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Relationship between muscle fibre characteristics and meat sensory properties in three nutria (*Myocastor coypus*) colour types

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ABSTRACT: The study determined the muscle fibre characteristics and sensory properties of the *longissimus lumborum* muscle (LL) of eight-month-old nutrias of three colour types and the correlations between meat histochemical measurements and eating quality. The following nutria colour types were used in the experiment: Standard (ST), Moravian Silver (MS), and Prestice Multicolour (PM). The nutria colour type significantly ($P <$ 0.001) affected the number of type IIB fibres with the lowest number in ST (108 per mm^2). The proportion of type I fibres varied between 10.6 and 14.2%; type IIA fibres varied between 6.1 and 7.8%; and type IIB fibres varied between 78.2 and 83.4% and it was not affected by colour type. The cross-sectional area (CSA) was 2.565–2.841 μm^2 in type I, 2.867–3.010 μm^2 in type IIA, and 4.698–5.517 μm^2 in type IIB fibres. The CSA of type IIB fibres ($P < 0.001$) was the largest in ST. The sensory trait of tenderness ($P < 0.05$) was the lowest in MS. Correlations between the proportion of fibres and sensory traits were not observed. The CSA of type I fibres correlated with flavour (0.19) and the CSA of type IIB fibres with tenderness (0.10).

Keywords: nutria; muscle histochemical measurements; sensory characteristics; correlation

INTRODUCTION

A sufficient and natural supply of essential nutrients in a form suitable and available to humans can be achieved either by the consumption of functional food (Suchy et al. 2014) or the meat of certain indigenous species (Hoffman and Cawthorn 2013). For instance, nutria became invasive rapidly with the spreading from Argentina, Chile, and Uruguay into the USA, Europe, and China (Lowe et al. 2000). Nutrias have been used for fur and meat. Meat has become the main product since the fur market has changed. The increasing nutria meat consumption in Europe, Russia, China, and southern states of the USA requires a more detailed study of meat quality than only of a basic nutritional or physical value (Tulley et al. 2000; Migdal et al. 2013). Meat quality and sensory traits are affected by muscle fibre composition. Skeletal muscle is composed of several fibre types, and the composition can vary markedly in different muscles depending on their function (Klont et al. 1998). Fibre types are most frequently determined according to the histochemical method by Brooke and Kaiser (1970) classifying fibres as I, IIA, and IIB. Fibres of type I, or slow-twitch fibres, possess low myosin ATPase activity levels and a glycolytic capacity (Choi and Kim 2009). Fibres of type IIB, fast-twitch glycolytic fibres, mainly perform glycolysis, and their metabolism contributes to the fast glycolytic rate in the early post mortem period (Choi et al. 2013). Type IIA has a greater lipid and myoglobin content than type IIB (Essen-Gustavsson et al. 1992). The morphological characteristics of

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muscle fibres are factors that influence energy metabolism in living and post mortem muscle (Choi and Kim 2009). Sensory traits can be affected by many factors, such as breed, sex, carcass weight, diet, genetic variation, and biochemical changes that occur during further processing (Nam et al. 2009). A few studies have evaluated the relationship of muscle fibre characteristics and meat sensory properties in cattle (Chriki et al. 2013), pigs (Lee et al. 2012), and rabbits (Combes et al. 2008). However, no data concerning muscle fibre features and sensory traits have been published for nutria. Therefore, the present study determined the muscle fibre characteristics and sensory properties of the *longissimus lumborum* muscle (LL) in three nutria colour types and the correlations between meat histochemical measurements and eating quality.

