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Evaluation of Protein Hydrolysis and Amino Acid Ratio among Different Goat Cuts by *in vitro* Digestion Model

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ABSTRACT - The purpose of this study was to evaluate protein hydrolysis and the amino acid ratio among different cuts of goat meat, such as the foreleg, hindleg, loin, and rib, using an *in vitro* digestion model. The corresponding cuts of beef and pork were used to compare with the goat meat. The hindleg (8.32%) and rib (8.32%) had the highest levels of protein hydrolysis among the goat cuts. There was no significant difference in protein hydrolysis between goat and pork (8.57%), ribs ($P > 0.05$), which had higher levels of protein hydrolysis than the beef ribs. Before digestion, the glutamine (53.44%) and glycine (11.03%) ratios were highest in the pre-digested goat foreleg and loin ($P < 0.05$). After *in vitro* digestion, goat ribs had the highest lysine ratio (17.54%) among the different cuts, and the lysine ratio was significantly higher in goat ribs than beef ribs ($P < 0.05$). This study provides basic data on protein hydrolysis and the amino acid composition of different cuts of goat meat, which may facilitate the evaluation of protein digestion patterns and bioavailability.

Keywords: Goat meat, *In vitro* digestion model, Protein hydrolysis, Amino acid

Goat is consumed mostly in extracts rather than meat itself, and is considered as a folk health food[1]. However, the consumption of Korean native black goat has increased to 30% during recent years and the number of slaughtered goats increased up to 161,667 in 2020, which is 50% up from 2018[2,3]. Goat meat is a good dietary source for children and the elderly as well as pregnant women due to its composition of low fat and cholesterol, high protein, calcium, iron, and vitamins[4]. In addition, it was reported that goat meat had high levels of bioactive compounds such as L-carnitine, creatine, and carnosine[5].

Protein is known to have functions in nutrition and physiological activity[6]. It is important to assess the degree of protein hydrolysis and the stability of dietary proteins in digestion to study the effects of amino acids and bioactive peptides produced by protein degradation[7,8]. In particular, protein is known as one of the important nutrients for the elderly, and it has been reported that protein intake prevents age-related loss of muscle mass so that better digestibility of dietary protein is more needed[9-11].

The gastrointestinal tract is an organ used to absorb energy and nutrients from food, and release waste[12]. The digestion and absorption of food in the human digestive tract is a complex process involving physical, chemical, and biological process[13]. In recent years, researches have been conducted to study the absorption, digestion, and availability of nutrients such as protein and iron by *in vitro* methods that simulate the digestion process[14]. Through *in vitro* digestion model, the digestibility of food materials and their physiological activity can be quickly screened, but as the correlation with *in vivo* experiments is not clear, *in vitro* digestion model is more suitable for an initial experiment to assess the efficacy of the food materials[14].

In the last four decades, meat proteins are a common source of bioactive peptides and high levels of essential amino acids, and are known to have various functions[15-17]. Despite of its value as an animal dietary protein source, the goat has been studied for animal husbandry such as feed values, its reproductive potentials, and feeding system[18-21]. Although there are some studies on compositions of goat meat quality and physiochemical properties, the studies are limited on protein availability of different cuts in goat cut compared to other red meats such as beef and pork[5,18]. Therefore, the present study assessed the proteins of four cuts (front leg, hind leg, loin, and rib) from goat meat through *in vitro* digestion model, compared and analyzed with beef and pork.

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Materials and Methods

Preparation of meat samples and reagents

The front legs, hind legs, loins, and ribs from twelve-month-old goat were purchased from Gaon agricultural corporation in Jeollanam-do, Korea. The four cuts of pork and beef were purchased from a commercial butcher shop in Seoul, Korea, and used as groups for comparison with the goat meats. All meat samples were stored at -20°C until use.

