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Comparative evaluation of the quality and fatty acid profile of meat from brown hares and domestic rabbits offered the same diet

Bożena Króliczewska[a,*], Dorota Miśta[a], Małgorzata Korzeniowska[b], Ewa Pecka-Kiełb[a], Andrzej Zachwieja[c]

[a] Department of Animal Physiology and Biostructure, Wrocław University of Environmental and Life Sciences, C.K. Norwida 31, 50-375 Wrocław, Poland
[b] Department of Animal Products Technology and Quality Management, Wrocław University of Environmental and Life Sciences, J. Chełmońskiego 37, 51-630 Wrocław, Poland
[c] Institute of Animal Breeding, Faculty of Biology and Animal Science, Wrocław University of Environmental and Life Science, J. Chełmońskiego 38 C, 51-630 Wrocław, Poland

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ABSTRACT

Since animal diets have a strong influence on meat quality, a comparative study on farmed brown hares and domestic rabbits offered the same diet was undertaken to assess the physical and chemical properties of their meat. Ten brown hares and ten domestic rabbits were used to characterize the traits of meat from the foreleg, hind leg, and Longissimus lumborum muscles. The study indicated higher protein content in hare meat than in rabbit meat. The meat of hares had a concentration of heme iron that was more than twice as high as that of rabbits. Lower SFA and MUFA content and higher PUFA content contributed to the superior PUFA/SFA ratio in hares. An unfavorable n-6/n-3 ratio but superior atherogenic and thrombogenic indices was observed for hare meat. The higher TBARS of hares indicated a higher susceptibility of hare meat to lipid oxidation. Hare meat was also characterized by a higher water holding capacity and higher color indices (redness and chroma).

1. Introduction

One of the challenges of the meat industry in the 21st century is to meet consumer expectations of delivering safe, high-quality meat. This challenge is especially important for meat producers due to the growing demand for high-quality meat products (Joo, Kim, Hwang, & Ryu, 2013). Modern consumers desire valuable, soft and tender meat that is rich in nutrients and vitamins, which have positive influences on human health (McMichael & Bambrick, 2005). Therefore, the meat industry should aim to produce and supply meat that tastes good, has high nutritive value and is safe for consumers, with the absence of pesticides, antibiotics and drug residues (Pinheiro, Outor-Monteiro, Silva, Silva, & Mourão, 2011). In addition, a feature of meat products that can be attractive for consumers and increase demand is their derivation from rearing systems that adhere to high standards of animal welfare (Dal Bosco, Castellini, & Mugnai, 2002).

To meet the expectations of consumers, the attention of breeders and meat producers in many countries has been focused on small mammals, such as domestic rabbits (*Oryctolagus cuniculus*), which provide approximately 1.8 million metric tons of meat per year globally (Dalle Zotte, Cullere, Alberghini, Catellani, & Paci, 2016). Moreover, although rabbit breeding is becoming more common, another leporid species, the brown hare *(Lepus europaeus)*, has also been generating interest from meat producers (Trocino et al., 2017). The meat of these animals differs from that of poultry and other farmyard animals (Cobos, De la Hoz, Cambero, & Ordoñez, 1995). However, the availability of hares, unlike that of domestic rabbits, is usually restricted by hunting seasons (Cobos et al., 1995). In addition, the consumption of rabbit and hare meat is not as popular as the consumption of other meats. There is a potential of adding hare meat from hunting or farming into human diets because of its favorable sensory characteristics, high protein content (CP) and low-fat content (Mertin, Slamečka, & Ondruška, 2012). Moreover, under farming conditions, slaughter traits and meat characteristics can be controlled to guarantee consistent product quality (Trocino et al., 2017).

From a nutritional point of view, rabbit meat has beneficial biological characteristics; it is easily digested, lean and rich in proteins, and has high levels of essential amino acids. It also contains highly unsaturated lipids, is low in cholesterol and sodium and rich in potassium, phosphorus, and magnesium. Moreover, rabbit meat is a good source of B vitamins (Hernández & Dalle Zotte, 2010). It was found that rabbit meat is healthier than other meats frequently used in human nutrition,

* Corresponding author.
E-mail address: bozena.kroliczewska@upwr.edu.pl (B. Króliczewska).

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such as chicken, beef, and pork (Nistor et al., 2013). Hare meat, although also rich in proteins, minerals, vitamins and unsaturated fatty acids, is classified as red meat, and hare meat differs from rabbit meat in its composition, mainly in terms of its high iron (Fe) content (Strmiskova & Strmiska, 1992).

An animal's diet has a strong influence on its meat quality. However, in wild animals, it is difficult to establish the influence of diet on meat (Cobos et al., 1995). To produce high-quality meat, it is necessary to understand the characteristics of meat quality traits and the factors that control them. Hares, like wild rabbits, are herbivorous and consume a wide variety of plants and grains that differ depending on the season, which may cause large variation in the composition of the meat (Papadomichelakis, Zoidis, Pappas, & Hadjigeorgiou, 2017). Therefore, the farming of brown hares fed a strictly defined fodder under controlled conditions may be an alternative method for producing this meat that could increase its availability to consumers. To address this, we conducted a pilot feeding experiment on caged brown hares and domestic rabbits offered the same diet to assess the physicochemical properties of the meat.

2. Materials and methods

2.1. Animals, diet and slaughter

The animals used in this experiment were housed and slaughtered in compliance with the ethical standards of Wroclaw University of Environmental and Life Sciences, where the study was conducted. Approval for the study was given by the Local Ethics Commission for Experiments on Animals in Wrocław, Poland to D. Mišta (License No. 46/2015).

