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CARCASS, MEAT AND FAT QUALITY CHARACTERISTICS OF UKRAINIAN RED WHITE BELTED PIGS COMPARED TO OTHER COMMERCIAL BREEDS

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ABSTRACT

Carcass composition, and pH and electrical conductivity, were compared among Red White Belted (n = 10), Landrace (n = 9) and Large White (n = 10) pigs commercially reared and slaughtered at a live weight between 108 and 118 kg. Carcass yield was lower (P <0.05) in Red White Belted pigs (70.97 %) compared to Landrace (72.72 %) or Large White (72.83 %). At both the withers and between the 6th and 7th thoracic vertebrae, Red White Belted pigs presented greater (P <0.05) backfat measurements (45.80 and 33.70 mm, respectively) compared to Landrace (35.11 and 22.89 mm, respectively) or Large White (37.20 and 23.90 mm, respectively). Greater (P <0.05) pH values were measured at 24 hours *post-mortem* in the *musculus longissimus thoracis et lumborum* of Red White Belted pigs compared to Landrace. No differences (P >0.05) were detected in proximate composition (moisture, protein, fat, ash) of pork or in fat characteristics (moisture, melting point, refraction index) among pig breeds (five pigs per breed analysed).

Keywords: Red White Belted pigs; carcass characteristics; meat quality; fat traits

INTRODUCTION

Consumer demands for high quality pork in the absence of imports of pig breeds from outside Ukraine have resulted in the development of the Ukrainian Red White Belted pig. This synthetic breed was established from 1976 to 2007 at the Institute of Pig Breeding and Agro-industrial Production of the National Academy of Agricultural Sciences (Poltava, Ukraine) through complex crossing methods, which comprised Duroc (43.75 %), Poltava Meat (21.88 %), Hampshire (21.87 %), Landrace (6.25 %) and Large White (6.25 %) pigs (Rybalko *et al.*, 2011a). Red White Belted pigs:

1. are red-coloured with a narrow white strip on the chest behind the shoulder blades;
2. have a strong skeletal structure with a light head;
3. reach a live weight of 100 kg in 185 days;
4. have a high reproduction rate of 10 piglets in a litter;
5. produce a carcass with a carcass lean content of 62 % and backfat thickness of 26 mm (Rybalko *et al.*, 2011b).

Quality characteristics of pig carcasses and pork are largely affected by pig breed. Breed is often included as a variable while meat quality is an important consideration (Mörlein *et al.*, 2007), partly to help optimising the genetic choice of animals (Edwards *et al.*, 1992). With few published information on the meat producing quality of pig breeds developed in Ukraine, the objective of the current study was to compare carcass traits and meat and fat quality characteristics obtained

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with Red White Belted to those from Landrace and Large White pigs. Information obtained could be utilized in countries outside of Ukraine with interest to introduce the Red White Belted pig into their local breeding programmes.

MATERIAL AND METHODS

Animals

Fifty eight barrows and 62 gilts which originated from three commercially available breeds (Red White Belted, Landrace, Large White) were reared and slaughtered at the facilities of the commercial company Freedom Farm Bacon, Ukraine. Landrace and Large White pigs were imported from Northern Ireland in 2003 and 2005, and their Ukrainian-bred offspring (sows) were inseminated in 2008 with semen from boars from the United States to improve feed efficiency and meat quality.

Pigs were housed by breed in pens of 30–40 animals during the weaner period and 25–30 animals during the grower and finisher periods. All animals were fed *ad libitum* on standard complete commercial pig diets. During growth from 30 to 60 kg, diets contained (per dry matter) 12.9 MJ kg^{-1} net energy, 19.1 % crude protein and 1.1 % lysine. These quantities were decreased to 12.8 MJ kg^{-1} net energy, 18.0 % crude protein and 1.0 % lysine during the phase from 60 to 90 kg live weight, and to 12.6 MJ kg^{-1} net energy, 17.1 % crude protein and 0.8 % lysine during 90 to 120 kg, respectively. All pigs were slaughtered at a live weight between 108 and 118 kg at 6–6.5 months of age. Nine to 10 animals per breed were selected for evaluation of carcass and meat (pH, electrical conductivity) quality, whereas proximate composition of pork and fat quality were measured in five animals per breed.