Digestion model

The artificial digestive enzyme (saliva, gastric fluid, and intestinal fluid) for *in vitro* digestion was prepared according to the method of Gawlik-Dziki et al[22]. Artificial saliva solution was made of NaCl 8 g, KH_2PO_4 0.19 g, Na_2HPO_4 2.38 g, and α-amylase (Sigma-Aldrich, St. Louis, MO, USA) with 200 U/mL enzymatic activity and 100 mg mucin (Sigma-Aldrich) dissolved in 1 L distilled water. The solution was adjusted to pH of 6.75. Synthetic gastric fluid was made of NaCl 1.76 g and 300 U/mL of pepsin (Sigma-Aldrich) dissolved in 1 L distilled water. Artificial intestinal fluid was made of 8.58 g bile extract (Sigma-Aldrich), 8.4 g $NaHCO_3$, and 1.425 g pancreatin (Sigma-Aldrich) dissolved in 1 L distilled water. As 1 g of the front legs, hind legs, loins, and ribs of beef, pork, and goat meat was placed in a sample bag (3M™, St. Paul, MN, USA), 15 mL of the saliva was added into the sample bag, and the sample was homogenized in a stomacher (BagMixer®, Interscience, St.Nom, Yvelines, France) for 1 min. The sample was shaken at 200 rpm, and 37°C for 10 min. Subsequently, 15 mL of the gastric fluid adjusted to pH of 1.2 using 5 mol/L HCl was added to the sample, and the sample was shaken at 200 rpm and 37°C for 1 h. After the digestion in the gastric fluid, each sample was adjusted to pH of 6.0 using 0.1 mol/L of $NaHCO_3$, and 15 mL of the intestinal fluid was then added to the samples. It was adjusted to pH of 7.0 using 1 mol/L NaOH, and 5 mL of 120 mmol/L NaCl and 5 mL KCl were then added. The samples were shaken at 200 rpm and 37°C for 2 h in darkness. Finally, the digestive sample was centrifuged at 14,000×rpm for 3 min to obtain supernatants for protein hydrolysis and amino acid analysis.

Degree of protein hydrolysis

The protein hydrolysis of the sample was measured using the colorimetric reaction between the amino group produced by dithiothreitol (DTT; Sigma-Aldrich) and *o*-phthalaldehyde (OPA; Sigma-Aldrich)[23]. Disodium tetraborate (7.62 g; Samchun Chemicals, Seoul, Korea) and 200 mg sodium dodecyl sulfate (Biosesang, Gyeonggi, Korea) were dissolved in 150 mL of distilled water, and 160 mg OPA dissolved in 4 mL of ethanol was then added. Subsequently, 176 mg DTT was added to the solution with 46 mL of distilled water, making the final volume of OPA reagent up to 200 mL. OPA reagent 3 mL and 300 μL of the standard and sample solution were mixed for 5 sec, and the mixture was incubated at room temperature for 2 min. The absorbance of the mixture was measured at 340 nm. The standard solution was used by dissolving 50 mg of serine in 500 mL of distilled water, and the hydrolysis degree was calculated as following the equations (1) and (2)[24].

$$\text{Serine-NH}_2 = (OD_{sample} - OD_{blank})/(OD_{standard} - OD_{blank}) \times 0.9516 \text{ meqv/L} \times 0.1 \times 100/X \times P \quad (1)$$

$$\text{Degree of protein hydrolysis (\%)} = [(\text{serine-NH}_2\text{-}\beta)/(\alpha \text{ meqv/g protein})] / 7.6 \times 100\% \quad (2)$$

(X: weight of sample, P: percentage of protein concentration, β=0.4, α meqv=1)

