Palatability and protein components of beef and bone broth

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Introduction

In preparing beef broth, we usually use beef meat, some vegetables and seasonings. Use of cattle bones is not so common for the preparation of beef soup stock. The extract of cattle bones mainly contains gelatin and a small amount of water-soluble substances like organic acids. Migita (1969) has reported that the gelatinization of collagen improves the taste of fish soup stock and Kim et al. (1994) have shown that fish skin gelatin hydrolysates have a brothy and sweet taste. In a pharmaceutical research, it has been reported that low-molecular-weight gelatin reduces the bitter taste of ibuprofen (Kimura, 1992). These results suggest that the addition of cattle bones to boiling broth during the preparation of beef broth must increase gelatin content in it. Our objective is to investigate the effect of the addition of cattle bone on the palatability and protein constituents of the beef broth.

Methods

Cooking procedures. Three kinds of broths, beef meat broth, cattle bone broth, and broth of beef meat and bone (meat-bone broth), were prepared. Fresh beef round meat and beef leg bone were obtained from a commercial source. Beef meat was stored at 0°C for 20 days after exsanguination, followed by storage at -35°C. The bone was stored at -35°C immediately after deboning. Meat and bone were thawed at 5°C for one night. Before cooking, meat was cut to 30 g cube and bone was broken to small pieces. After 30 g of meat had been soaked in 100ml of distilled water for 20 min, it was boiled for 1, 3, and 6 hr, respectively. During boiling, the evaporated water was replenished with boiling distilled water. The broth was filtered through Toyo No.5 filter paper and made up to 100 ml with distilled water (meat broth). Bone broth was prepared in the same way using 60 g of bone in place of meat. Each 30 g of meat and bone were used to prepare the meat-bone broth in the same way. Three samples were made in each broth.

Sensory evaluation procedure. Sensory ratings of the three kinds of broths were evaluated by 9 panelists (ages from 21 to 23) who had previously been trained. The panelists evaluated overall likeness, umami taste, sour taste, body and aftertaste. Overall likeness was evaluated by ranking the degree of preference and significance of the rank sums were analyzed by method of Kramer et al. (1974). Four attribute of broth taste were determined by pretests and were evaluated in different sensory session than overall likeness. Samples were evaluated and analyzed by Scheffé's paired-comparison method (1952) using 5-point scales where +2 was strong taste and -2 was week taste. Each broth was served to panelists at 70°C.

Measurement of Protein concentration. Protein concentration was measured by the method of Lowry et. al. (1951) using bovine serum albumin as a standard.

Tricine-sodium dodecyl sulfate-polyacrylamide gel electrophoresis (Tricine-PAGE). Tricine-PAGE was performed according to the method of Schagger et al. (1987). The soluble proteins samples were prepared in a buffer containing 50 mM Tris-HCl (pH6.8), 4% SDS, 12% glycerol, 2% 2-mercaptoethanol, and 0.002% bromohoenol blue. Fifty ug of each protein sample was applied onto the gel. PAGE was carried out on a slab gel using SDS-Tris-Tricine discontinuous buffer system. Stacking gel was 4%T and 3%C, space gel 10%T and 3%C, and separating gel 16.5%T and 3%C respectively. The approximate molecular weights of proteins were determined using broad range (Bio-Rad) and low range molecular weight standards (Promega).

Results and Discussions

Sensory evaluation. The result of the evaluation of overall likeness showed that among the three broth samples examined, the broth prepared from meat and bone (meat-bone broth) was most preferable ($p<0.01$) and the broth of bone was least preferable ($p<0.05$) (Table 1). Table 2 shows that the meat broth had the highest scores in every attributes. Especially, it had the strongest sour taste and aftertaste. On the other hand, the bone broth had the weakest taste and it seems that the least preference of the bone broth (Table 1) is due to the weakness of taste. The taste of meat-bone broth lies between the scores of meat broth and bone broth. There was no significant difference in Umami taste and body between meat broth and meat-bone broth. These results suggest that the components of the extract of bone soften the strong taste of meat broth and make it mild or gentle.

