Chemical Compositions of Pectoral Meat of Japanese Native Chicken, Hinai-jidori, and Broiler of the Same and Marketing Age

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(Received November 20, 1995)

Abstract The meat of Hinai-jidori has generally been appreciated for its delicious taste and which was confirmed by sensory tests. In order to know the factors affecting the deliciousness of poultry meat, water, protein, lipid, ash, amino acids and minerals of the pectoral meat of 8 weeks old Cobb strain broilers and 8 and 18 weeks old Hinai-jidori, were compared. Fatty acid components of Hinai-jidori at 8 and 18 weeks and broilers at 8 weeks of age were also compared. The water, protein, lipid and ash contents were 73.0, 24.5, 0.77 and 1.12%, respectively for Hinai-jidori at 18 weeks of age, and 74.2, 23.8, 0.82 and 1.17%, respectively for broiler at 8 weeks of age. The protein and water contents differed significantly, however, these differences were not considered to have significant effect on the taste difference between the strains. There were also no significant differences in the ash and amino acids contents. There were no differences in the contents of 9 major fatty acids and 5 minerals. Each fatty acid content of Hinai-jidori decreased with advancing age from 8 to 18 weeks, but the pattern of 9 fatty acids was similar to that of broilers at 8 weeks of age. As a conclusion, it was difficult to elucidate the factors providing the difference in the deliciousness of meat between both strains at respective marketing weights based on the contents of water, protein, lipid, ash, amino acids, minerals and 9 fatty acids.

Anim. Sci. Technol. (Jpn.) 67 (6) : 541-548, 1996

Key words : Meat composition, Native-chicken, Hinai-jidori, Broiler, Fatty acid

Introduction

Hinai-dori is one of the 22 Japanese memorial native chickens. Since the memorial native chicken is prohibited to cook to eat, F₁ of Hinai-dori and Rhode Island Red is named as Hinai-jidori and is now commercially available. Hinai-jidori has been appreciated to be palatable and delicious ingredient for a traditional local dish in Akita prefecture, Kiritampo,

and evaluated to be more palatable than broilers by the sensory evaluation in our previous report⁵⁾. There are a few reports on the taste of poultry meat. Therefore, a series of experiments were made to elucidate the factors affecting the deliciousness of poultry meat. There were many reports related to meat compositions of broilers. Leeson and Summers¹⁷⁾ reported that the body lipid content increased drastically from 9.9 to 22.5% of total body

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weight with advancing age from 0 to 10 weeks, while body protein content increased only 1.5% from 14.6 to 16.1%. On the contrary, Fukunaga *et al.*⁸⁾ compared the body composition of native chicken, Satsuma-jidori and modern bred strains (broilers), and reported that there were no significant differences in contents of body moisture, protein and lipids of both the strains. In our previous report³⁾, water, protein and lipid contents of edible fraction of Hinai-jidori, layer pullets and broilers were compared, after all strains were given free access to a commercial diet for broilers containing 23.0% CP and 3,200 kcal ME per kg for 0 to 7 weeks. Though the growth rate of Hinai-jidori was slower than that of broilers⁵⁾, lipid content of edible fraction increased, and the water adversely decreased with advancing age in both strains. However, there was no significant difference in protein contents of edible fraction at the same age. The marketing ages of Hinai-jidori and broilers are about 18 and 8 weeks of age, respectively²²⁾. The body composition of Hinai-jidori at the marketing weight has not yet been reported. The difference of marketing weight may affect the difference in the composition and taste of meat of both strains. Therefore, it is necessary to compare the taste components at the respective marketing ages of both strains meat. In this report, meat components of Hinai-jidori, such as water, protein, lipid, ash and amino acids were compared with those of broiler chickens at marketing weight. Since it is widely believed that fatty acids and minerals are related to meat taste¹⁵⁾, composition of fatty acids and minerals of broilers at 8 weeks were also compared with those of Hinai-jidori at the same age of broilers and at marketing age of 18 weeks.

