).

Protein contents in milk for each breed are 3.20–3.49% for PHF, 3.28––3.79% for SM, and 3.23–3.37% for ZB (Sawicka-Zugaj 2010, Litwińczuk et al. 2012, Barłowskiej et al. 2014, Koperska and Litwińczuk 2014, Balcerak et al. 2015, Matwiejczuk et al. 2015).

The average lactose contents for each breeds are 4.75–4.84%, 4.67–4.99, 4.75––4.76% for PHF, SM and ZB, respectively (Sawicka-Zugaj 2010, Litwińczuk et al. 2012, Barłowskiej et al. 2014, Balcerak et al. 2015, Matwiejczuk et al. 2015).

Balceraka et al. (2015) calculated average urea content for PHF and SM (338.44 mg/l and 112.91 mg/l, respectively). Different values were presented in studies carried out by Litwińczuk et al. (2012) and PHF, SM and ZB had urea content in milk at the level of 178.23 mg/l, 216.40 mg/l, 174.45 mg/l, respectively. On the other hand, Czaplicka et al. (2013) suggest that milk from PHF cows imported from France contained more urea (445 mg/l) than milk of native cows (286 mg/l). However, various urea content in milk can be directly connected with nutrition. Therefore, values can be the result of imbalanced diet or differences in efficiency of feed utilization by mentioned breeds.

Country of origin can also have an impact on animal yield and milk composition (Czerniawska-Piątkowska et al. 2009, Gnyp 2012, Czaplicka et al. 2013, Balcerak et al. 2015). Obtained results (Table 2) showed that cows from NE had the highest ($P < 0.01$) daily milk yield (25.45 kg) but their SCC (2.38 Log SCC) was also the highest ($P < 0.01$). Milk from cows imported form AT contained the highest ($P < 0.01$) level of fat (4.57%) and the highest ($P < 0.01$) level of lactose (4.81%) and urea (175.68 mg/l) was in milk from cows imported from DE.

Balcerak et al. (2015) did not observed statistically significant differences between native cows and animals imported from European countries but cows from France had the highest milk yield (27.03 kg). However, Gnyp (2012) suggested that cows imported from France and the Netherlands have 25–30% higher milk production. Similar results were presented also by Czaplicka et al. (2013). On the other hand, analysis by Czerniawska-

TABLE 2. Average milk yield of cows according to country of origin

Country of origin	*N*	Daily milk yield (kg)	Fat content (%)	Protein content (%)	Lactose content (%)	Dry matter (%)	Log SCC (thou./ml)	Urea content (mg/l)
Denmark	687	22.16^{AB} ±7.41	4.09^{ABC} ±0.67	3.54^{aB} ±0.39	4.81^{AB} ±0.22	13.11^{aBC} ±0.92	1.62^{B} ±0.44	175.68^{A} ±55.34
Poland	412	20.91^{AC} ±8.08	4.32^{AD} ±0.82	3.49^{aC} ±0.44	4.72^{AC} ±0.26	13.24^{aDE} ±1.01	2.16^{A} ±0.41	170.67^{B} ±65.11
Netherlands	667	25.45^{BCD} ±8.66	4.39^{B} ±0.85	3.67^{BCD} ±0.61	4.79^{C} ±0.19	13.53^{BD} ±1.30	2.38^{ABC} ±0.45	168.80^{C} ±73.29
Austria	341	21.21^{D} ±7.80	4.57^{CD} ±0.77	3.48^{D} ±0.48	4.74^{B} ±0.22	13.50^{CE} ±1.01	1.51^{C} ±0.38	144.91^{ABC} ±60.84
Average		21.49 ±8.00	4.28 ±0.79	3.51 ±0.44	4.74 ±0.25	13.24 ±1.01	2.28 ±0.50	170.26 ±63.33

Differences significant at $P < 0.01$ for A, B, C; $P < 0.05$ for a

Piątkowska et al. (2009) showed that native cows of Holstein-Friesian breed can achieve higher production results.

Authors suggest that lactation number also effects cow yield and milk composition (Grodzki et al. 1998, Sawicka-Zugaj 2010). Obtained results showed that cows reached the highest ($P < 0.01$) production during 3rd lactation and milk composition varied according to the lactation number (Table 3). According to previous studies, the utilization of ZB breed is longer than PHF, and cows of our native breed reach production peak later (5–7th lactation) comparing to PHF (Sawicka-Zugaj 2010).

SCC and milk yield are connected (Litwińczuk et al. 2011). Balcerak et al. (2015) calculated that 1 ml of PHF and SM milk contained 2.34 and 1.96 Log SCC, respectively. Higher results were presented by Czaplicka et al. (2013) for Holstein-Friesian cows imported from France. According to presented data, farmers from the Netherlands export cows with high yield but elevated SCC. It may suggest that breeders remove from herds cow more susceptible to mastitis. The strong relationship ($P < 0.01$) between SCC and cattle breed is connected with breed sensitivity for SCC changes. Probably, it's the result of blood proteins permeability in udder veins. Therefore, Holstein-Friesian breed susceptibility is higher than e.g., SM or Jersey breeds (Litwińczuk et al. 2011). Nevertheless, good environmental conditions and high level of nutrition can balanced this negative correlation (Castillo-Juarez et al. 2000).