MATERIAL AND METHODS

Animals and muscle samples. Samples for histochemical and sensory analyses were collected from 36 nutria at the end of a fattening experiment. The experiment was approved by the Ethics Committee of the Central Commission for Animal Welfare by the Ministry of Agriculture of the Czech Republic. In the fattening experiment, 120 nutrias were used. Nutrias were placed in 12 indoor pens (10 nutrias per pen) with hard slatted floor (1 m^2 per animal) under uniform environmental conditions (temperature 14–16°C, relative humidity 55–60%, 12 h light). Nutrias were split into three groups according to colour type with four pens in each breed. In the experiment, three nutria colour types were used: Standard (ST), Moravian Silver (MS), and Prestice Multicolour (PM). The detailed characteristics of different nutria genotypes are described by Kaplanova et al. (2012). The nutrias were fattened from weaning at two months of age until they were eight months old, in conditions described by Tumova et al. (2015). The nutrias for slaughtering (12 animals per colour type) were selected based on the average weight of each colour type (3 nutrias per colour type and pen) and were fasted for 12 h. Live weight of ST nutrias was 5221 ± 429 g, MS 4776 ± 652 g, and PM 5403 ± 541 g. The nutrias were slaughtered in an experimental slaughterhouse by electric stunning and bleeding. Within 45 min post mortem, the loin was taken. It was cut between the last thoracic vertebra and the seventh lumbar vertebra.

Muscle fibre determination. The muscle fibre characteristics of the LL were measured in 12 nutrias of each colour type. Samples sizing 2 cm^2 were collected from the right LL. The samples were immediately frozen in liquid nitrogen and stored at –80°C until analysis. Serial cross-sections (12 μm) of muscle were obtained with a cryostat CM 1850 (Leica, Wetzlar, Germany) at –20°C. The sections were subjected to myofibrillar ATPase staining after successive pre-incubations in alkaline buffer as recommended by Brooke and Kaiser (1970). The fibres were classified as type I (red, slow oxidative), type IIA (red, fast oxido-glycolytic), and IIB (white, fast glycolytic). All samples were examined with an image analysis system described by Chodova et al. (2014). For each muscle fibre type, the number, percentage, and mean cross-sectional area (CSA, μm^2) were determined.

Sensory analysis. The LL from the left side was used for the sensory analysis. The samples for sensory trait evaluation were vacuum-packed and stored for four days post mortem at 5°C. Meat samples were evaluated by a panel of ten selected assessors trained according to ISO 8586-1 (1993). The evaluation was performed in a sensory laboratory equipped with booths. The samples were individually coded and cooked for 60 min at 80°C under humid heat without salt or seasoning. The cooked samples were served at 50°C in a random order. To prevent cooling, the samples were served on preheated plates. There was a 10 min interval between serving each sample. Room temperature water and bread were provided to the panel members to neutralize their sensory percepts. Five parameters were assessed: meat flavour, juiciness, tenderness, taste, and total desirability. Each category scale had 9 points (1 = low, 9 = high).

Statistical analysis. The data were analyzed using the GLM procedure of SAS (Statistical Analysis System, Version 9.1.3., 2003). The muscle fibre characteristics were analyzed using one-way ANOVA. The colour type effect was assessed with Duncan's test. The sensory data were evaluated using the GLM procedure of SAS with colour type and panelist as fixed effects. Differences between colour types were tested with Tukey's method. Significant differences ($P < 0.05$) were indicated by different superscripts. Correlations between histochemical measurements and sensory traits were calculated with Pearson's coefficients (Statistical Analysis System, Version 9.1.3., 2003) to

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determine the relationship between the sensory traits and muscle fibre characteristics of nutria meat.