Amino acid analysis

Samples for analyzing amino acid were prepared according to a method by Cho et al.[25]. The meat sample (3 g) before digestion was placed in 50 mL conical tube, homogenized with 15 mL of 0.01 N HCl for 1 min by a vortexer and centrifuged at 1,912 ×g for 5 min. The supernatants were used as pre-digestive samples. The pre-digestive samples (600 μL) and the digestive samples (600 μL) were respectively mixed with 20 μL of internal standard substance L-citrulline (Sigma-Aldrich) and 1,380 μL of acetonitrile (Duksan, Ansan, Korea) in a microcentrifuge tube, and incubated at room temperature for 30 min. The samples were then centrifuged at 10,000 ×g for 15 min, and the supernatants were filtered with a 0.45-μm filter for amino acid analysis. The quantitative determination of amino acids was performed at National Instrumentation Center for Environmental Management (Seoul, Korea). The samples were injected into HPLC (Ultimate 3000, Thermo Scientific™ Dionex™, Sunnyvale, CA, USA), and INNO C 18 column (150 mm × 4.6 mm, 5 μm; Youngjin Biochrom Co., Ltd., Seongnam, Korea) was used. The absorbance was measured at 333 nm using an HPLC detector (Agilent 1260 infinity II fluorescence detector, Agilent, Santa Clara, CA, USA). The mobile solvents A and B were 40 mM sodium phosphate adjusted to pH of 7 and 3 deionized distilled water:acetonitrile:methanol=10:45:45(v/v/v), respectively.

Statistical analysis

The data were analyzed by the general linear model procedure of SAS® ver. 9.4 (SAS OnDemand on, SAS Institute Inc., Cary, NC, USA). Least square means among

the treatments were compared by pairwise t-test at α=0.05.

Results and Discussion

The protein hydrolysis of digested meat samples is presented in Table 1. There was no significant difference in protein hydrolysis between goat meats, but the protein hydrolysis of the hind leg (8.32%) and rib (8.32%) was the highest among the four goat cuts. For front leg and loin, beef (8.57% and 8.65%) showed the highest protein hydrolysis among meat types, but there was no significant difference between goat and beef. Similarly, the protein hydrolysis of the pork rib (8.57%) was significantly higher (P<0.05) than that of beef (7.38%), but the protein hydrolysis of goat (8.32%) was not significantly different from that of pork. As the digestion of meat progressed, the degree of protein hydrolysis increases[24], and Yin et al.[26] assessed protein digestion by the degree of protein hydrolysis *in vitro* digestion model. Protein hydrolysate produced by digestion after actual dietary intakes are defined as a source of releasable bioactive peptides with potential health benefits[27]. This means that goat meat can be regarded as a significant nutritional protein source for human consumption with the other animal-derived protein sources such as beef and pork.

Table 2 and 3 exhibits the non-essential and essential amino acid contents before and after digestion of goat, beef, and pork cuts, respectively. In this study, the respective ratio (%) of 10 non-essential amino acids and 9 essential amino acids in total amino acid content was identified by each sample. There was no significant difference in the content (mg/g) of essential and non-essential amino acids among the meat type and cuts in both pre-digestion and post-digestion stages. The ratios of asparagine (1.63%) and alanine (18.98%) in the pre-digested goat rib were higher than those of beef (asparagine: 0.85%; alanine: 14.19%) and the pork (asparagine: 1.45%; alanine: 14.55%). The ratios of glycine (11.03%) and glutamine (53.44%) were the highest in the pre-digested goat loin and foreleg (P<0.05). According to a study by Ali et al.[28], the contents of aspartic acid and glutamic acid were the highest in the rib among the four goat cuts, and the asparagine and alanine contents were found to be high in the front leg. Differences in amino acid composition by studies can be explained as the quality of goat meat varies by age, genotype, gender and diet, and meat protein denatures according to the storage conditions[9,29,30]. In this study, the goat meat tended to have a lower ratio of essential amino acids in the pre-digestion stage compared to other meats, but the values became similar between the meats after digestion. Although lysine in goat foreleg (0.75%) was significantly lower (P<0.05) than those of beef except for foreleg and rib and pork before the digestion. However, after the digestion, the ratio of lysine in the goat foreleg (16.64%) became either higher or similar compared to beef and pork samples. As the digestion of goat meat progressed in the body, the ratio of free amino acids (arginine, tyrosine, histidine, methionine, tryptophan, phenylalanine, leucine, and lysine) can be increased, it indicates that the bioavailability of amino acids may increase in the body. Lysine accounted for the highest proportion of total essential amino acids in goat rib (17.54%) compared to other meats after digestion and was significantly higher than beef rib (P<0.05). Lysine is an essential amino acid that can be supplied by diet and is involved in animal growth[31]. Canfield and Bradshaw[32] reported that lysine supplementation was associated with a decrease in abnormal blood glucose levels. Among non-essential amino acids, the glutamine ratio in the foreleg of goat (6.97%) was significantly high compared to beef except for rib and pork except for forelegs after digestion (P<0.05). Madruga et al[33] reported that one of the most abundant non-essential amino acids in goats was glutamine, and glutamine is a glutamate precursor synthesizing glutathione, which is well known as one of the main antioxidants in cells and tissues[34].