Carcass measurements

Carcass weight was calculated with skins intact, but without heads, feet, viscera and internal fat. Heads were separated cross-section perpendicular to the spine before the 1st cervical vertebra. The front feet were removed at the wrist joint, and rear feet at the hock joint. Carcass yield was calculated as the percentage of hot carcass weight divided by live weight. Carcass length was measured in the hanging position, and defined as the distance from the front surface of the 1st cervical vertebra (atlas) to the front perimeter of the pubic symphysis bones. Length of the bacon side was measured from the middle of the 1st rib to the front perimeter of the pubic symphysis bones.

Backfat thickness (together with skin) was measured in:

1. the thickest part of the withers;
2. over the 6–7 thoracic vertebrae;
3. in the loin.

Minimum thickness of visible fat (including rind) was determined on the midline of the split carcass which is covering the lumbar muscle (*gluteus medius*; *F*), whereas visual thickness of the lumbar muscle was measured as the shortest distance between the front (cranial) end of the lumbar muscle and the upper (dorsal) edge of the vertebral canal (*M*). From these two measurements, the percentage carcass lean ($CL = 58.10122 - (0.56495 \times F) + (0.13199 \times M)$) was calculated according to the 'Zwei-Punkt-Messverfahren' method used in Germany for pig carcasses weighing between 50 and 120 kg (EU, 2011).

Meat and fat quality characteristics

The pH and electrical conductivity (EC) values were recorded with a universal (multipurpose) portable digital LF-Meter "LF-Star CPU-Pistole" (Ing.-Büro & Klassifizierungsservice Rudolf Matthäus, Klausa, Germany) at 1, 5 and 24 hours *post-mortem*. Measurements were made on seven points in the carcass which were the most easily accessible on the slaughterhouse conveyor:

1. musculus semimembranosus (SM);
2. *musculus longissimus thoracis et lumborum* between the 4th and 5th lumbar vertebra (LTL1);
3. *musculus longissimus thoracis et lumborum* between the 10th and 12th thoracic vertebra (LTL2);
4. *musculus longissimus thoracis et lumborum* between the 2nd and 3rd thoracic vertebra (LTL3);
5. *musculus rectus thoracis* (RTH);
6. *musculus intercostales externus* between the 6th and 7th ribs (INEX);
7. *musculus rectus abdominis* (REAB). Temperature was adapted for by use of a digital thermometer 'AMA-digit ad 14th' (Amarell GmbH & Co. KG, Germany).

Ultimate pH (pH_{48}) was measured, as described above, after cooling of carcasses for 48 hours in the LTL2 of five pigs, and muscle and backfat samples for chemical and physical analyses, respectively, were sampled from this position on the right sides of carcasses. Moisture content of muscle samples was determined by drying of a sample at 103 °C to constant weight, ashing was performed at 550 °C in a muffle furnace, crude protein by the Kjeldahl method (nitrogen × 6.25), and ether-extractable intramuscular fat by Soxhlet solvent (petroleum ether) extraction (AOAC, 1990).

Fat analyses of the backfat samples were done according to methods described in the Methodical Recommendations of Agricultural Sciences (Misik, 1978). Moisture content of fat was measured by heating of a 0.5 g sample for 2.5 hours at 105 °C to a constant weight. Melting point temperature of fat was determined by the rising melting point (open capillary) method, and the refractive index by refractometry (IRF-454 B2M, Kazan Optical and Mechanical Plant, Russia) at 40 °C.

Statistical analysis

Preliminary statistical analyses showed that there were no differences between genders, probably due to small sample size. Therefore data for barrows and gilts were pooled. Differences among breeds in carcass, meat and fat quality characteristics were detected by one-way analysis of variance (ANOVA) followed by Tukey's test at the 0.05 level of significance. The General Linear Model procedure (GLM) of SAS version 9.2 (SAS Institute Inc, Cary, NC) was used as statistical package. With muscles originating from the same carcass dependent onto each other, breed was the only independent variable that could be evaluated for meat quality characteristics.