Materials and Methods

Animals and diets: Eggs of Hinai-jidori produced at Akita Prefectural Experimental Station of Animal Industry and of Cobb strain

broilers purchased from a commercial hatchery (Ishida Egg and Poultry Co. Ltd., Nagaoka) were hatched in an incubator (Zenkeien, Hamamatsu) in our laboratory. All hatched chicks were kept in a battery with electrical heaters for 2 weeks after hatching in a thermo- $(30 \pm 2^\circ\text{C})$ and light-controlled (15 h light from 5 : 00 to 20 : 00) room, housed randomly in 8 pens of 4 female chicks each for the next 2 weeks, and then raised individually in wire cages until the end of feeding period, 8 weeks for broilers and 8 and 18 weeks for Hinai-jidori. They were given free access to the adequate diets developed for each strain^{6,13,18)} and water. At 6 weeks of age, the diets formulated for each strain for 0 to 5 weeks were switched to those for 6 to 10 weeks, respectively, and at 11 weeks diets for Hinai-jidori for 6 to 10 weeks to 11 to 18 weeks of age. The composition of used experimental diets is represented in Table I. The diets for the both strains for respective growing stage were formulated to meet the respective requirements of amino acids, ME and other nutrients of broilers recommended by NRC¹⁹⁾ and those of Hinai-jidori by Muramoto *et al.*¹⁸⁾

Preparation of meat samples for chemical analysis: Breast muscles, *M. pectoralis superficialis*, were taken from 8 female broilers at 8 weeks and Hinai-jidori at 8 and 18 weeks of age with average body weights. The blood veins were removed from muscles with tweezers carefully at $4 \pm 2^\circ\text{C}$, then stored at -20°C until analysis. The meats of Hinai-jidori at 18 weeks and broilers at 8 weeks were used for the determination of water, protein, lipid, ash and amino acids. Minerals and fatty acids in the meat of Hinai-jidori at 8 and 18 weeks were compared with those of broilers at 8 weeks of age.

Chemicals: Chemicals used were analytical grade and commercially available unless otherwise stated. Water was ion-exchanged and glass filtered with Yamato WQ500 (Tokyo). Standard solutions for atomic absorption anal-

Components of Hinai-jidori and Broiler Meats

Table 1. Composition of experimental diets (%)

Age (weeks)	0-5		6-10		11-21
Strain	Hinai-jidori	Broiler	Hinai-jidori	Broiler	Hinai-jidori
Corn grain	64.7	67.1	70.8	77.7	70.8
Wheat bran	5.5	0.0	6.7	0.0	12.1
Soybean meal (CP 44%)	13.3	17.8	8.0	11.6	1.0
Fish meal (CP 62%)	6.6	8.9	4.0	6.5	0.5
Rice bran	5.5	0.0	6.7	0.0	12.1
Soybean oil	1.9	3.4	1.2	1.9	0.6
Amino acids*	0.1	0.5	0.0	0.0	0.2
CaCO ₃	0.0	0.0	0.0	0.0	0.4
Ca ₃ (PO ₄) ₂	1.7	1.7	1.9	1.6	1.6
NaCl	0.3	0.3	0.3	0.3	0.3
Vitamin and mineral	0.4	0.4	0.4	0.4	0.4
Chemical compositions					
CP (%)	17.6	19.8	14.5	16.0	11.2
ME (kcal/kg)	3,004	3,193	3,000	3,200	2,900

*: crystalline lysine, arginine, methionine+cystine and tryptophan were added to meet the requirements of broilers by NRC⁽⁹⁾, and those of Hinai-jidori by Fujimura *et al.*⁽³⁾ and Muramoto *et al.*⁽¹⁸⁾.

ysis grade (Wako Pure Chemical Co., Osaka, and iron: Kanto Chemical Co. Inc., Tokyo) were used for the analysis of minerals.