In conclusion, as the degree of protein hydrolysis and ratios of amino acids in digested goat meat samples were similar or higher compared to those of pork and beef, goat meat could be an effective source of bioavailable amino acids. In addition, the results can be fundamental data for protein digestion patterns and bioavailability of goat meat. The results in this study were from *in vitro* digestion model.

Table 1. Degree of protein hydrolysis (%) of goat, beef, and pork within different parts after *in vitro* digestion

Type of meat	Cut			
	Foreleg	Hindleg	Loin	Rib
Goat	8.07±0.52$^{Aab1)}$	8.32±0.74^{A}	7.70±1.02^{Ab}	8.32±0.54^{Aab}
Beef	8.57±0.69^{Aa}	8.21±0.8^{AB}	8.65±0.50^{Aa}	7.38±1.13^{Bb}
Pork	7.30±0.80^{Bb}	9.04±0.85^{A}	7.63±0.61^{Bb}	8.57±0.51^{Aa}

1) Datas are mean±SD of triplicate experiments.

A-B) Means in the same row with different letters are significantly different at P<0.05.

a-b) Means in the same column with different letters are significantly different at P<0.05.

Table 2. Non-essential amino acid and essential amino acid ratio (%) in total amino acids in cuts of goat, beef, and pork before digestion

Amino acid		Goat				Beef				Pork			
		Foreleg	Hindleg	Loin	Rib	Foreleg	Hindleg	Loin	Rib	Foreleg	Hindleg	Loin	Rib
Non-essential amino acid	Asp[1]	0.35±0.61$^{ABC2)}$	0.12±0.2^{C}	0.29±0.11^{BC}	0.34±0.06^{ABC}	0.07±0.11^{C}	0.00±0.00^{C}	0.12±0.21^{C}	0.37±0.18^{C}	0.39±0.14^{ABC}	0.58±0.21^{AB}	0.63±0.3^{AB}	0.75±0.4^{A}
	Glu	3.8±1.21^{CD}	2.95±0.21^{D}	3.13±0.57^{CD}	5.99±0.12^{A}	3.02±0.21^{CD}	5.69±0.49^{AB}	4.48±0.58^{BC}	3.87±0.33^{CD}	3.00±0.84^{D}	6.73±1.7^{A}	6.16±0.57^{A}	6.98±1.57^{A}
	Asn	0.92±0.19^{D}	0.94±0.17^{D}	1.28±0.2^{BC}	1.63±0.2^{A}	1.08±0.2^{CD}	1.46±0.14^{AB}	1.6±0.08^{A}	0.85±0.18^{DE}	0.64±0.05^{E}	1.4±0.03^{AB}	1.38±0.2^{AB}	1.45±0.17^{AB}
	Ser	2.54±0.12^{E}	1.98±0.16^{EF}	3.40±0.63^{CD}	3.72±0.56^{BCD}	3.26±0.23^{D}	4.05±0.56^{ABC}	4.54±0.13^{A}	2.45±0.26^{E}	1.71±0.09^{F}	4.57±0.23^{A}	4.15±0.64^{AB}	4±0.53^{ABC}
	Gln	53.44±6.31^{A}	43.22±2.32^{BC}	38.79±1.15^{C}	25.25±1.36^{D}	41.28±1.16^{C}	17.38±0.5^{E}	23.26±4.83^{D}	46.64±2.88^{B}	44.06±5.34^{BC}	14.2±0.88^{E}	14.39±1.25^{E}	12.57±2.67^{E}
	Gly	5.64±0.05^{D}	7.76±2.1^{B}	11.03±0.44^{A}	6.52±0.11^{CD}	3.75±0.37^{E}	3.01±0.17^{E}	2.94±0.08^{E}	2.88±0.10^{E}	4.00±0.19^{E}	6.89±0.43^{BC}	5.62±0.43^{D}	6.56±0.48^{CD}
	Arg	1.75±0.97^{E}	2.80±0.33^{BCDE}	3.36±0.16^{ABCD}	4.16±0.08^{AB}	2.21±0.70^{DE}	3.83±0.44^{ABC}	4.67±0.17^{A}	2.69±1.17^{CDE}	3.47±1.33^{ABCD}	4.22±1.52^{A}	3.73±0.24^{ABC}	4.23±0.91^{A}
