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ORIGINAL PAPER

Effect of dietary supplementation with *β*-hydroxy-*β*-methylbutyrate (HMB) on the carcass and meat quality characteristics of goat kids*

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Abstract

The experiment was performed on 20 male Alpine goat kids that were weaned at 30±3 days of age, and were divided into a control group (C, n=10) and an experimental group (E, n=10). During a 60-day rearing period, all animals were fed identical diets composed of milk replacer, supplementary feed mix and haylage. The diet for group E was supplemented with β-hydroxy-β-methylbutyrate (HMB) in the amount of 50 mg kg^{-1} body weight. The kids were slaughtered at 90±3 days of age. Carcass quality was evaluated, and the chemical composition, physicochemical parameters, and sensory attributes of the quadriceps femoris muscle (*musculus quadriceps femoris*) were determined. It was found that group E animals were characterized by higher ($p \leq 0.05$) values of live weight at slaughter, warm carcass weight, weights of the neck, middle neck, and flank with ribs, as well as higher ($p \leq 0.05$) values of leg length, loin eye height and area. An analysis of meat quality revealed that meat from kids administered HMB was characterized by lower ($p \leq 0.05$) water-holding capacity, and lower ($p \leq 0.05$) juiciness and tenderness, as confirmed by shear force values. In comparison with group C, the intramuscular fat of group E kids had a lower ($p \leq 0.05$) content of linolenic acid and a higher ($p \leq 0.05$) content of eicosapentaenoic acid. The results of this study indicate that HMB dietary supplementation has a positive effect on increasing the body weight and thus the carcass weight, and that it improves some carcass quality indicators of goat kids.

Keywords: goat kids, β-hydroxy-β-methylbutyrate (HMB), carcass quality

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INTRODUCTION

Dairy goats can be raised in intensive, semi-intensive or extensive systems. In intensive systems, which are most common in industrialized countries, kids are weaned early because early separation is believed to be the best way to produce the largest amount of milk for consumption and processing (Högberg et al. 2021). Early weaning can be stressful for kids, often leading to stunted growth and development. Zwierzchowski et al. (2020) report that supplementation of transitional milk with very good quality colostrum affects the indicators of non-specific humoral immunity and serum biochemical parameters in sucklings. Drinking very good quality colostrum also reduces the incidence of upper respiratory tract infections and diarrhea. Therefore, it is important to properly manage kids during the weaning period to minimize stress and reduce the negative impacts of separation (Vickery et al. 2022). Rational feeding of kids is an important issue because it can contribute to improving the meat yield of goats. By using traditional feeding systems, a final product of health-promoting quality can be obtained. It should be noted, however, that traditional systems are characterized by low production efficiency (Escareño et al. 2012). Efforts are being made to develop effective technological solutions in this regard. One of them could be the supplementation of kid diets with effective stimulants, such as β-hydroxy-β-methylbutyric acid (HMB) (Wójcik et al. 2020), β-carotene and omega-3 fatty acids (Zwierzchowski et al. 2016).

HMB is a metabolite of the amino acid leucine. As an oxidation product of α-ketoisocaproic acid, it is produced in muscle, liver and adipose tissue (Brosnan and Brosnan 2006). Leucine acts as a signaling molecule that stimulates protein synthesis and triggers muscle-building pathways. HMB promotes protein synthesis in skeletal muscles by affecting extracellular signaling-regulated kinase, an enzyme that is activated in a signaling pathway known as the mitogen-activated protein kinase cascade. In addition, HMB influences the expression of the growth hormone IGF-1 (insulin-like growth factor), which affects muscle catabolism. IGF-1 suppresses the breakdown of muscle proteins (myotubules) by decreasing the expression level of the muscle-specific ubiquitin ligase atrogin-1 in the PI3K/Akt metabolic pathway (Kornasio et al. 2009). IGF-1 stimulates chondrocyte proliferation and provokes osteoblasts to secrete collagen and other non-collagenous proteins (Christou et al. 2001). According to Kimura et al. (2014), HMB exerts its beneficial effects by activating the PI3K/Akt signaling pathway, leading to the phosphorylation of the transcription factors FoxO1 and FoxO3 and attenuation of the expression of the catabolic enzyme MuRF-1, which degrades muscle proteins. A potential mechanism of its action on muscle protein metabolism is also the effect exerted on protein synthesis by activating the mammalian Target of Rapamycin (mTOR), a ubiquitous kinase that regulates protein synthesis in the initiation phase of mRNA translation.

