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The influence of diet on collagen content and quality attributes of *infraspinatus* muscle from Holstein–Friesian young bulls

Monika Modzelewska-Kapituła [a,*], Zenon Nogalski [b]

[a] Department of Industrial Commodity, Basics of Techniques and Energy Management, Faculty of Food Sciences, University of Warmia and Mazury in Olsztyn, Plac Cieszyński 1, 10-719 Olsztyn, Poland
[b] Department of Cattle Breeding and Milk Evaluation, Faculty of Animal Bioengineering, University of Warmia and Mazury in Olsztyn, ul. Oczapowskiego 5, 10-719 Olsztyn, Poland

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ABSTRACT

The aim of the study was to determine effects of feeding intensity on collagen content and eating quality of *infraspinatus* (INF) muscle. Twenty Polish Holstein-Friesian bulls (11-month-old) were fed either intensively (I, n = 10, with triticale meal addition to total mixed ration) or semi-intensively (SI, n = 10, without triticale meal) before slaughter at 19 months. The animals from I group showed higher body weight at the end of fattening, average daily gain and dressing percentage than SI group. The INF muscle from I treatment had higher fat content and the proportion of water-soluble collagen, whereas lower insoluble collagen content compared with SI treatment. There were no differences in shear force values, cooking loss and eating quality between the treatments. In conclusion, feeding Holstein-Friesian bulls with increased energy value fodder beneficially affected its slaughter value and collagen profile in *infraspinatus* muscle.

1. Introduction

The effect of diet on beef carcass and meat quality was studied extensively. However, the results of feeding experiments are difficult to interpret and compare due to the fact that many factors are involved, such as age, live weight, fatness degree, and plane of nutrition (Blanco et al., 2010). The feeding regimen might have a different influence on various muscles of beef carcass, because it has a significant role in muscle characteristic regulation, which is muscle-dependent (Cassar-Malek et al., 2004). It was shown also that diet had a different impact on individual muscles in terms of collagen solubility (Archile-Contreras, Mandell, & Purslow, 2010; Cassar-Malek et al., 2004). Archile-Contreras et al. (2010) concluded that cattle growth rate, which is affected by diet, and more precisely by the energy value of the ration, affected heat soluble collagen in various muscles to a different extent. The influence of diet on the content and solubility of collagen and meat quality was analyzed in *longissimus dorsi et thoracis*, *semimembranosus*, *semitendinosus*, *triceps brachii* muscles (Blanco et al., 2010; Cassar-Malek et al., 2004; Therkildsen, Houbak, & Byrne, 2008), but not in *m. infraspinatus* (INF), which is one of the chuck muscles of the beef carcass and is characterized by high intramuscular connective tissue content (Hildrum et al., 2009; Purslow, 2002). Moreover, the INF muscle has a high content and proportion of soluble collagen fractions compared to a round muscle (Modzelewska-Kapituła & Nogalski, 2014). The lean tissue of the muscle, excluding large connective tissue inclusions, shows good tenderness (Highfill, Esquivel-Font, Dikeman, & Kropf, 2012; Rhee, Wheeler, Shackelford, & Koohmaraie, 2004). On the other hand, collagen characteristics differ not only among muscles, but also among breeds due to variation in the maturity of the breed (Blanco et al., 2013). In Poland, the most popular cattle breed is Holstein-Friesian, which is a dairy breed and accounts for approx. 90% of livestock (Iwanowska & Pospiech, 2010). Polish Holstein-Friesian young bulls show satisfactory average daily gain ranging from 0.8 to 1.2 kg and dressing percentage from 55% to 57% (Nogalski et al., 2014; Wajda, Kondratowicz, Burczyk, & Winarski, 2014), which lead to increased interest in slaughter value and meat quality of the breed. Holstein-Friesian cattle have been analyzed taking into consideration primarily their dairy purpose and less frequently their slaughter value, concerned the dressing percentage and the EUROP classification, and rarely muscle collagen profile (Domaradzki, Florek, & Litwińczuk, 2013; Wajda et al., 2014; Zając, Midura, Palka, Węsierska, & Krzysztoforski, 2011). The meat from dairy breeds, such as Holstein-Friesian, is characterized by relatively high total collagen content and shear force values compared with meat obtained from beef breeds (Christensen et al., 2011; Domaradzki et al., 2013; Szałkowska & Modzelewska-Kapituła, 2016; Therkildsen et al., 2008). One way of increasing slaughter value and the quality of meat obtained from Holstein-Friesian cattle is modification of feeding regimen. Thus, the aim of the present study was to determine the influence of feeding

* Corresponding author.
E-mail address: monika.modzelewska@uwm.edu.pl (M. Modzelewska-Kapituła).

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Holstein-Friesian young bulls with a fodder with increased energy value on the slaughter value of carcasses and selected quality attributes of *infraspinatus* muscle such as chemical composition, the content and solubility of collagen, cooking loss, shear force values and eating quality.