	Ala	13.00±0.41^{FG}	17.47±0.19^{AB}	14.17±1.05^{DEF}	18.98±1.53^{A}	16.82±1.57^{ABC}	13.81±1.71^{EFG}	13.75±1.55^{EFG}	14.19±0.73^{DEF}	15.67±0.85^{BCDE}	16.46±2.14^{BCD}	11.48±1.11^{G}	14.55±2.64^{CDEF}
	Tyr	0.94±0.25^{E}	1.65±0.23^{CDE}	1.81±0.10^{CDE}	3.05±0.65^{C}	2.50±0.17^{CD}	5.35±0.36^{B}	5.3±1.04^{B}	1.28±0.13^{DE}	3.07±0.3^{BC}	10.49±2.19^{A}	11.83±0.59^{A}	10.62±1.68^{A}
	Pro	0.99±0.86^{B}	1.46±0.95^{AB}	1.62±0.85^{AB}	1.67±0.87^{AB}	1.46±1.09^{AB}	2.34±1.09^{AB}	2.13±0.59^{AB}	1.43±1.24^{AB}	1.87±0.83^{AB}	2.77±1.03^{A}	2.52±1.22^{AB}	2.24±1.31^{AB}
	Total (mg/g)	5.39±4.43	3.74±2.24	3.72±1.93	3.15±1.5	3.22±2.30	2.58±1.65	3.38±1.67	3.43±2.71	7.91±7.59	7.77±9.77	2.00±0.80	7.39±9.63
Essential-amino acid	His	1.07±0.93^{DEF}	1.26±0.17^{BCDEF}	1.62±0.09^{ABCDE}	1.83±0.05^{ABC}	1.21±0.23^{CDEF}	1.99±0.1^{A}	1.93±0.17^{AB}	0.91±0.79^{F}	0.96±0.34^{EF}	1.68±0.36^{ABCD}	1.19±0.01^{CDEF}	1.65±0.29^{ABCD}
	Thr	1.26±0.10^{I}	1.36±0.02^{I}	1.73±0.15^{GHI}	2.47±0.35^{DEF}	2.15±0.07^{EFG}	2.68±0.41^{CDE}	2.88±0.14^{BCD}	1.61±0.35^{HI}	2.00±0.07^{FGH}	3.33±0.33^{AB}	3.58±0.68^{A}	3.21±0.44^{ABC}
	Val	1.33±0.32^{G}	1.59±0.23^{FG}	1.67±0.25^{EFG}	2.52±0.54^{DEF}	2.54±0.28^{DE}	5.24±0.94^{A}	4.7±0.18^{AB}	2.01±0.1^{EFG}	1.44±0.19^{G}	3.30±0.83^{CD}	3.97±0.99^{BC}	3.43±0.76^{CD}
	Met	0.26±0.23^{F}	1.08±0.19^{DE}	0.84±0.06^{EF}	1.94±0.37^{BC}	1.69±0.19^{CD}	3.65±0.51^{A}	3.15±0.19^{A}	0.85±0.02^{EF}	0.62±0.13^{EF}	1.89±0.56^{BC}	3.44±0.74^{A}	2.43±0.63^{B}
	Trp	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.00±0.00	0.62±1.08	0.53±0.91	0.00±0.00	0.00±0.00	0.00±0.00	0.58±1.01	0.62±1.07
	Phe	0.91±0.28^{G}	1.9±0.37^{EFG}	1.37±0.2^{FG}	2.95±0.72^{CDE}	2.31±0.27^{DEF}	4.75±0.64^{A}	3.96±0.19^{ABC}	1.42±0.02^{FG}	1.23±0.31^{FG}	2.8±1.26^{CDE}	4.36±1.3^{AB}	3.13±1.32^{BCD}
	Ile	0.91±0.42^{E}	1.44±0.23^{DE}	1.14±0.13^{DE}	2.36±0.49^{C}	1.96±0.17^{CD}	4.11±0.62^{A}	3.71±0.1^{A}	1.22±0.03^{DE}	0.91±0.22^{E}	2.56±0.86^{BC}	3.31±0.97^{AB}	2.69±0.82^{DE}
	Leu	1.74±0.64^{F}	3.07±0.41^{DEF}	2.30±0.27^{EF}	5.15±1.07^{BC}	3.79±0.34^{CDE}	8.16±1.22^{A}	7.08±0.3^{A}	2.59±0.01^{EF}	1.90±0.36^{F}	4.75±1.73^{CD}	6.78±2.01^{AB}	5.05±1.6Z^{BC}
	Lys	0.75±0.65^{D}	1.43±0.10^{CD}	1.97±0.30^{BCD}	2.73±0.32^{ABCD}	1.39±0.68^{CD}	3.50±0.81^{ABC}	3.95±0.20^{AB}	1.85±1.60^{BCD}	3.77±2.23^{AB}	4.54±2.45^{A}	3.44±0.35^{ABC}	4.55±2.46^{A}
	Total (mg/g)	0.51±0.41	0.62±0.38	0.6±0.32	1.01±0.56	0.74±0.54	1.59±1.03	1.66±0.68	0.6±0.48	1.31±1.26	2.51±2.88	1.02±0.5	2.65±3.12