HMB increases protein synthesis directly through the activation of the mTOR kinase pathway, specifically the mTORC1 subunit, probably affecting the phosphorylation of ribosomal S6 kinase (S6K1) – Pimentel et al. (2011). S6K1 and the 4E-binding protein 1 (4E-BP1) are the key regulatory proteins involved in the initiation of mRNA translation (Yoshizawa et al. 2013). Upon activation, mTOR phosphorylates 4E-BP1, which accelerates the release of the eukaryotic translation initiation factor eIF4E (Weigl 2012). Research has shown that HMB also stimulates muscle protein synthesis through the activation of the mTOR-4EBP1-p70SK1 pathway (Aversa et al. 2011, Kimura et al. 2014). In addition, HMB may increase muscle protein synthesis under catabolic conditions (e.g., elevated levels of lipopolysaccharides or cytokines) via numerous other mechanisms that have not yet been fully elucidated (Duan et al. 2016).

As a supplement, HMB is usually commercially available as an edible salt-calcium HMB monohydrate (EFSA 2011), which can be easily incorporated into feed. Animal studies have demonstrated that HMB supplementation can improve bone and tooth development, enhance immune function and promote health, as well as affect productivity, e.g. by increasing milk fat content in lactating animals (Nissen, Abumrad 1997, Tatara et al. 2007, Śliwa et al. 2010, Świetlicka et al. 2016). HMB can be fed to livestock as a productivity stimulant. The ability of HMB to enhance protein synthesis is used to stimulate muscle growth in animals. However, the results of studies investigating the effects of HMB on animals are inconclusive. Nissen et al. (1994*a*) were the first to discover that feeding HMB to broiler chickens increased their growth rate, decreased mortality, and accelerated the growth of muscle tissue. The cited authors also found that HMB resulted in an increase in the body weight of growing lambs (Nissen et al. 1996), as well as an increase in colostral milk fat percentage in sows and weight gains in piglets (Nissen et al. 1994*b*). Buyse et al. (2009) demonstrated that broiler chickens fed a diet supplemented with 300 mg HMB kg^{-1} feed were significantly heavier at 14 days of age, but the noted difference decreased at later ages.

Considering the above, it is justified to pursue further studies on the efficacy of livestock diet supplementation with HMB. In particular, it is important to determine the application potential of this stimulator in the nutrition of animals with lower production efficacy, such as goats. This matter was undertaken in the present publication to demonstrate the impact of HMB used in diets of early-weaned kids on features of meat utility. Therefore, the aim of this study was to determine the effect of dietary supplementation with HMB on the carcass and meat quality characteristics of goat kids.

MATERIALS AND METHODS

The experimental material comprised 20 male Alpine goat kids from a dairy goat farm in the region of Warmia and Mazury (north-eastern Poland). All procedures involving animals were approved by the Local Ethics Committee for Animal Experiments in Olsztyn (decision No. 18/2013). Animal experiments were carried out in conformance with the Animal Protection Law and under the supervision of a veterinarian. No disease symptoms were observed during the experiment.

The kids were weaned at 30±3 days of age, and were divided into a control group (C) and an experimental group (E), of 10 animals each, by the analogue method, based on body weight. At the beginning of the experiment, the average body weight of kids was 6.09 kg in group C and 5.90 kg in group E.

During the experiment (60 days), the animals in both groups were fed according to the regime presented in Table 1. The kids received milk replacer three times a day (at 8.00 a.m., 1.00 p.m., and 6.00 p.m.) for the first 30 days, and twice a day (at 8.00 a.m. and 6.00 p.m.) for the next 30 days. Supplementary feed mix produced by Wipasz Olsztyn (Poland) was administered in the morning at 9.00 a.m. and in the afternoon at 2.00 p.m., in two equal doses. Haylage was administered every day in the morning (around 9.30 a.m.), after the concentrate. The diet for group E was supplemented with HMB (Metabolic Technologies Inc. Ames, IA, USA), which was administered every day, in the morning, with supplementary feed mix, in the amount of 50 mg kg^{-1} body weight.

