

# PRERIMINARY INVESTIGATION ON THE BEHAVIOR OF BEEF PATTIES DURING GASTRIC DIGESTION

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**Abstract – In order to clarify physical digestibility of beef patties during human gastric digestion, patties prepared from two beef breeds were subjected to digestion experiments using a human gastric digestion simulator with peristaltic movement. Patties were digested for 180 min in the simulator after cooking and cutting in 5 mm cube. Size distribution of the meat pieces before and after digestion was measured. After the digestion, meat pieces that did not pass through a sieve of the coarsest mesh size (3.35 mm) were left significant amount. Reduction rate of the meat weight of this size fraction (> 3.35 mm) was different between breeds. It was higher in Japanese Black beef than in Angus beef (72.5% and 53.7%, respectively). The difference may be due to variation in content/structure of adipose and collagenous tissues between the two breeds.**

**Key Words – Angus, Japanese Black, patties, digestion**

## I. INTRODUCTION

To digest food into smaller size is an important function of stomach. Peristaltic movement and digestive enzymes are responsible for the physical digestion. When the physical digestion less progresses for some reason, residence time of the food in stomach will be longer and it is said to be a cause of heavy-stomach feeling.

There are some reports on changes of beef during digestion. Impacts of cooking time on enzymatic digestibilities of protein and lipid have been reported [1, 2]. However, reports of the physical digestion, namely, fragmentation of meat are limited.

In this study, the changes in the size distribution after eating beef patties were

investigated by using a human gastric digestion simulator having peristaltic movement [3]. Angus and Japanese Black beef were used as the sample, and the discussion will be made from a view point of their histological differences.

## II. MATERIALS AND METHODS

### *Sample*

Frozen beef samples (lumber longissimus muscle) of Japanese Black (n=2) and Certified Angus (n=2) were obtained from retail market. They thawed the day before digestion experiments. Ground beef were prepared just before the experiment by a grinder with 4-mm hole plate. pH of the ground beef was measured by a semiconducting electrode. The ground beef was shaped into disks of 6-cm diameter and 1-cm thickness with removing void air. Prepared patties were c.a. 25 g.

Patties were cooked both sides with an electric griddle set at 230°C. The cooking was stopped when achieving 55°C at the center of the patties, or reaching 3 minutes of cooking time. The patties allowed cooling at room temperature. When became c.a. 40°C, they were cut with a knife every 5 mm to simulate chewing.

### *Artificial Digestion*

A human gastric digestion simulator with a mimic peristaltic movement [3] was used. 60 g of the cut samples were mixed gently with 30 mL of artificial saliva, and allowed to stand for 2 minutes at 37°C. Simulated saliva was prepared by dissolving 0.117 g/L NaCl, 0.14 g/L KCl, 2.1 g/L NaHCO<sub>3</sub>, and 2.0 g/L  $\alpha$ -amylase (E.C. 3.2.1.1,

02100447, MP Biomedicals, Inc.) in Milli-Q water. The sample was put into the simulator and 50 mL of enzyme containing artificial gastric fluid was added and mixed thoroughly at 0, 10, 30, 60 and 90 min of digestion. Artificial gastric fluid was prepared by dissolving 8.775 g/ L NaCl in Milli-Q water and adjusting to pH 1.3 using 1 N HCl. Pepsin (E.C. 3.4.23.1, P7000 “pepsin from porcine gastric mucosa”, Sigma-Aldrich, Inc. ) and triacylglycerol lipase (E.C. 3.1.1.3, “lipase A”, Amano enzyme) solutions were prepared and added separately to the simulator to prevent lipase from being digested by pepsin before application. The final concentration was 250 unit/mL for pepsin and 60 unit/mL for lipase. For a constant action of the enzymes among experiments, pH of the digestive juice in the simulator was adjusted immediately after the addition of gastric fluid by using aqueous NaOH (1N) and HCl (1N). The gastric fluids and the simulator kept at 37°C. The digestion ended after 180 minutes.

#### *Size distribution of samples*

Before and after the digestion, the size distribution was examined using a set of sieves. Mesh size of the sieves were 3.35, 2.36, 1.18, and 0.60 mm.

#### *Sample Constituent and Histological Analyses*

Basic constituents of the sample ground beef and digested meat of each size fraction were analyzed. Water, fat and protein contents were determined by standard methods [4-6]. Due to limited sample volume, other standard methods were applied for the digested meat [7, 8]. Remaining that obtained by excluding these three constituent from 100% was expressed as ‘others’.

Histological observations were conducted on Sirius-red stained sections of the thawed beef samples of both breeds.

### III. RESULTS AND DISCUSSION

Constituent composition of the ground beef samples (mean value) are shown in Table 1. Significant difference between beef breeds was observed especially in fat content.

Cooked and cut patty samples were subjected to digestion using the gastric digestion simulator with a peristaltic movement [3]. Addition of the artificial gastric fluid (pH 1.3) to the simulator reduced pH of digestive juice. The decline was smaller in Angus than in Japanese Black. It is plausible since protein content was higher in Angus beef (Table 1) and considered to have a higher buffering function. The variation in pH among samples was canceled by adjusting pH.

Size distribution of the sample before and after the digestion is shown in Figure 1. Before the digestion, the total amount of meat trapped by the set of sieves was approximately the same in the both breeds. After 180 minute digestion, the total amount was decreased. Weight of trapped meat was smaller in Japanese Black. Reduction rate of the weight of meat trapped by the coarsest mesh (> 3.35 mm) was larger in Japanese Black compare to Angus (72.5% versus 53.7%). Japanese Black beef is likely to be more susceptible to human gastric digestion.