[1)] Asp, aspartic acid; Glu, glutamic acid; Asn, asparagine; Ser, serine; Gln, glutamine; Gly, glycine; Arg, arginine; Ala, alanine; Tyr, tyrosine; Pro, proline; His, histidine; Thr, threonine; Val, valine; Met, methionine; Trp, tryptophan; Phe, phenylalanine; Ile, isoleucine; Leu, leucine; Lys, lysine.

[2)] Datas are mean±SD of triplicate experiments.

[A-I)] Means in the same row with different letters are significantly different at $P<0.05$.

Table 3. Non-essential amino acid and essential amino acid ratio (%) in total amino acids in cuts of goat, beef, and pork after digestion

Amino acid		Goat				Beef				Pork			
		Foreleg	Hindleg	Loin	Rib	Foreleg	Hindleg	Loin	Rib	Foreleg	Hindleg	Loin	Rib
Non-essential amino acid	Asp[1)]	0.42±0.26[2)]	0.37±0.18	0.28±0.24	0.44±0.11	0.36±0.32	0.36±0.11	0.33±0.29	0.38±0.33	0.51±0.26	0.39±0.2	0.38±0.12	0.5±0.28
	Glu	1.59±0.04	1.58±0.15	1.13±0.31	1.73±0.03	1.21±1.04	1.79±0.29	1.15±1.00	1.35±1.17	1.63±0.04	1.31±0.23	1.46±0.10	1.99±0.17
	Asn	1.00±0.22	1.04±0.25	0.96±0.28	1.08±0.35	0.67±0.26	1.07±0.36	0.62±0.54	0.63±0.55	0.94±0.24	0.76±0.16	0.88±0.33	1.03±0.16
	Ser	0.96±0.05^{B}	0.91±0.01^{B}	0.91±0.12^{B}	0.96±0.07^{B}	0.79±0.26^{B}	0.97±0.15^{B}	1.41±0.73^{A}	0.95±0.14^{B}	0.85±0.01^{B}	0.78±0.03^{B}	0.8±0.13^{B}	1.01±0.10^{B}
	Gln	6.97±1.37^{A}	6.26±0.71^{AB}	4.55±0.1^{BCD}	4.63±1.02^{ABCD}	4.45±1.86^{BCD}	4.36±1.07^{BCD}	2.65±2.30^{D}	4.94±2.85^{ABCD}	5.14±0.48^{ABC}	3.05±0.62^{CD}	3.31±0.53^{CD}	3.67±0.93^{CD}
	Gly	8.18±5.28	8.34±5.68	7.6±4.9	6.92±4.47	7.52±5.94	6.69±4.46	8.46±2.45	10.48±3.78	7.81±5.27	6.3±4.36	6.32±3.78	8.9±6.2
	Arg	16.82±1.62^{ABC}	16.5±2.34^{ABC}	13.94±2.00^{ABC}	17.89±1.62^{AB}	11.64±6.87^{BC}	16.67±1.02^{ABC}	10.77±9.33^{C}	10.83±6.39^{C}	17.12±1.82^{ABC}	18.95±1.55^{A}	19.2±0.26^{A}	16.92±2.63^{ABC}
	Ala	2.88±0.17^{ABC}	3.06±0.03^{AB}	2.86±0.49^{ABC}	2.77±0.14^{BC}	2.60±0.35^{CD}	2.70±0.46^{BC}	2.88±0.34^{ABC}	3.26±0.21^{A}	2.75±0.07^{BC}	2.15±0.03^{DE}	2.14±0.28^{E}	2.86±0.06^{ABC}