Table 1

Feeding regime of goat kids

Age (days)	Supplementary feed mix (kg/animal/day)	Haylage (kg/animal/day)	Milk replacer (l/animal/day)
30-40	0.15	0.30	0.8
41-50	0.20	0.40	1.2
51-60	0.25	0.50	1.3
61-70	0.30	0.60	1.4
71-80	0.35	0.70	1.5
81-90	0.40	0.80	1.7

The amount of the administered feed and leftovers was monitored throughout the experiment to determine nutrient intake. The chemical composition of feed and leftovers was analyzed by standard methods (AOAC 1990). Nutrient intake was similar in groups C and E (Table 2), which confirms that feeding levels were identical in both groups.

The animals were slaughtered at 90±3 days of age. Hot carcass weight and dressing percentage were determined. After chilling (24 h, 4°C), the fol-

Table 2

Total nutrient intake per goat kid during the experiment

Specification	Group	
	C	E
Dry matter (kg^{-1})	263.59	270.13
Feed unit for meat production (UFV)	0.35	0.35
Crude protein (kg^{-1})	32.45	33.27
Protein digested in the small intestine when rumen-fermentable energy is limiting (PDIE) (kg^{-1})	34.83	35.71
Protein digested in the small intestine when rumen-fermentable nitrogen is limiting (PDIN) (kg^{-1})	31.31	32.08
Crude fiber (kg^{-1})	49.47	50.72

lowing carcass measurements were performed: fat thickness over the loin eye, fat thickness over the last rib and loin eye area. The following right half-carcass cuts were weighed: kidneys with perirenal fat, fore shank, hind shank, shoulder, neck, middle neck, best ribs, saddle, flank with ribs, tenderloin, leg, and total valuable cuts (leg, saddle, best ribs). All values were expressed as a percentage too. Tissue composition was evaluated based on leg dissection, and the weight and percentage content of meat, fat and bones in the leg were determined (Colomer-Rocher et al. 1987). During carcass dressing, samples of the *quadriceps femoris* muscle were collected for qualitative and quantitative analyses performed 48 h post mortem. Muscle samples were analyzed to determine (AOAC 2005) the content of: dry matter – drying at a temp. of 105°C, crude protein – by the Kjeldahl method, crude fat – by the Soxhlet method, crude ash – mineralization at a temp. of 550°, total collagen – hydroxyproline content was determined (ISO3496 1994), and the result was converted into total collagen content using a conversion factor of 7.25 (Palka 1999).

The values of pH were measured in meat homogenates (demineralized water to meat sample ratio of 1:1) using a combination of a Polilyte Lab electrode (Hamilton) and an inoLab Level 2 pH-meter (WTW) with a TFK 325 temperature sensor. The values of color parameters L* (lightness), a* (redness) and b* (yellowness) were measured in the CIE Lab system with the MiniScan XE Plus spectrocolorimeter (HunterLab). The water-holding capacity of meat was determined by the Grau and Hamm method (Van Oeckel et al. 1999), and cooking loss was determined as described by Honikel (1998). The sensory attributes of meat (tenderness, juiciness, aroma, taste) were evaluated after heat treatment, on a five-point scale (5 points – most desirable, 1 point – least desirable), according to the method proposed by Baryłko-Pikielna et al. (1964). Shear force of cooked meat (Honikel 1998) was measured in the INSTRON 5542 universal testing machine fitted with a Warner-Bratzler head (500 N, cylinder-shaped samples, 1.27 cm in diameter and 2 cm in height, cut across the grain).

The fatty acid profile was analyzed in intramuscular fat extracted by the Soxhlet method. Fatty acid methyl esters were obtained by fat methylation using the modified method of Peisker (methanol:chloroform:concentrated sulfuric acid, 100:100:1 v/v) – Żegarska et al. (1991). Fatty acids were separated by gas chromatography on the Varian CP-3800 gas chromatograph (Varian Inc., Palo Alto, CA, USA) coupled to a flame ionization detector (FID) and a CP-Sil 88 capillary column (length – 50 m, inner diameter – 0.25 mm, film thickness – 0.25 μm). Detector temp. was 250°C, and helium was the carrier gas.

The results were processed statistically by one-way analysis of variance (ANOVA). Arithmetic means ($\bar{x}$) and standard deviations (SD) were calculated, and the significance of differences between group means was estimated by the Duncan's test ($p \leq 0.05$). All calculations were performed using Statistica ver. 13 software (StatSoft 2018).