RESULTS AND DISCUSSION

Muscle histochemical measurements. Skeletal muscle is a heterogeneous tissue composed of muscle fibres of different contractile and metabolic types (Gondret et al. 2009). Using the myosin ATPase method in determining nutria LL muscle fibre characteristics, three types of muscle fibres were determined (Table 1). Glycolitic fibres type IIB prevailed, while oxidative fast twitch fibres type IIA were the least frequent. The number of type I fibres was moderately higher than of type IIA. Although the fibre type composition depends on the animal species, the results are similar to rabbits, in which we also detected the highest density of fibre type IIB (Tumova et al. 2014). The nutria colour type only affected ($P < 0.001$) the number of type IIB fibres and the lowest number was observed in ST nutrias (MS and PM did not differ). Similar trends in the effect of breed on the number of muscle fibre type II were observed in rabbits (Tumova et al. 2014). In comparison with muscle fibre number, the proportion of all muscle fibre types was not affected by colour type. The results are not comparable with literature because of lack of data. However, in our previous study, colour type did not affect muscle fibre proportion in *biceps femoris* (Tumova et al. 2015). On the other hand, in rabbits, the effect of genotype on muscle fibre percentage has been reported for type I fibres (Dalle Zotte and Ouhayoun 1998; Bianospino et al. 2008; Tumova et al. 2014). In rabbits, the proportion of type I muscle fibres is related to live weight. Heavier rabbits have a greater proportion of type I muscle fibres (Lambertini et al. 1996; Bianospino et al. 2008). A relationship between live weight and number of type I fibres was found in pigs (Choi et al. 2013). In contrast with these reports in rabbits and pigs, in nutrias there is a very low slaughter weight variability among colour types (Tumova et al. 2015). The proportion of type I fibres was 10.6–14.2%, of type IIA 6.1–7.8%, and of type IIB 78.2–83.4%. Although the muscle fibre distribution is specific according to animal species, the results are similar to rabbits. In rabbit LL, approximately 90% of muscle fibres are IIB and 10% are type I (Tumova et al. 2014). In contrast, Fuentes et al. (1998) reported significant differences in muscle fibre type distribution between rats and rabbits. Numerically, ST had the highest percentage of type I fibres and the lowest of type IIB. This colour type also had the best nonspecific sensory score. A similar relationship between muscle fibre distribution and sensory analysis has been described in pigs (Ryu et al. 2008).

Muscle fibre type distribution and size are closely correlated. In nutria LL, the CSA was the smallest in type I (2565–2841 μm^2), moderately large in type IIA (2867–3010 μm^2), and the largest in type IIB fibres (4698–5517 μm^2). These findings correspond with a general description of muscle fibre types reported by Klont et al. (1998). In nutrias, the CSA of IIB fibres were almost doubled compared to type I. Similar results were obtained by Dalle Zotte and Ouhayoun (1998) in rabbits. Additionally, Choi and Kim (2009) reported that in general, fibre type IIB has a larger CSA than type I,

Table 1. Muscle fibre characteristics in the *longissimus lumborum* muscle

Characteristic	Type of fibre	Standard nutria	Moravian Silver	Prestice Multicolour	Root MSE	Significance
Number of fibres (n in mm^2)	I	19.7	18.3	17.3	9.9	0.25
	IIA	10.7	10.7	13.0	7.3	0.18
	IIB	108^b	138^a	135^a	24	0.001
Percentage of total fibres (%)	I	14.2	10.6	10.6	5.6	0.22
	IIA	7.7	6.1	7.8	4.2	0.45
	IIB	78.2	83.4	81.6	6.4	0.12
CSA (μm^2)	I	2.565	2.841	2.569	965	0.33
	IIA	2.896	2.867	3.010	944	0.67
	IIB	5.517^a	4.784^b	4.698^b	1793	0.001

CSA = cross-sectional area

^{a,b}values within a row with different superscripts differ significantly ($P < 0.05$)

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Table 2. Sensory analysis of *longissimus lumborum* muscle

Characteristic	Standard nutria	Moravian Silver	Prestice Multicolour	SEM	Significance
Flavour	5.68	5.67	5.56	0.21	0.12
Tenderness	6.34[a]	5.69[b]	5.93[a]	0.26	0.05
Juiciness	5.77	5.68	5.81	0.23	0.14
Taste	5.69	5.79	5.66	0.16	0.17
Total desirability	5.82	5.74	5.50	0.26	0.12

[a,b]values within a row with different superscripts differ significantly ($P < 0.05$)

including human muscle. In the present study, the CSA of type IIB fibres was affected by colour type. The largest CSA ($P < 0.001$) was observed in ST compared with MS and PM. There are no data concerning the effect of colour type on the CSA of type IIB fibres in nutrias. Similarly, Jurie et al. (2007) did not find differences in the area of all three muscle fibre types between Holstein and Salers cows. However, in rabbits, Dalle Zotte and Ouhayoun (1998), and Tumova et al. (2014) observed differences in the CSA depending on genotype. The CSA data demonstrates a negative relationship between fibre number and size in nutrias, which has also been described in pigs (Kim et al. 2013).