2. Materials and methods

2.1. Animals

The experimental material comprised 20 Polish Holstein-Friesian bulls reared at Agricultural Experiment Station in Bałcyny (Poland). The protocol for animal research was approved by the Ethics Committee of the University of Warmia and Mazury. The calves were fed milk replacer, hay and concentrate. Starting from 6-months of age, animals were fattened semi-intensively and they were fed ad libitum a total mixed ration (TMR) composed of grass silage and concentrate. When calves were 11 months old and had body weight (BW) approx. 370 kg they were assigned to two groups, 10 animals in each. During fattening, the animals were kept in a free-stall system and fed individually in the system of feed intake control (RIC System Instentec Control, Holland). Between the 1st and 60th day of fattening semi-intensively (SI) fattened group received exclusively ad-libitum a total mixed ration (TMR) I composed of maize silage, post-extraction rapeseed meal and premix in dry matter (DM) proportion 87:12:1, respectively (Table 1). The animals from the other, intensively (I) fattened group were fed TMR and additionally 2 kg of triticale meals per animal per day. The triticale meal was fed individually. After 60 days of fattening, the TMR proportion was modified to 89:10:1 (TMR II), for maize silage, rapeseed meal and premix, respectively and triticale meal ration was increased to 2.5 kg. The TMR were distributed twice a day using self-propelled fodder wagon. The I group bulls got the triticale meals from automatic fodder station. The premix consisted of commercial mineral mix for fattening cattle (Cargill Polska Sp. z o.o). Additionally, in order to supplement mineral compounds salt licks (Lisal M, LNB Poland Sp. z o.o.) were used. The samples of all components and TMR mixtures were subjected to chemical analyses prior to the experiment and three times during the fattening experiment. The fattening was carried out for 8 months, until the bulls were 19 months old. In total 2 slaughterings were proceeded in which 10 animals were slaughtered (5 bulls intensively reared and 5 semi-intensively reared in each slaughtering). They were then transported to a meat processing plant where they were kept in individual boxes with access to water for 15 to 20 h. The animals were weighed before slaughter and all slaughter and post-slaughter processes were carried out in accordance with the current meat industry regulations. Half-carcasses were weighed with an accuracy of 0.5 kg and conformation and fatness were evaluated based on the EUROP system criteria by a trained grader (Kien, 2004).

2.2. Muscle preparation

Muscle *infraspinatus* (INF, n = 20) was removed from each carcass 96 h post-mortem and then delivered to a laboratory in isothermal containers at refrigerated temperature. The delivery lasted about 1 h. The next day (after 5 days of post-mortem aging), the muscles were trimmed of all external connective tissue (*epimysium*) and weighed. The whole muscle (average muscle weight 1060.5 ± 119.1 g, 985.0 ± 123.2 g, for intensive and semi-intensive feeding, respectively) was used for the experiment. The muscles were placed in a cool convectional-steam oven (Küppersbusch CPE 110, Küppersbusch Großküchentechnik GmbH, Gelsenkirchen, Germany) and subjected to thermal treatment at 180 °C to obtain 80 °C in the center of the muscles. In roasts cooking loss, collagen profile, Warner–Bratzler shear force and the sensory quality of the cooked meat were determined. The procedure of cooking, sampling, as well as cooking loss and collagen determinations were previously described in our earlier papers (Modzelewska-Kapituła, Kwiatkowska, Jankowska, & Dąbrowska, 2015; Modzelewska-Kapituła & Nogalski, 2014).

2.3. Proximate chemical composition

The chemical composition of raw *infraspinatus* muscle was determined with the use of an NIT analyzer (FoodCheck, Bruins Instrument, Purchheim, Germany). From each end of the muscle a slice was cut to obtain a portion approx. 300 g, which was comminuted in a meat grinder through a 3-mm mesh and then homogenized with a cutter (R2, Robot Coupe, Vincennes Cedex, France) for 1 min. After that, the meat was placed on three plastic Petri dishes (7 cm diameter, 1 cm height) and its surface was smoothed with a spatula. Each dish was subjected to measurements separately and three results for moisture, protein and fat content were recorded.

2.4. Warner–Bratzler shear force

The Warner–Bratzler shear force (WBSF) values (N) were measured using an Instron 5965 (Instron, Norwood, MA, USA) equipped with a shear blade. Samples, being cylindrical cores (1.27 cm diameter, approx. 40 mm long), were cut using a cork borer in the direction of muscle fibers. Five samples were cut from each muscle. The shear blade (V-shaped, with a triangular aperture of 60°) was applied perpendicularly to the direction of fibers at a crosshead speed of 2 mm/s (Walsh et al., 2010). The test was done on meat at room temperature (about 18 °C). The measured data was evaluated using Bluehill 3 software (Instron, Norwood, MA, USA).

Table 1
Chemical composition and nutritional value of experimental diets (mean values and standard error in brackets).

Specification	Maize silage	Rapeseed meal	Triticale	TMR I	TMR II
Composition of TMR, % in DM					
Maize silage				87	89
Rapeseed meal				12	10
Premix				1	1
Dry matter	326.8 (0.91)	890.3 (3.01)	906.0 (0.84)	391.2 (1.42)	379.9 (1.39)
On DM basis, g/kg					
Organic matter	880.3 (2.45)	927.4 (1.32)	944.0 (1.38)	349.5 (0.81)	338.1 (1.42)
Crude protein	88.7 (0.93)	400.7 (0.47)	159.1 (1.08)	125.3 (0.70)	119.3 (0.88)
Crude fat	29.7 (0.41)	95.7 (0.39)	31.0 (0.75)	37.6 (0.87)	36.3 (0.91)
Crude fiber	233.2 (0.96)	149.3 (0.97)	46.1 (0.54)	223.1 (1.17)	224.8 (1.10)
Meat production units (UFV)	0.8 (0.02)	0.96 (0.01)	1.22 (0.02)	0.82 (0.00)	0.82 (0.00)

n = 8 for silage; n = 5 for rapeseed meal and triticale; n = 8 for TMR I and II.
1 kg premix: Ca 235 g; Na 79 g; P 48 g; Mg 28 g; Fe 500 g; Mn 2 000 mg; Cu 375 mg; Zn 3 750 mg; I 50 mg; Co 12.5 mg; Se 12.50 mg; vitamin A 250 000 IU; D_3 50 000 IU; E 1 000 mg; DL alpha tocopherol 909.10 mg.