RESULTS AND DISCUSSION

The carcass quality characteristics of goat kids are presented in Table 3. Live weight at slaughter and hot carcass weight were higher ($p \leq 0.05$) in group E than in group C.

In a study by Wan et al. (2017), the offspring of sows that were supplemented with HMB-Ca at 2.0 g kg^{-1} feed during lactation were characterized by higher (6.0%) finishing body weight, higher (6.4%) average daily gain, and a lower (3.5%) feed/gain ratio than control group piglets. Piglets from HMB-supplemented sows had also higher carcass weight ($p<0.05$) and lean meat percentage ($P=0.07$).

In the study conducted by Van Koevering et al. (1994), crossbred steers at different ages were fed HMB during the final 82 days before slaughter. It was found that the performance of animals slaughtered at different dates was not altered by HMB, but an interaction was noted between HMB and time on feed. Dietary supplementation with HMB increased daily gain in steers slaughtered after 105 days on feed, but decreased daily gain in those slaughtered at 147 days. Qiao et al. (2013) supplemented broiler chickens with HMB for the first 42 days of life and noted that dressing percentage increased only in birds fed 0.1% HMB-Ca, compared with those receiving the control diet and 0.05% HMB-Ca.

Zheng et al. (2022) analyzed the effects of different dietary inclusion levels of HMB in Bama Xiang mini-pigs. Animals were fed either a basal diet with no supplement (control group), or a diet supplemented with 0.13% (low-dose), 0.64% (moderate-dose) and 1.28% (high-dose) HMB, respectively. The authors found that carcass yield in animals fed a diet with different levels of HBM did not differ statistically significantly.

Table 3

Live weight at slaughter and carcass quality characteristics of goat kids

Specification	Group							
	control (C)				experimental (E)			
	(kg-1)		(%)		(kg-1)		(%)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Live weight at slaughter	14.82[b]	2.03	-	-	16.39[a]	2.49	-	-
Warmer carcass weight	6.69[b]	1.16	-	-	7.60[a]	1.37	-	-
Dressing percentage	-	-	44.95	2.14	-	-	46.56	2.49
Head	1.13[b]	0.13	7.64	0.35	1.25[a]	0.19	7.67	0.73
Forelegs	0.26	0.04	1.74	0.14	0.29	0.06	1.78	0.4
Hind legs	0.23[b]	0.04	1.57	0.21	0.26[a]	0.03	1.61	0.19
Skin	0.93	0.22	6.26	1.06	1.11	0.30	6.66	0.973
Gastrointestinal tract	4.01	0.53	27.18	2.36	4.26	0.60	26.18	2.96
Lungs	0.25	0.04	1.68	0.18	0.27	0.07	1.62	0.26
Trachea and diaphragm	0.10	0.02	0.70	0.15	0.12	0.02	0.72	0.14
Heart	0.07	0.01	0.46	0.04	0.08	0.01	0.47	0.05
Liver	0.36	0.05	2.43	0.28	0.38	0.06	2.35	0.17
Spleen	0.03	0.01	0.20	0.05	0.03	0.01	0.19	0.03
Testes	0.15	0.23	0.96	1.55	0.07	0.05	0.41	0.24
Blood	0.62	0.07	4.22	0.67	0.67	0.14	4.08	0.72

[a,b] – mean values in rows followed by different litters differ significantly at $p \leq 0.05$

In the present study, group E kids were characterized by higher ($p \leq 0.05$) weights of head and hind legs, whereas HMB had no influence on the weights of internal organs, including the stomach, liver, kidneys, heart and spleen. Similar results were obtained by Nissen et al. (1994*a*) in a study of broiler chickens. In turn, Flummer et al. (2012) demonstrated that HMB exerted a significant effect on the weights of selected internal organs in piglets. The liver, spleen, kidneys and cecum were heavier in the offspring of sows fed HMB in late gestation. The supplement had no influence on the weights of heart and stomach, and the total weight of the small intestine decreased by 15% in HMB group piglets. In Bama Xiang mini-pigs fed diets with low, moderate and high levels of HMB, the weights of heart and liver were highest in the low HMB group (basal diet + 0.13% HMB) – Zheng et al. (2022). The cited authors concluded that HMB may improve the growth performance of Bama Xiang mini, but its high dietary inclusion levels may be ineffective.