Sensory properties. Table 2 describes the average values for the sensory characteristics of each nutria colour type. Most of the sensory parameters were not affected by colour type (flavour, juiciness or taste). However, Combes et al. (2008) revealed significant differences between genotypes for sensory properties in rabbits, and Lee et al. (2012) observed a significant effect of pig breed on flavour intensity and juiciness. Nutria colour type affected tenderness ($P < 0.05$). The lowest tenderness values were in MS compared with ST and PM. In rabbits, Pascual and Pla (2008) observed that tenderness was affected more by rabbit breed than live weight. The effect of breed on tenderness has also been described for pigs (Lee et al. 2012) and cattle (Jurie et al. 2007). Tenderness is the most important factor (among sensory traits) affecting meat acceptability (Maltin et al. 1997). However, in the present study, there were no differences between the tested colour types for total desirability. These sensory analysis results in nutrias and other species are conflicting and may be related to differences in meat structure or method of sensory analysis. In pork, differences in eating quality are considered to be related to muscle fibre composition (Lee et al. 2012). It is likely that the observed differences in tenderness between breeds were also affected by genetic influences because the nutrias were housed under the same conditions and slaughtered at the same age.

Correlations between muscle fibre characteristics and sensory traits. The correlation coefficients between muscle fibre characteristics and sensory traits are reported in Table 3. There were no correlations between sensory traits and proportion of

Table 3. Correlation coefficients for muscle fibre characteristics and sensory traits (with significance)

Characteristic	Type of fibre	Flavour	Tenderness	Juiciness	Taste	Total desirability
Percentage of total fibres	I	–0.11 (0.51)	0.15 (0.39)	0.17 (0.32)	0.02 (0.92)	0.15 (0.38)
	IIA	–0.30 (0.07)	0.02 (0.91)	–0.13 (0.46)	–0.17 (0.31)	–0.06 (0.74)
	IIB	0.29 (0.09)	–0.14 (0.41)	–0.07 (0.69)	0.09 (0.58)	0.09 (0.58)
CSA	I	0.19 (0.02)	0.11 (0.15)	0.05 (0.52)	–0.12 (0.13)	0.14 (0.07)
	IIA	0.04 (0.70)	0.03 (0.79)	0.02 (0.81)	–0.11 (0.26)	0.11 (0.28)
	IIB	–0.01 (0.95)	0.11 (0.05)	0.08 (0.15)	0.07 (0.16)	0.08 (0.14)
Flavour						0.16 (0.001)
Tenderness						0.44 (0.001)
Juiciness						0.51 (0.001)
Taste						0.32 (0.001)

CSA = cross-sectional area

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each muscle fibre type. These data agree with the report by Nam et al. (2009) that appearance, flavour, juiciness, tenderness, and overall acceptability do not significantly correlate with muscle fibre percentage. There were no correlations between sensory traits and the CSA of type IIA fibres. The CSA of type I fibres was correlated ($P < 0.02$) with flavour. This relationship has not been previously reported in the literature. Type I fibres possess a low glycolytic capacity but contain a higher amount of lipid (Choi and Kim 2009). The CSA of type IIB fibres was correlated with tenderness ($P < 0.05$). The results in nutrias are similar to the results in pigs reported by Lee et al. (2012) that initial tenderness is associated with the CSA of type IIB fibres. Zochovska (2005) and Kim et al. (2013) observed that muscle with large type IIB fibres exhibited tougher meat or greater hardness in pigs. Similarly, Chriki et al. (2013) reported that lower tenderness was associated with a higher average CSA in cattle. In the present study, ST nutrias had the largest CSA of type IIB fibres and the best sensory tenderness rating. This disproportion may be related to muscle fibre composition and its characteristics in nutrias. The relationship of each sensory trait is important for total desirability. All evaluated sensory traits had significant impact on total desirability. However, total desirability was mainly affected by tenderness and juiciness, which agrees with Maltin et al. (1997).