Table 1. Ranking score of palatability of broths

	Ranking score
meat	19
bone	24*
meat and bone	11**

*p<0.05, **p<0.01

Table 2. Mean sensory scores of three broth samples and the significance

	Broth samples			Contrast		
Attributes	Meat	Bone	Meat-bone	Meat vs. bone	Meat vs. meat-bone	Bone vs. meat-bone
Umami taste	0.667	-0.972	0.306	**	ns	**
Sour taste	0.667	-0.583	-0.083	**	**	*
Body	0.528	-0.750	0.222	**	ns	**
Aftertaste	0.722	-0.694	-0.028	**	*	*

*p<0.05, **p<0.01

Dissolution of proteins from meat and bone to broth. Figure 1 shows the concentration of solubilized proteins in the broths from meat, bone or meat-bone respectively, provided that the concentration of bone broth was shown as half values of actual data when comparing with those of meat broth and meat-bone broth, because the bone broth was prepared from 60 g of bone. The concentration of meat broth after 1 hr boiling was 1.4mg/1 ml and increased gradually with elongating the heating time. This result

was coincident with the results of our previous paper (Tajima et al. 1991). Dissolution of bone proteins during 1 hr boiling was very small, but it increased rapidly with elongating the heating time.

The protein concentrations of the meat-bone broth after heating for 1 hr and 3 hr were approximately coincident with total concentrations of the extracts (broths) of meat and bone. However, the concentration of the meat-bone broth after 6 hr boiling was lower than the total concentration of the two broths. The decrease in the concentration of the extract may be due to the loss of the solubilized proteins during heating and filtration probably because o f the formation of aggregation composed of the solubilized proteins and fat during prolonged heating.

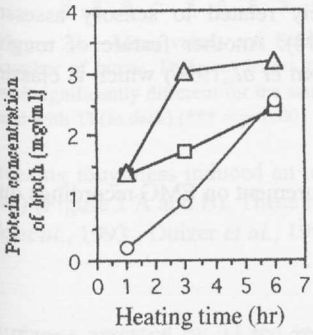

Fig.1 Changes of protein concentration of broth samples.

□ : meat broth, O: bone broth

△ : meat-bone broth

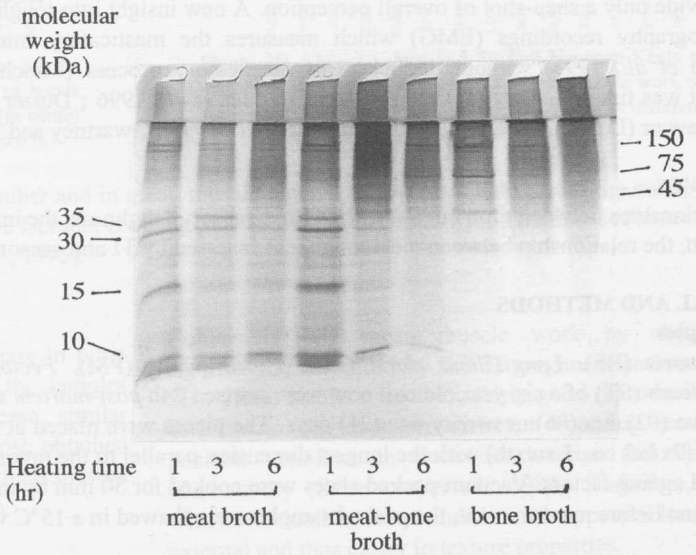

Fig.2 Tricine-PAGE gel patterns of three kinds of broth

Tricine-sodium dodecyl sulfate-polyacrylamide gel electrophoresis (Tricine-PAGE). The tricine-PAGE gel patterns of soluble proteins in the broths prepared from meat, bone and meat-bone were compared (Fig.2). The meat broth heated for 1 hr had several protein bands having lower molecular weights than 35kDa, and those proteins were observed after heating for 6 hr, while gel patterns of bone broth after heating for 1 hr showed several clear bands in the range of 35 kDa-150 kDa. These bands became smeary after heating for 6 hr and many obscure bands were observed in the same molecular weight range. Western blotting by collagen antibody suggested that those bands were originated from collagen. Meat-bone broth heated for 1 hr showed similar patterns to the patterns of meat broth. However, with elongating the heating time, most of those bands became unclear following the appearance of several bands that seemed to be originated from bone. These observations in the gel patterns of meat-bone broth suggest that the extraction of collagen from bones may improve the palatability of the meat-bone broth.

Conclusion

Our results demonstrated that the addition of bone to boiling broth during the preparation of beef broth may improve the palatability of the broth and also soften the strong sour taste and aftertaste of the broth. The tricine-PAGE gel patterns of beef-bone broth after heating for 1 hr revealed that most of the soluble proteins were originated from beef meat. However, after 3 hr heating, many bands were observed because of the occurrence of the solubilized proteins from both of beef and bone. Therefore, 3 hr heating seems to be necessary to extract the gelatin from bone. The molecular weights of gelatin from bone were approximately in the range of 35-150 kDa and these proteins seem to improve the taste of beef broth.

Pertinent literature

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