RESULTS AND DISCUSSION

Carcass characteristics

Notwithstanding comparable (P >0.05) live and hot carcass weights, carcass yield and length of the bacon side were lower (P <0.05) in Red White Belted pigs compared to Landrace and Large White (Table 1). Furthermore, backfat thickness measured at both the withers and between the 6^{th} and 7^{th} thoracic vertebrae were greater (P <0.05) in Red White Belted pigs. Differences in backfat thickness were also illustrated by computing the degree of evenness of backfat, determined by the difference in the thickness of backfat on the withers (at the thickest part) and loin (at thinnest part), among pig breeds. This measurement (in mm) presented a greater (P <0.05) value for Red White Belted (15.50 ± 2.099) compared to Landrace (8.22 ± 1.935) or Large White (6.50 ± 1.384). The greater backfat thickness in Red White Belted pigs could be attributed to the large proportion of Duroc genes used in the development of this breed. Duroc pigs are characterised by a greater backfat thickness compared to other breeds (Edwards *et al.*, 1992). A lower muscle growth potential was stated as the reason for a greater backfat thickness and lower carcass lean content in Creole pigs compared to Large White (Renaudeau and Mourot, 2007). However, carcass lean content did not present any differences among breeds in the current study (Table 1).

Meat and fat quality

Table 2 shows that breed had no effects on pH measured at 1 hour *post-mortem*, whereas differences in the LTL3 and REAB at 5 hours *post-mortem* were greater (P <0.05) in Red White Belted pigs compared to Landrace. However, at 24 hours *post-mortem*, values obtained in all parts of the LTL were greater (P <0.05) in Red White Belted pigs compared to Landrace, and in the SM and REAB compared to both Landrace and Large White. Greater (P <0.05) values in Red White Belted pigs (5.52 ± 0.045) compared to Landrace (5.39 ± 0.015) were also found by measuring pH at 48 hours *post-mortem* in the LTL2, with Large White presenting intermediate (5.44 ± 0.017) values.

Greater pH values in muscles from Red White Belted pigs could have resulted from the Duroc proportion used in their development. Duroc pigs present the greatest ultimate pH in the LTL, followed by Hampshire, Large White and Landrace (Barton-Gade, 1988). Whereas muscle metabolic activity (mainly ATPase activity) at slaughter will determine the speed of pH decline, the magnitude of pH decline depends mainly on muscle glycogen reserves (Hambrecht *et al.*, 2005). A low *post-mortem* pH could reduce the acceptability and shelf-life of meat, and its suitability for the manufacture of cured meat products (Ramírez and Cava, 2007).

Table 1: Effects of breed on carcass characteristics (mean ± standard error)

Characteristic	Red White Belted (n = 10)	Landrace (n = 9)	Large White (n = 10)
Live weight (kg)	118.60 ± 4.782	116.22 ± 3.205	108.50 ± 2.566
Hot carcass weight (kg)	84.22 ± 3.580	84.93 ± 2.536	79.04 ± 2.013
Carcass yield (%)	70.97 ± 0.491^{b}	72.71 ± 0.367^{a}	72.83 ± 0.483^{a}
Carcass length (cm)	99.38 ± 1.850	101.00 ± 0.816	101.55 ± 0.677
Length of bacon side (cm)	65.15 ± 1.145^{b}	68.89 ± 0.978^{a}	69.00 ± 0.394^{a}
Backfat thickness at withers (mm)	45.80 ± 2.133^{a}	35.11 ± 1.852^{b}	37.20 ± 1.504^{b}
Backfat thickness between the 6^{th} and 7^{th} thoracic vertebrae (mm)	33.70± 2.082^{a}	22.89 ± 1.728^{b}	23.90 ± 1.847^{b}
Backfat thickness at loin (mm)	30.30 ± 1.633	26.89 ± 2.003	30.70 ± 1.033
Carcass lean content (%)	56.61 ± 0.860	57.60 ± 1.478	59.24 ± 1.014

means in the same row with different subscripts are significantly different (P <0.05); n – number of pigs

Table 2: Effects of breed on pH (mean ± standard error) measured at different time periods in different pig muscles