Carcass and loin measurements are presented in Table 4. The carcasses of kids from group E were larger and wider than those of C. The differences found were significant at $p \leq 0.05$. The values of loin eye length and area were

Table 4

Carcass and loin measurements in goat kids

Specification	Group			
	C		E	
	$\bar{x}$	SD	$\bar{x}$	SD
Carcass length (cm)	47.20^b	2.97	48.30^a	2.71
Chest depth (cm)	19.75^b	1.65	19.25^a	1.33
Chest width (cm)	9.40	0.94	9.55	1.30
Width at shoulders (cm)	11.60	1.56	11.75	1.30
Chest girth (cm)	50.00	2.58	50.90	3.84
Rump width (cm)	12.10	1.52	11.80	0.89
Circumference of hips (cm)	41.60	2.07	42.40	1.78
Scrotal circumference (cm)	26.65	1.60	26.95	2.41
Leg length (cm)	29.20^b	1.42	30.40^a	1.71
Shank length (cm)	17.30	0.95	17.65	1.16
Loin eye width (cm)	4.61	0.26	4.81	0.49
Loin eye height (cm)	2.79^b	0.27	3.08^a	0.53
Loin eye area (cm^2)	10.32^b	1.42	11.97^a	3.12
Fat thickness over the loin eye (cm)	0.10	0.00	0.10	0.00
Fat thickness over the last rib (cm)	0.10	0.00	0.10	0.00

^{a,b} – mean values in rows followed by different litters differ significantly at $p \leq 0.05$

also higher in group E than in group C ($p \leq 0.05$). In a study by Zheng et al. (2022), where Bama Xiang mini-pigs were fed diets with three different levels of HMB (0.13%, 0.64% and 1.38%), the loin eye area was highest in the 0.13% HMB group, and lowest in the 0.64% HMB group.

In the present study, the higher carcass weight of group E kids resulted in higher weight of the right half-carcass (by 0.42 kg^{-1}, i.e. 12.9%; $p \leq 0.05$), compared with group C (Table 5). In group E, the right half-carcass was characterized by higher ($p \leq 0.05$) weights of neck (by 20%), middle neck (by 15.38%), flank with ribs (by 14.04%), as well as a higher body weight of the leg and total weight of valuable cuts relative to group C (significant differences at $p > 0.05$). The addition of HMB to the experimental diet contributed to muscle development, thus alleviating the negative impact of early weaning. At the same time, carcass fat content did not increase ($p > 0.05$) in group E kids, which is an important consideration for consumers.

Leg dissection (Table 6) revealed that leg meat content was higher ($p > 0.05$) in group E compared to group C. The addition of HMB to the experimental diet did not induce changes ($p > 0.05$) in the content or proportion (%) of fat and bones in the leg of goat kids.

The effect of HMB on meat quality traits in goat kids is presented in Table 7. The proximate chemical composition of meat was similar ($p > 0.05$)

Table 5

Right half-carcass cuts in goat kids

Specification	Group							
	C				E			
	(kg^{-1})		(%)		(kg^{-1})		(%)	
	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD	$\bar{x}$	SD
Half-carcass weight	3.25^{b}	0.54	100	0.00	3.67^{a}	0.65	100	0.00
Neck	0.30^{b}	0.06	9.21	0.68	0.36^{a}	0.07	9.80	1.02
Middle neck	0.26^{b}	0.06	7.88	0.71	0.30^{a}	0.07	8.24	0.61
Shoulder	0.53	0.11	16.19	1.16	0.59	0.09	16.11	0.96
Flank with ribs	0.57^{b}	0.11	17.44	1.57	0.65^{a}	0.15	17.70	1.71
Fore shank	0.14	0.02	4.46	0.63	0.16	0.02	4.29	0.32
Hind shank	0.20	0.03	6.04	0.61	0.21	0.04	5.77	0.42
Tenderloin	0.05	0.01	1.63	0.27	0.06	0.02	1.62	0.34
Kidney	0.04	0.01	1.29	0.23	0.04	0.01	1.14	0.16
Perirenal fat	0.04	0.02	1.10	0.53	0.05	0.04	1.36	0.94
Valuable cuts								
- leg (kg^{-1})	0.78^{b}	0.15	24.00	1.72	0.87^{a}	0.15	23.76	1.64
- saddle (kg^{-1})	0.17	0.02	5.14	0.65	0.18	0.04	4.82	0.60
- best ribs (kg^{-1})	0.18	0.03	5.62	0.68	0.20	0.02	5.41	0.46
- total (kg^{-1})	1.03^{b}	0.08	33.76	1.05	1.35^{a}	0.09	34.99	0.7