CONCLUSION

The results of the study demonstrate the low effect of the nutria colour type on muscle fibre characteristics. We assume that a lower variability in muscle fibre characteristics between the evaluated colour types might explain the small differences in meat sensory properties. The correlation coefficients between muscle fibre characteristics and sensory meat quality were low.

REFERENCES

Bianospino E., Moura A.S.A.M.T., Wechsler F.S., Fernandes S., Dal-Pai-Silva M. (2008): Age-related changes in muscle fiber type frequencies and cross-sectional areas in straightbred and crossbred rabbits. Animal, 2, 1627–1632.

Brooke M.H., Kaiser K. (1970): Muscle fiber types: How many and what kind? Archives of Neurology, 23, 369.

Chodova D., Tumova E., Martinec M., Bizkova Z., Skrivanova V., Volek Z, Zita L. (2014): Effect of housing system and genotype on rabbit meat quality. Czech Journal of Animal Science, 59, 190–199.

Choi Y.M., Kim B.C. (2009): Muscle fiber characteristics, myofibrillar protein isoforms, and meat quality. Livestock Science, 122, 105–118.

Choi Y.M., Nam K.W., Choe J.H., Ryu Y.C., Wick M.P., Lee K., Kim B.C. (2013): Growth, carcass, fiber type, and meat quality characteristics in Large White pigs with different live weights. Livestock Science, 155, 123–129.

Chriki S., Renand G., Picard B., Micol D., Journaux L., Hocquette J.F. (2013): Meta-analysis of the relationships between beef tenderness and muscle characteristics. Livestock Science, 155, 424–434.

Combes S., Gonzalez I., Dejean S., Baccini A., Jehl N., Juin H., Cauquil L., Gabinaud B., Lebas F., Larzul C. (2008): Relationships between sensory and physicochemical measurements in meat of rabbit from three different breeding systems using canonical correlation analysis. Meat Science, 80, 835–841.

Dalle Zotte A., Ouhayoun J. (1998): Effect of genetic origin, diet and weaning weight on carcass composition, muscle physicochemical and histochemical traits in the rabbit. Meat Science, 50, 471–478.

Essen-Gustavsson B., Karlstrom K., Lundstrom K. (1992): Muscle fiber characteristics and metabolic response at slaughter in pigs of different halothane genotypes and their relation to meat quality. Meat Science, 31, 1–11.

Fuentes I., Cobos A.R., Segade A.G. (1998): Muscle fibre types and their distribution in the biceps and triceps brachii of the rat and rabbit. Journal of Anatomy, 192, 203–210.

Gondret F., Hernandez P., Remignon H., Combes S. (2009): Skeletal muscle adaptations and biomechanical properties of tendons in response to jump exercise in rabbits. Journal of Animal Science, 87, 544–553.

Hoffman J.J., Cawthorn D. (2013): Exotic protein sources to meet all needs. Meat Science, 95, 764–771.

Jurie C., Picard B., Hocquette J.F., Dransfield E., Micol D., Listrat A. (2007): Muscle and meat quality characteristics of Holstein and Salers cull cows. Meat Science, 77, 459–466.

Kaplanova K., Putnova L., Bryndova M., Bartonova P., Vrtkov I., Dvorak J. (2012): Microsatellite variability in nutria (Myocastor coypus) genetic resource in the Czech Republic. Czech Journal of Animal Science, 54, 171–177.