Muscle	pH_1			pH_5			pH_{24}		
	Red White Belted (n = 10)	Landrace (n = 9)	Large White (n = 10)	Red White Belted (n = 10)	Landrace (n = 9)	Large White (n = 10)	Red White Belted (n = 10)	Landrace (n = 9)	Large White (n = 10)
SM	6.12 ± 0.121	6.10 ± 0.053	6.16 ± 0.052	5.71 ± 0.044	5.67 ± 0.076	5.62 ± 0.069	5.81 ± 0.027^{a}	5.64 ± 0.046^{b}	5.59 ± 0.026^{b}
LTL1	6.13 ± 0.065	6.15 ± 0.051	6.21 ± 0.047	5.75 ± 0.027	5.79 ± 0.066	5.78 ± 0.052	5.73 ± 0.022^{a}	5.56 ± 0.049^{b}	5.62 ± 0.032^{ab}
LTL2	6.18 ± 0.058	5.93 ± 0.078	6.20 ± 0.106	5.74 ± 0.053	5.62 ± 0.042	5.72 ± 0.041	5.73 ± 0.026^{a}	5.60 ± 0.022^{b}	5.65 ± 0.025^{ab}
LTL3	6.31 ± 0.047	6.19 ± 0.038	6.33 ± 0.049	5.95 ± 0.015^{a}	5.80 ± 0.030b	5.92 ± 0.031^{a}	5.97 ± 0.043^{a}	5.73 ± 0.103^{b}	5.81 ± 0.047^{ab}
RTH	6.22 ± 0.062	6.23 ± 0.046	6.20 ± 0.050	5.90 ± 0.048	5.76 ± 0.040	5.88 ± 0.036	5.90 ± 0.063^{a}	5.77 ± 0.039^{ab}	5.71 ± 0.028^{b}
INEX	6.15 ± 0.044	6.16 ± 0.061	6.08 ± 0.043	5.84 ± 0.022	5.80 ± 0.054	5.89 ± 0.041	6.03 ± 0.106	5.88 ± 0.057	5.89 ± 0.042
REAB	6.19 ± 0.058	6.09 ± 0.061	6.09 ± 0.036	5.89 ± 0.038^{a}	5.68 ± 0.031^{b}	5.82 ± 0.069^{ab}	5.87 ± 0.047^{a}	5.71 ± 0.022^{b}	5.69 ± 0.047^{b}

means in the same row within pH classification (pH_1, pH_5, pH_{24}) with different subscripts are significantly different (P <0.05); n – number of pigs; SM – *musculus semimembranosus*; LTL1 – *musculus longissimus thoracis et lumborum* between the 4th and 5th lumbar vertebra; LTL2 – *musculus longissimus thoracis et lumborum* between the 10th and 12th thoracic vertebra; LTL3 – *musculus longissimus thoracis et lumborum* between the 2nd and 3rd thoracic vertebra; RTH – *musculus rectus thoracis*; INEX – *musculus intercostales externus* between the 6th and 7th ribs; REAB – *musculus rectus abdominis*

Table 3: Effects of breed on electrical conductivity (EC; mean ± standard error) measured at different time periods in different pig muscles

Muscle	EC_1			EC_5			EC_{24}		
	Red White Belted (n = 10)	Landrace (n = 9)	Large White (n = 10)	Red White Belted (n= 10)	Landrace (n = 9)	Large White (n = 10)	Red White Belted (n= 10)	Landrace (n= 9)	Large White (n= 10)
SM	6.19 ± 0.464	5.61 ± 0.453	6.87 ± 0.413	12.26 ± 0.477	12.62 ± 0.463	12.74 ± 0.374	12.31 ± 0.222	12.21 ± 0.144	11.73 ± 0.277
LTL1	5.41 ± 0.332	4.61 ± 0.357	5.42 ± 0.227	8.61 ± 0.694	9.83 ± 0.566	8.05 ± 0.570	7.82 ± 0.511	8.09 ± 0.829	7.43 ± 0.831
LTL2	4.48 ± 0.242	4.49 ± 0.210	4.62 ± 0.196	5.52 ± 0.456	6.06 ± 0.485	6.40 ± 0.583	5.67 ± 0.672	5.71 ± 0.625	6.08 ± 0.416
LTL3	4.40 ± 0.321	4.80 ± 0.509	4.98 ± 0.214	4.46 ± 0.281	5.14 ± 0.853	4.94 ± 0.721	5.62 ± 0.777	5.87 ± 0.673	7.09 ± 0.749
RTH	4.57 ± 0.251	4.93 ± 0.362	5.01 ± 0.210	4.16 ± 0.346	4.11 ± 0.362	3.82 ± 0.280	5.18 ± 0.404	5.01 ± 0.291	4.39 ± 0.491
INEX	3.59 ± 0.412	3.02 ± 0.344	3.03 ± 0.289	2.45 ± 0.239	3.11 ± 0.475	2.64 ± 0.302	1.72 ± 0.138	2.02 ± 0.413	2.13 ± 0.280
REAB	4.33 ± 0.342	3.86 ± 0.334	3.63 ± 0.192	4.04 ± 0.296	3.29 ± 0.587	2.63 ± 0.300	5.67 ± 0.406^{a}	4.42 ± 0.478^{ab}	3.61 ± 0.227^{b}