	Tyr	7.57±0.29^{AB}	7.25±0.53^{B}	9.39±0.54^{AB}	7.70±0.95^{AB}	10.09±3.73^{AB}	8.11±0.67^{AB}	10.57±3.47^{A}	9.62±3.99^{AB}	7.92±0.73^{AB}	9.52±0.31^{AB}	9.24±0.75^{AB}	7.89±0.19^{AB}
	Pro	0.23±0.06^{BC}	0.08±0.14^{CD}	0.00±0.00^{D}	0.22±0.01^{BC}	0.16±0.14^{BCD}	0.29±0.11^{AB}	0.22±0.19^{BC}	0.15±0.13^{BCD}	0.23±0.04^{BC}	0.20±0.01^{BC}	0.22±0.08^{BC}	0.44±0.10^{A}
	Total (mg/g)	13.01±8.49	16.75±15.57	5.05±2.74	19.08±14.68	5.97±4.51	11.27±2.81	6.12±5.15	6.78±5.68	11.35±4.51	14.86±9.75	13.11±3.86	11.29±6.21
Essential-amino acid	His	1.97±0.41	1.88±0.4	1.71±0.07	1.99±0.32	1.35±0.29	1.89±0.39	1.19±1.03	1.24±1.08	1.77±0.21	1.67±0.65	1.79±0.52	1.76±0.39
	Thr	1.42±0.29	1.47±0.34	1.39±0.36	1.62±0.53	1.05±0.27	1.48±0.46	0.87±0.75	0.99±0.86	1.45±0.27	1.23±0.23	1.27±0.4	1.48±0.25
	Val	2.17±0.33	2.17±0.22	2.63±1.15	2.18±0.35	2.51±1.29	2.27±0.64	2.27±0.26	2.3±0.35	2.04±0.24	1.78±0.46	1.95±0.64	2.22±0.23
	Met	2.34±0.18	2.3±0.07	2.53±0.27	2.55±0.16	2.76±1.03	2.5±0.1	2.47±0.1	2.19±0.03	2.39±0.11	2.47±0.43	2.45±0.42	2.5±0.23
	Trp	1.83±0.17^{BC}	1.59±0.32^{BC}	2.88±0.83^{AB}	1.75±0.55^{BC}	3.53±2.57^{A}	2.12±0.22^{ABC}	1.45±1.26^{BC}	1.12±0.97^{C}	2.09±0.28^{ABC}	2.47±0.24^{ABC}	2.35±0.06^{ABC}	2.55±0.31^{ABC}
	Phe	8.44±1.48^{AB}	8.21±1.98^{B}	11.68±0.28^{AB}	8.33±2.63^{B}	13.73±6.88^{AB}	9.14±2.07^{AB}	17.33±12.63^{A}	14.09±9.95^{AB}	8.74±1.71^{AB}	11.05±1.76^{AB}	9.82±1.82^{AB}	8.76±1.14^{AB}
	Ile	2.24±0.22	2.18±0.17	2.66±0.86	2.20±0.19	3.28±2.4	2.34±0.31	2.5±0.37	2.6±0.67	2.24±0.12	2.21±0.58	2.28±0.47	2.32±0.24
	Leu	11.84±0.82	11.6±1.46	15.28±1.68	11.69±1.98	17.23±8.62	12.58±1.14	17.61±7.81	16.52±8.12	11.97±1.29	12.81±0.5	12.09±0.05	12.16±0.58
	Lys	16.64±2.97^{AB}	17.09±3.33^{AB}	10.78±4.50^{AB}	17.54±2.81^{A}	10.92±8.19^{A}	17.26±0.69^{AB}	9.98±8.65^{AB}	9.28±8.04^{B}	16.22±2.96^{AB}	16.83±2.50^{AB}	17.35±0.80^{AB}	15.85±3.23^{AB}
	Total (mg/g)	14.26±10.72	18.95±19.16	5.97±2.67	21.81±17.47	6.63±3.7	13.56±3.61	6.82±5.52	6.41±5.15	12.76±6.45	18.94±14.62	15.74±6.52	13.03±8.9