Kim G.D., Jeong J.Y., Jung E.Y., Yang H.S., Lim H.T., Joo S.T. (2013): The influence of fiber size distribution of type IIB on carcass traits and meat quality in pigs. Meat Science, 94, 267–273.

Klont R.E., Brocks L., Eikelenboom G. (1998): Muscle fiber type and meat quality. Meat Science, 49, 219–229.

doi: 10.17221/59/2015-CJAS

Lambertini L., Barilli M., Lalatta Costerbosa G. (1996): Considerations on the composition of fibres of the skeletal muscle of rabbit. Revista di Coniglicoltura, 33, 47–51. (in Italian)

Lee S.H., Choe J.H., Choi Y.M., Jung K.C., Rhee M.S., Hong K.C., Lee S.K., Ryu Y.C., Kim B.C. (2012): The influence of pork quality traits and muscle fiber characteristics on the eating quality of pork from various breeds. Meat Science, 90, 284–291.

Lowe S., Browne M., Boudjelas S., De Poorter M. (2000): 100 of the World's Worst Invasive Alien Species. A Selection from the Global Invasive Species Database. The Invasive Species Specialist Group (ISSG), a specialist group of the Species Survival Commission (SSC) of the World Conservation Union (IUCN). Available from: http://calendar.k-state.edu/withlab/consbiol/IUCN_invaders.pdf (accessed Dec, 2000).

Maltin C.A., Warkup C.C., Matthews K.R., Grant C.M., Porter A.D., Delday M.I. (1997): Pig muscle fibre characteristics as a source of variation in eating quality. Meat Science, 47, 237–248.

Migdal L., Barabasz B., Niedbala P., Lapinski S., Pustkowiak H., Zivkovic B., Migdal W. (2013): A comparison of selected biochemical characteristics of meat from nutrias (Myocastor coypus Mol.) and rabbits (Oryctolagus cuniculus). Annals of Animal Science, 13, 387–400.

Nam Y.J., Choi Y.M., Lee S.H., Choe J.H., Jeong D.W., Kim Y.Y., Kim B.C. (2009): Sensory evaluations of porcine longissimus dorsi muscle: relationships with postmortem meat quality traits and muscle fiber characteristics. Meat Science, 83, 731–736.

Pascual M., Pla M. (2008): Changes in collagen, texture and sensory properties of meat when selecting rabbits for growth rate. Meat Science, 78, 375–380.

Risvik E. (1994): Sensory properties and preferences. Meat Science, 36, 67–77.

Ryu Y.C., Choi Y.M., Lee S.H., Shin H.G., Choe J.H., Kim J.M., Hong K.C., Kim B.C. (2008): Comparing the histochemical characteristics and meat quality traits of different pig breeds. Meat Science, 80, 363–369.

Suchy P., Strakova E., Herzig I. (2014): Selenium in poultry nutrition: a review. Czech Journal of Animal Science, 59, 495–503.

Tulley R.T., Malekian F.M., Rood J.J., Lamb M.B., Champagne C.M., Redmann S.M., Patrick R., Kinler N., Raby C.T. (2000): Analysis of the nutritional content of Myocastor coypus. Journal of Food Composition and Analysis, 13, 117–125.

Tumova E., Bizkova Z., Skrivanova V., Chodova D., Martinec M., Volek Z. (2014): Comparisons of carcass and meat quality among rabbit breeds of different sizes, and hybrid rabbits. Livestock Science, 165, 8–14.

Tumova E., Chodova D., Svobodova J., Uhlirova L., Volek Z. (2015): Carcass composition and meat quality of Czech genetic resources of nutrias (Myocastor coypus). Czech Journal of Animal Science, 60, 479–486.

Zochowska J., Lachowicz K., Gajowiecki L., Sobczak M., Kotowicz M., Zych A. (2005): Effects of carcass weight and muscle on texture, structure and myofibre characteristics of wild boar meat. Meat Science, 71, 244–248.

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