Figure 2 shows the constituent composition of each size fraction. Except that there was a difference in fat content, no marked difference was observed between the breeds.

Histological images of the both breed beef are shown in Figure 3. Significant differences were observed in adipose (unstained area, in white) and collagenous tissues (reddish purple, forms linear or mesh structure). Japanese Black has more adipose tissue and less developed collagen structure.

Table 1 Properties of the ground beef samples (raw).

	Percentage of major constituents				pH
	Fat	Protein	Water	Others	
Certified Angus	5.0	21.4	70.5	3.1	5.6
Japanese black	36.3	14.0	47.8	2.0	5.6

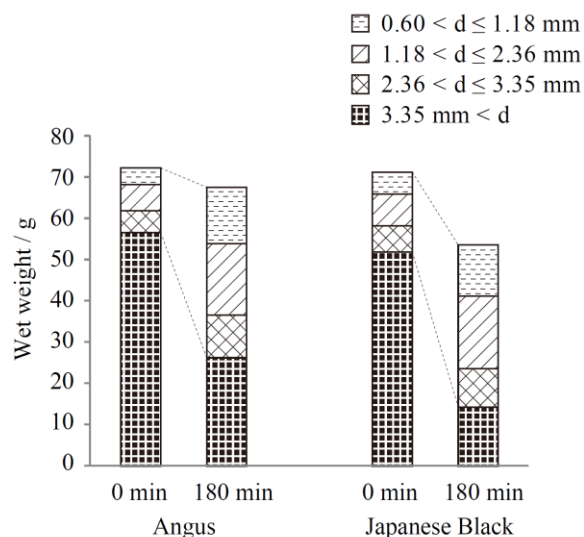


Figure 1. Wet weight in each size fraction before and after the artificial gastric digestion. Mean values of two replications are shown.

Since diffusion rate of large molecules such as digestive enzymes is small, enzymes' permeability to interior of the meat tissue within the experimental period (180 minutes) is highly

limited. Therefore, susceptibility to the peristaltic movement, the destructive mechanical force, is thought to be related to the gastric digestibility of meat. The observed histological differences were considered to be factors relating the fragmentation.

#### IV. CONCLUSION

Using the gastric digestion simulator with a peristaltic movement, difference in the digestibility of patties was observed between beef breeds. The difference was considered to be derived from the variation in the fat and collagen content and distribution of both breeds. It is necessary to continue experiment and add the number of samples for a conclusive result.

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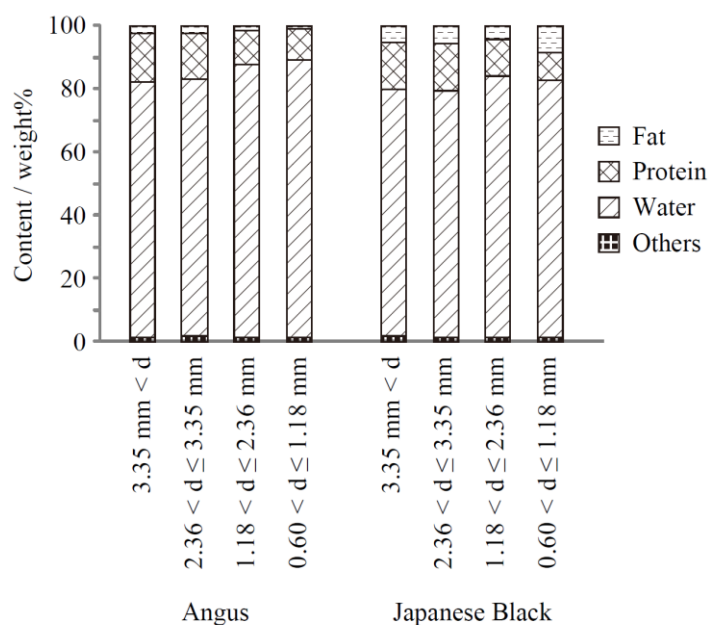


Figure 2. Fat, protein and water contents (weight%) of each size fraction of Angus beef and Japanese Black beef samples after digestion. Mean values of two replications are shown.

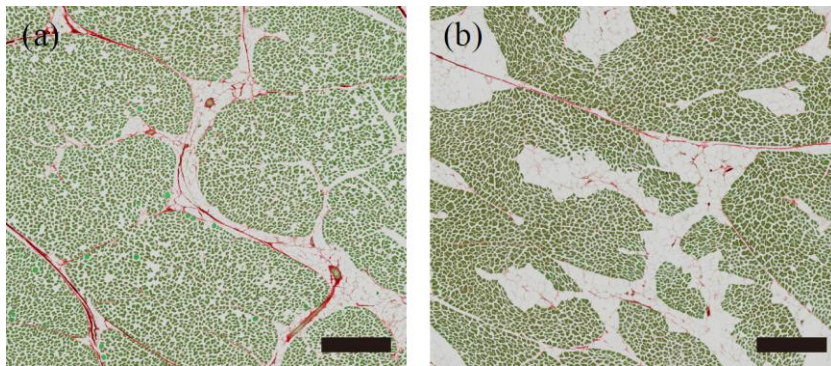


Figure 3. Tissue structure of sample beef. Sirius-red stained. (a) Angus beef, (b) Japanese-Black beef. Bars indicate 1 mm.

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