[1)] Asp, aspartic acid; Glu, glutamic acid; Asn, asparagine; Ser, serine; Gln, glutamine; Gly, glycine; Arg, arginine; Ala, alanine; Tyr, tyrosine; Pro, proline; His, histidine; Thr, threonine; Val, valine; Met, methionine; Trp, tryptophan; Phe, phenylalanine; Ile, isoleucine; Leu, leucine; Lys, lysine.

[2)] Datas are mean±SD of triplicate experiments.

[A-D)] Means in the same row with different letters are significantly different at $P<0.05$.

Thus, the interpretation of the results should not be implied for humans. Thus, additional *in vivo* studies should be conducted.

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국문요약

본 연구는 생후 12개월령의 염소를 사용하여 앞다리, 뒷다리, 등심 및 갈비 부위로 분할하여 *in vitro* 소화실험을 통해 부위별 단백질 가수분해도 및 아미노산 조성을 조사하였다. 이 때, 소고기 및 돼지고기의 분할육을 이용하여 염소고기와 비교, 분석하였다. 염소고기 분할육 중 뒷다리(8.32%) 및 갈비(8.32%)가 가장 높게 단백질 가수분해도가 나타났으며, 염소고기의 갈비 부위는 갈비 분할육 중 가장 높은 단백질 가수분해율을 보였던 돼지고기(8.57%)와 유의차가 없었다 (P>0.05). *In vitro* 소화 전에는 염소고기 분할육 중 등심에서 글리신(11.03%)이, 앞다리에서 글루타민(53.44%)이 다른 고기 종류 및 분할육들에 비해 유의적으로 높은 비율로 포함된 것이 확인되었다(P<0.05). *In vitro* 소화 후에는 염소고기 갈비 부위에서 라이신(17.54%)이 가장 높은 비율로 포함된 것으로 확인되었으며, 소 갈비 부위보다 유의적으로 높았다(P<0.05). 본 연구는 염소고기 분할육의 단백질 가수분해도 및 아미노산 조성을 제공하며 단백질 소화양상 및 생체 이용률을 평가하기 위한 기초 자료로써 활용되어질 수 있을 것으로 사료된다.

Conflict of interests

The authors declare no potential conflict of interest.

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