^{a,b} – mean values in rows followed by different litters differ significantly at $p \le 0.05$

Table 6

Leg weight and tissue composition in goat kids

Specification		Group			
	C		E		
	$\bar{x}$	SD	$\bar{x}$	SD	
Proportion					
Meat	(kg^{-1})	0.44^{b}	0.10	0.61^{a}	0,11
	(%)	68.20	2.75	70.02	2,78
Fat	(kg^{-1})	0.02	0.01	0.02	0,01
	(%)	2.83	0.75	2.80	0,57
Bones	(kg^{-1})	0.22	0.05	0.24	0,05
	(%)	28.97	2.56	27.19	2,73
Meat/bone ration		2,50	0.31	2.61	0.37
Fat/bone ratio		0,10	0.03	0.10	0.02

Table 7

Meat quality parameters

Specification	Group			
	C		E	
	$\bar{x}$	SD	$\bar{x}$	SD
Dry matter (%)	21.64	0.75	21.58	0.8
Fat (%)	0.59	0.26	0.71	0.23
Protein (%)	19.49	0.71	19.49	0.81
Ash (%)	1.15	0.04	1.15	0.04
Collagen (%)	0.59	0.19	0.51	0.22
pH_{48}	6.28	0.22	6.18	0.20
L*	47.11	1.84	47.32	1.92
a*	11.08	1.01	11.19	1.37
b*	14.36	0.89	14.47	0.59
Water-holding capacity (cm^2)	6.04^b	0.91	7.00^a	0.69
Cooking loss (%)	33.89	9.28	34.26	4.05
Aroma – intensity (points)	3.45	1.01	3.45	0.86
Aroma – desirability (points)	4.70	0.67	4.50	0.85
Taste - intensity (points)	3.75	0.42	3.65	0.41
Taste - desirability (points)	4.80	0.42	4.35	0.82
Juiciness (points)	3.90^a	0.39	3.55^b	0.44
Tenderness (points)	4.05^a	0.50	3.40^b	0.97
Shear force (N)	23.21^b	7.0	34.42^a	12.36

^{a,b} – mean values in rows followed by different litters differ significantly at $p \le 0.05$

in both groups. Meat from group E kids was characterized by lower ($p \le 0.05$) water-holding-capacity, juiciness and tenderness than meat from group C animals.

Flummer et al. (2012) analyzed the effect of HMB added to pig diets on the chemical composition of meat and reported that the meat of piglets from sows fed HMB with 15 mg Ca(HMB)2 kg^{-1} body weight in late gestation had higher crude protein content and lower fat content, compared with meat from control group piglets. Tang et al. (2021) evaluated the quality of meat from broiler chickens fed a basal diet supplemented with 0.05%, 0.10% or 0.15% HMB and found that the tested supplemented exerted varied effects on the color, shear force drip loss and cooking loss of breast and leg muscles. The cited authors found that HMB decreased the value of L*, drip loss, cooking loss of meat. However, the authors showed differences in the b* value, where in the breast muscles it increased and in the leg muscle decreased in response to HMB supplementation. In the breast muscle, shear force decreased and a* value increased after HMB supplementation, unlike in the

Table 8

Fatty acid profile of intramuscular fat in goat kids (%)