Presented data suggest that SM milk has the most favorable fat-protein ratio (Table 1). It is connected with the high-

TABLE 3. Average milk yield of cows, according to number of lactation

Lactation	*N*	Daily milk yield (kg)	Fat content (%)	Protein content (%)	Lactose content (%)	Dry matter (%)	Log SCC (thou./ml)	Urea content (mg/l)
1	334	18.33^{ABCD} ±5.62	4.19^{aB} ±0.70	3.50^{AB} ±0.41	4.92^{ABCD} ±0.17	13.28^{A} ±0.89	1.89^{aBCD} ±0.40	177.64^{aB} ±63.64
2	588	21.78^{AE} ±7.92	4.30^{a} ±0.78	3.61^{ACD} ±0.48	4.78^{AEFG} ±0.22	13.37^{BC} ±1.02	2.08^{aEF} ±0.41	166.93^{acD} ±59.34
3	488	23.06^{BEF} ±8.39	4.28 ±0.78	3.56^{EF} ±0.45	4.74^{BEHI} ±0.22	13.27^{D} ±1.04	2.40^{BGH} ±0.41	176.33^{cE} ±63.54
4	251	22.68^{Cg} ±8.94	4.20^{C} ±0.85	3.44^{CE} ±0.41	4.63^{CFH} ±0.27	13.01^{ABD} ±1.00	2.51^{CEG} ±0.44	151.80^{BDEF} ±61.57
5 or more	446	21.11^{DFg} ±7.96	4.37^{BC} ±0.85	3.39^{BDF} ±0.40	4.64^{DGI} ±0.25	13.14^{C} ±1.05	2.52^{DFH} ±0.41	172.76^{F} ±66.83
Average		21.49 ±8.00	4.28 ±0.79	3.51 ±0.44	4.74 ±0.25	13.24 ±1.01	2.28 ±0.50	170.26 ±63.33

Differences significant at $P < 0.01$ for A, B, C, D, E, F, G, H, I; $P < 0.05$ for a, c, g

est technological value of SM milk and similar conclusions were showed in previous studies (Litwińczuk et al. 2012).

Several authors presented analysis comparing costs and benefits of maintaining different breeds in Polish dairy farms (Chabuz 2013, Chabuz et al. 2013, Koperska and Litwińczuk 2014). Satisfying income in herds that maintain PHF and SM is possible with high production and keeping costs at low level. Similar income was reached in semi-intensive system based on SM, because pasture using significantly decreases production cost and calves are additional source of income (Chabuz 2013). In case of native breed, important source of finances are subsidies from EU and farms that did not received them generate losses. On the other hand, European subsidies are the main reason of maintaining native breeds (Chabuz 2013, Chabuz et al. 2013). Therefore, alternative sources of income (cheese production or promotion of properties of native breeds milk) are necessary for small farms (Chabuz 2013, Chabuz et al. 2013, Koperska and Litwińczuk 2014). Therefore, producers should more often consider other breeds than PHF, especially if having large permanent grasslands area that can significantly decrease feeding costs and balance lower production.

CONLUSION

Dairy industry is still significant part of Polish agriculture industry. Polish Holstein-Friesian breed achieved the highest daily milk yield ($P < 0.01$). The highest milk yield cows reached during the 3rd lactation. Cattle breed and country of origin influenced cow yields and milk composition ($P < 0.01$). Cattle imported from the Netherlands had higher ($P < 0.01$) milk yield, protein content and SCC comparing to cows from other countries. Presented data may suggest that breeders in the Netherland export cows more susceptible to mastitis. Farmers in Poland nay consider breeds different than PHF e.g., SM if having semi-intensive system based on large areas of grasslands. However, this decision requires precise calculation of production costs, feeding costs and possible income if using different breed than PHF.

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Streszczenie. *Wpływ rasy i kraju pochodzenia na wydajność i skład mleka krów mlecznych*. Hodowla bydła mlecznego i sektor mleczarski stanowią ważną część polskiego rolnictwa. Polscy producenci mleka mają znaczącą pozycję w Europie i na świecie, a bydło stanowi ich główne źródło dochodów oraz jest głównym gatunkiem użytkującym trwałe użytki zielone w Polsce. Celem pracy było określenie wpływu rasy, kraju pochodzenia i numeru laktacji na wydajność mleczną oraz skład mleka trzech ras: polskiej holsztyńsko-fryzyjskiej, polskiej czarno-białej, simentalskiej. Krowy utrzymywano w krajowych gospodarstwach objętych oceną użytkowości mlecznej. Wpływ wybranych czynników określono, dzięki jednoczynnikowej analizie wariancji. Rasa polska holsztyńsko-fryzyjska osiągnęła najwyższą dzienną wydajność ($P< 0,01$). Najwyższą wydajność krowy osiągały w trzeciej laktacji. Jednakże, krowy importowane z Holandii osiągały największą produkcję, ich mleko zawierało najwięcej białka i komórek somatycznych ($P < 0,01$) w porównaniu do krów z innych krajów. Uzyskane dane sugerują, że hodowcy w Holandii brakują ze stad krowy z wyższą skłonnością do zapalenia wymienia (*Mastitis*). Polscy producenci mleka mogą rozważyć utrzymanie innych ras bydła niż PHF, np. simentali, jeśli mogą wykorzystać w produkcji duże obszary użytków zielonych.

Słowa kluczowe: bydło, rasa, pochodzenie, produkcja mleka

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