means in the same row within EC classification (EC_1, EC_5, EC_{24}) with different subscripts are significantly different (P <0.05); n – number of pigs; SM – *musculus semimembranosus*; LTL1 – *musculus longissimus thoracis et lumborum* between the 4th and 5th lumbar vertebra; LTL2 – *musculus longissimus thoracis et lumborum* between the 10th and 12th thoracic vertebra; LTL3 – *musculus longissimus thoracis et lumborum* between the 2nd and 3rd thoracic vertebra; RTH – *musculus rectus thoracis*; INEX – *musculus intercostales externus* between the 6th and 7th ribs; REAB – *musculus rectus abdominis*

Table 4: Effects of breed on proximate composition of pork and characteristics of backfat (mean ± standard error)

Characteristic	Red White Belted (*n* = 5)	Landrace (*n* = 5)	Large White (*n* = 5)
	Proximate composition (% wet weight)		
Moisture	73.70 ± 0.356	74.09 ± 0.198	73.98 ± 0.142
Protein	22.16 ± 0.348	22.64 ± 0.174	22.60 ± 0.138
Fat	1.98 ± 0.412	1.23 ± 0.149	1.32 ± 0.149
Ash	1.16 ± 0.012	1.15 ± 0.008	1.14 ± 0.013
Backfat			
Moisture (%)	9.48 ± 0.591	10.52 ± 0.773	9.80 ± 0.581
Melting point (°C)	27.74 ± 0.236	28.76 ± 0.604	28.88 ± 0.907
Refraction index	1.46 ± 0.000	1.46 ± 0.000	1.46 ± 0.000

n – number of pigs

It could be postulated that meat from Red White Belted pigs (with greater ultimate pH values) should provide better processing abilities into cured products compared to Landrace and Large White.

With muscle containing continuous electrolytes with relatively great EC values, this measurement could be applied for detection of exudative meat (Swatland, 2003). However, except for a greater (P <0.05) value in the REAB of Red White Belted pigs compared to Large White found at 24 hours *post-mortem*, no differences occurred among breeds in EC of the respective muscles (Table 3).

Proximate composition (moisture, protein, fat, ash) measured in the LTL2 did not differ (P >0.05) among the three pig breeds evaluated (Table 4). Although intramuscular fat content did not differ among breeds, it tended (P = 0.138) to be greater in Red White Belted pigs compared to Landrace and Large White. This could be attributed to the 44 % Duroc proportion, a breed from the United States that was introduced in Europe mainly due to its greater intramuscular fat content compared to other breeds (Barton-Gade, 1987). It was shown (Wood, 1993; NPPC, 1995) that Duroc pigs produce pork with a greater intramuscular fat content in comparison to the white European breeds, including the Large White and Landrace. According to De Vol *et al.* (1988), a threshold value of 2.5–3.0 % intramuscular fat in pork presented the most tender (lowest Warner-Bratzler values), with tougher meat obtained at lower levels of fat, and little effect of greater levels on tenderness. With Red White Belted pigs showing intramuscular fat levels near to this threshold value compared to other breeds, it could be assumed that they would have more tender meat than either Landrace or Large White.

Backfat characteristics were similar (P >0.05) among pig breeds (Table 4). With a decrease in melting point when unsaturation of fat increased (Wood *et al.*, 2004), the absence of any differences indicated that there would probably be no differences in the amount of saturation of backfat among breeds. Furthermore, no differences (P >0.05) among breeds were detected in the refractive index, which could be identified as the ratio of the speed of light in a vacuum to the speed of light in the fat.

CONCLUSIONS

It can be concluded from this study that Red White Belted pigs present comparable carcass lean contents to Landrace and Large White pigs, notwithstanding lower carcass yields and greater backfat thickness. However, differences among breeds in pH measured at 24 hours *post-mortem* suggested an evaluation of the rate of glycolysis in different muscles in future studies. Furthermore, the processing abilities of meat from Red White Belted pigs into cured products compared to other breeds should be evaluated.

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