Specification	Group			
	C		E	
	$\bar{x}$	SD	$\bar{x}$	SD
$C_{10:0}$	0.08	0.01	0.08	0.01
$C_{12:0}$	0.10	0.02	0.10	0.03
$C_{14:0}$	1.13	0.16	1.20	0.18
$C_{14:1}$	0.07	0.04	0.09	0.08
$C_{15:0}$	0.29	0.05	0.30	0.10
$C_{16:0}$	20.81	0.90	21.24	0.83
$C_{16:1}$	1.70	0.35	1.72	0.37
$C_{17:0}$	0.94	0.13	0.89	0.08
$C_{17:1}$	0.91	0.18	0.91	0.33
$C_{18:0}$	17.60	2.20	17.38	2.99
$C_{18:1}$	37.05	2.77	37.14	2.87
$C_{18:2}$	12.84	2.08	12.75	1.70
$C_{18:3}$	0.60^{a}	0.17	0.50^{b}	0.10
$C_{20:0}$	0.20	0.02	0.20	0.04
$C_{20:1}$	0.19	0.03	0.20	0.02
$C_{20:2}$	0.13	0.04	0.13	0.04
$C_{20:4}$	4.06	0.98	3.89	0.68
$C_{20:5}$	0.05^{b}	0.02	0.09^{a}	0.09
$C_{22:0}$	0.31	0.05	0.30	0.06
$C_{22:5}$	0.80	0.19	0.77	0.20
$C_{22:6}$	0.12	0.05	0.11	0.05
SFA	41.46	2.60	41.70	3.33
MUFAs	39.93	3.10	40.05	3.34
PUFAs	18.61	3.09	18.24	2.33
UFAs	58.54	2.60	58.30	3.33
MUFA/SFA ratio	0.97	0.11	0.97	0.15
PUFA/SFA ratio	0.45	0.09	0.44	0.08
UFA/SFA ratio	1.42	0.14	1.41	0.19
PUFA/MUFA ratio	0.47	0.11	0.46	0.08

^{a,b} – mean values in rows followed by different litters differ significantly at $p \leq 0.05$, SFAs – saturated fatty acids, MUFAs – monounsaturated fatty acids, PUFAs – polyunsaturated fatty acids, UFAs - unsaturated fatty acids, n-3 – omega-3 fatty acids, n-6 – omega-6 fatty acids leg muscle, where no such effects were observed. The cited authors specified that the optimal level of HMB was 0.10%.

Zheng et al. (2022) investigated the effects of dietary supplementation with HMB on mini-pigs with three different levels of HMB (0.13%, 0.64% and 1.38%). An analysis of the quality of meat from two different muscles, *longissimus thoracis* and *soleus*, revealed that the values of L* and b* as well as the values of pH measured 45 min and 24 h post mortem were not significantly affected by HMB. However, a tendency to a linear decrease in shear force (P=0.097) was noted in the *longissimus thoracis* muscle with increasing levels of dietary HMB.

In the current study, HMB had a minor effect on the fatty acid profile of intramuscular fat (Table 8). Only the content of linolenic acid ($C_{18:3}$) decreased ($p \leq 0.05$), and the concentration of eicosapentaenoic acid increased ($p \leq 0.05$).

Zhong et al. (2019) reported that dietary HMB supplementation in growing pigs may increase the synthesis of PUFAs in a tissue-specific manner. HMB induced an increase in the proportion of PUFAs and a significant decrease in the percentage of SFAs and the SFA/PUFA ratio in the *longissimus dorsi* muscle, whereas no such effect was observed in the *soleus* muscle.

A similar study involving mini-pigs (Zheng et al. 2021) demonstrated that dietary supplementation with 0.13% HMB decreased intramuscular fat content, increased PUFA concentrations in the *longissimus thoracis* muscle, and increased *n*-3 PUFA concentrations in the *soleus* muscle, in comparison with the control group. In a study by Wan et al. (2023), HMB supplementation in the diet with 0.15% increased the SFA content and decreased the content of C18:1*n*9c and MUFA in the breast muscle of broilers. Moreover, it reduced the content of *n*-6 PUFA and PUFA as well as the PUFA/SFA ratio in the leg muscles of broilers.

CONCLUSIONS

The carcasses of kids from group E were larger and wider than those from group C. The differences found were significant at $p \leq 0.05$. The meat of kids from group E was characterized by lower water capacity and shear force value. Intramuscular fat of kids from group E was noted to contain lower linolenic acid (C18:3) and higher eicosapentaenoic acid (C20:5). In group E, the right half-carcass was characterized by higher weights of neck, middle neck, flank with ribs, as well as a higher body weight of the leg and total weight of valuable cuts relative to group C (significant differences at $p > 0.05$). Leg section showed that the meat content in the leg was higher ($p > 0.05$) compared to group C.

The results of this study indicate that HMB dietary supplementation has a positive effect on increasing the body weight and thus the carcass weight and improves some carcass quality indicators of kids.

Author contributions

K.Z., J.M. – conceptualization, K.Z. – methodology, K.Z., S.M. – formal analysis, T.D. – writing – original draft preparation, Z.A. – visualization, T.K. – editing. All authors have read and agreed to the published version of the manuscript.

Conflicts of interest

The authors declare no conflict of interest.

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