Analysis of components: The meats were cut with a knife coated with Teflon®, and freeze dried for 55 h. Water contents were calculated from the differences of weights before and after freeze drying. The freeze dried matters were mixed with a needle coated with Teflon®, and used for the analysis of protein, lipid, ash and minerals. Protein was determined by the Kjeldahl method and lipid by the AOAC Soxhlet method⁽¹⁾. For amino acid analysis, about 0.5 g of dried meats were hydrolyzed in 10 vol of 6 N hydrochloride solution *in vacuo* at 110°C for 22 h. The hydrolyzate was filtered through a 0.45µm cellulose nitrate filter (Nihon Millipore Kogyo, Yonezawa), added 5 ml of 5 N NaOH to neutralize pH to 6.0 and filled up to 50 ml. The samples were stored at -80°C in a freezer until analysis. Amino acids in the meat hydrolyzate were analyzed by the method of Ishida *et al.*⁽¹⁰⁾ with a HPLC (LC-10 A system, Shimadzu, Kyoto) using Shim-Pak Amino-Na column

(sodium type, 150×6.0 mm, Shimadzu, Kyoto) with a linear gradient from pH 3.2 with 0.2 N sodium citrate and 7% ethanol to pH 10.0 with 0.6 N sodium citrate, as described by Fujimura *et al.*⁽⁴⁾. The methods of preparation and measurement of minerals were the same as described in a previous report⁽¹⁴⁾. For the analysis of fatty acids, more than 20 g of fresh pectoralis meat was cut off from chicken carcasses with a knife coated with Teflon®. Then hexane was added to the meat and mixed well for 1 h. After saponification by potassium hydroxide and ethanol, and methylated by boric methanol fluoride, the methylated fatty acid fractions were recovered using a separation flask. The fatty acid fractions were dried up and weighed as total fatty acid weights. Then the fractions were filled up to 5 or 10 ml with hexane. After filtrated, fatty acids were analyzed with a Gas Chromatograph (GC-14 A, Shimadzu, Kyoto) using Unisole 3000 column (Uniport C 80/100 glass, 3 m×3 mm, GL Science, Tokyo).

Statistics: For statistical analysis, one-way ANOVA was employed using the General

Linear Models procedure in SAS^{®20}. Significant differences between means were determined according to Duncan's multiple range test²⁾.

Results

The water, protein, lipid and ash contents in the pectoral meat of Hinai-jidori and broiler at respective marketing ages are summarized in Table 2. The water and protein contents of Hinai-jidori were 73.0 and 24.5%, respectively, and 74.2 and 23.8% for broilers, respectively, which were significantly different ($P < 0.05$) in both strains. On the contrary, there were no differences in lipid and ash contents in the meat of both strains.

Amino acids contents of hydrolyzed meat of both strains at the same marketing age are shown in Table 3. Sixteen amino acids were detected. Glutamic acid was determined as Glx, a mixture of glutamic acid and glutamine, after acid hydrolysis. The contents of Glx were found to be 3.30 and 3.21% in Hinai-jidori and broilers, respectively, which comprised 15.6 and 15.8% of the sum of the analyzed amino acids. Of all the amino acids detected, only Glx exceeded 3.0%. Glycine, isoleucine, methionine, phenylalanine, proline, serine, threonine, tyrosine and valine contents were less than 1% in the muscle. In spite of the significant differences of protein content between both strains, no significant differences

were found in amino acid pattern.

Minerals contents of Hinai-jidori at 8 and 18 weeks and broilers at 8 weeks are shown in Table 4. Nine compounds such as potassium, phosphorus, sodium, magnesium, calcium, zinc, iron, copper and manganese were detected. The main compound was potassium, whose content was 4.2, 4.3 and 4.1 mg per g fresh meat of Hinai-jidori at 8 and 18 weeks and broilers at 8 weeks, respectively. These values were about twice of that of phosphorus, and about 14 times of sodium and magnesium. The total amounts of potassium, phosphorus, sodium and magnesium of Hinai-jidori at 8 and 18 weeks and broilers at 8 weeks were 7.2, 7.3 and 6.9 mg per g meat, which shared 99.5, 99.4 and 99.4% of total minerals detected, respectively. The phosphorus and sodium contents of Hinai-jidori at 18 weeks were higher than those of 8-week-old Hinai-jidori and broilers, but the zinc and iron contents of Hinai-jidori at 18 weeks were lower.