Ten brown hares with an initial age of 7 months and an average initial live weight of 2.4 kg were obtained from the Caged Hare Breeding Unit (Paszków, Poland). Ten New Zealand White rabbits with an initial age of 4 months and an average initial live weight of 2.9 kg were obtained from the Centre for Experimental Medicine, Medical University of Silesia (Katowice, Poland). Six females and four males were included in each group. All animals were housed in individual cages, and each animal was an experimental unit. The hares were maintained in individual wooden outdoor pens under natural daylight and temperature, and the rabbits were housed in standard stainless-steel cages at 20 ± 2 °C in a room as described previously (Króliczewska et al., 2017; Króliczewska, Mišta, Zawadzki, Wypchło, & Króliczewski, 2011). The diet was formulated according to the nutritional requirements of rabbits (De Blas & Mateos, 1998); it was offered once a day in the morning, and animals were allowed to feed ad libitum.

The results of a chemical analysis of the diet are shown in Table 1. Samples of pelleted food and meadow hay were analysed using standard methods to measure dry matter (DM; AOAC 2005 method 934.01), crude protein (CP; Kjeldahl method, AOAC 2005 method 984.13), ether extract (EE; AOAC 2005 method 920.39), crude fiber (AOAC 2005 method 978.10), ash content (AOAC 2005 method 942.05), neutral detergent fiber (NDF; method of Holst 1973), and acid detergent fiber (ADF; AOAC 2005 method 973.18). The gross energy in the feed samples was measured using an adiabatic oxygen bomb calorimeter KL-10 (Precyzja, Bydgoszcz, Poland).

Table 1
Chemical composition (%) of animal feed.

Item	Pelleted feed	Meadow hay
Dry matter	90.93	93.16
Crude protein	15.73	8.54
Ether extract	2.76	3.31
Crude fiber	7.45	38.25
Neutral detergent fiber	23.38	61.53
Acid detergent fiber	7.97	34.42
Ash	5.75	7.50
Gross energy (MJ/kg DM)	16.88	17.47

After 6 weeks, the animals were slaughtered. The average body weight at slaughtering was 2.57 ± 0.218 and 3.63 ± 0.644 for hares and rabbits respectively. Euthanasia (using xylazine and sodium pentobarbital injections) and sampling occurred at approximately 6 p.m. Head, viscera, and skin were removed from each carcass, and the fore legs, hind legs and *Longissimus thoracis et lumborum* (LTL) were separated from the skeleton. Tissue samples were then delivered to the laboratory within 30 min after slaughter. Next, the samples were placed in polyethylene bags and chilled on ice, frozen at −20 °C for 30 min, and stored at −80 °C until analysis. Immediately before analysis, the muscles were defrosted by placing them at −20 °C in a chilling room, which was then set to +2 °C. When a temperature of −2 °C was reached in the centre of the samples, the muscles were prepared for analysis by grinding to obtain homogenous samples.

2.2. Chemical composition of the meat

Proximate analyses of the meat were carried out according to the standard ISO methodology: Nitrogen (N) was measured by the Kjeldahl method (Polish Standard PN-75/A-04018, 1998) using a Kjeltec 2300 Foss Tecator apparatus (Hilleroed, Denmark), CP was measured by multiplying the N content by 6.25, crude fat was measured by ether extraction (EE), (Polish Standard PN-ISO 1444, 2000), DM was measured by the drying method (Polish Standard PN-ISO 1442, 2000), and ash content was measured by completely burning the samples at 550 °C for 16–18 h (Polish Standard PN-ISO 936, 2000).

2.3. Iron assay

Total Fe concentrations in the meat samples were analysed by the modified methods of (Ward & Carpenter, 2010). Briefly, 2 g of each meat sample was homogenized (IKA T18 basic ULTRA-TURRAX) with 6 ml phosphate-citric buffer (14 g KH_2PO_4 and 8.8 g citric acid dissolved in 1 liter of distilled water). Next, 0.5 ml of 2% ascorbic acid in 0.2 M HCl was added to 1.5 ml of collected homogenate and incubated at 22 °C for 15 min (Julabo TW 12, Seelbach, Germany). Simultaneously, a blank sample containing 0.2 M HCl, but no ascorbic acid was prepared. The reaction was stopped by the addition of 1 ml of 11.3% trichloroacetic acid (TCA). Following centrifugation (MPW-351R, Warsaw, Poland) of the samples for 15 min at 3000 x *g*, 2 ml of collected supernatant was mixed with 0.8 ml of 10% ammonium acetate and 0.2 ml of ferrozine. The whole mixture was then incubated for 5 min at room temperature. Finally, the absorbance (A) of the samples was measured at 562 nm (EVOLUTION 160 US-VIS, Waltham, MA, USA). Total Fe concentration was calculated based on a previously prepared standard curve with the following equation: Fe = (A - 0.0675)/36.971. Concentrations are expressed as mg Fe/g meat.

Heme Fe was analysed by the modified methods of Clark, Mahoney, and Carpenter (1997). Ground meat samples (10 g) were homogenized for 30 s with 20 ml of acid-acetone mixture (40 ml of acetone, 9 ml of water, 1 ml of concentrated HCl). Next, 20 ml of acid-acetone mixture was added to the homogenates. The samples were mixed thoroughly and incubated at room temperature without light exposure for 60 min. Extracts were then centrifuged at 2200 x *g* for 10 min (Sigma 3 K30, Newtown, Great Britain), and the supernatant was filtered through filter paper (Whatman #1 paper). Finally, the absorbance was measured at 640 nm against the absorbance of a blank reagent. Absorbance was multiplied by 6800 and then divided by the sample weight to obtain the final concentration of total pigments in the meat, which was expressed as μg hematin/g meat. The Fe content was calculated using a factor of 0.0882 μg Fe/μg hematin (MERCK, 1989).