The fatty acid compositions of Hinai-jidori at 8 and 18 weeks and broilers at 8 weeks are

Table 2. Water, protein, lipid and ash contents in pectoral meats of Hinai-jidori and broiler chickens at marketing weight (% of wet weight)

Strain Age (week)	Hinai-jidori 18	Broilers 8
Water	73.0 $\pm$ 0.1 ^a	74.2 $\pm$ 0.2 ^b
Protein	24.5 $\pm$ 0.2 ^a	23.8 $\pm$ 0.1 ^b
Lipid	0.77 $\pm$ 0.07	0.82 $\pm$ 0.07
Ash	1.12 $\pm$ 0.03	1.17 $\pm$ 0.02

Values are means $\pm$ SE for 4 chickens, and those in each row with different superscripts^{a, b} are significantly different ($P < 0.05$).

Table 3. Amino acid contents in pectoral meats of Hinai-jidori and broilers (% of wet weight)

Strain Age (week)	Hinai-jidori 18	Broilers 8
Ala	1.32 $\pm$ 0.06	1.22 $\pm$ 0.04
Arg	1.38 $\pm$ 0.07	1.33 $\pm$ 0.03
Asp	2.09 $\pm$ 0.12	2.04 $\pm$ 0.06
Glx	3.30 $\pm$ 0.13	3.21 $\pm$ 0.10
Gly	1.02 $\pm$ 0.03	0.92 $\pm$ 0.03
His	1.11 $\pm$ 0.04	1.08 $\pm$ 0.02
Ile	0.99 $\pm$ 0.10	0.93 $\pm$ 0.02
Leu	1.62 $\pm$ 0.09	1.58 $\pm$ 0.04
Lys	2.70 $\pm$ 0.08	2.57 $\pm$ 0.03
Met	0.64 $\pm$ 0.04	0.63 $\pm$ 0.01
Phe	0.71 $\pm$ 0.04	0.68 $\pm$ 0.01
Pro	1.00 $\pm$ 0.07	0.93 $\pm$ 0.02
Ser	0.86 $\pm$ 0.03	0.83 $\pm$ 0.04
Thr	0.98 $\pm$ 0.04	0.98 $\pm$ 0.05
Tyr	0.72 $\pm$ 0.03	0.70 $\pm$ 0.02
Val	0.71 $\pm$ 0.05	0.68 $\pm$ 0.00

Values are means $\pm$ SE for 3 chickens.

Components of Hinai-jidori and Broiler Meats

Table 4. Mineral and fatty acids in pectoral meats of Hinai-jidori and broilers

Strain Age (week)	Hinai-jidori 8	Hinai-jidori 18	Broilers 8
Minerals ($\mu\text{g/g}$ wet weight)			
Potassium	4261 $\pm$ 37	4173 $\pm$ 41	4141 $\pm$ 22
Phosphorus	2489 $\pm$ 30 ^a	2408 $\pm$ 26 ^a	2261 $\pm$ 14 ^b
Sodium	294 $\pm$ 8 ^b	366 $\pm$ 13 ^a	299 $\pm$ 4 ^b
Magnesium	296 $\pm$ 3	298 $\pm$ 8	281 $\pm$ 3
Calcium	32.6 $\pm$ 1.0	29.8 $\pm$ 0.1	31.3 $\pm$ 0.3
Zinc	4.9 $\pm$ 0.1 ^a	4.4 $\pm$ 0.1 ^b	5.1 $\pm$ 0.1 ^a
Iron	3.6 $\pm$ 0.0 ^b	3.1 $\pm$ 0.1 ^c	4.4 $\pm$ 0.1 ^a
Copper	0.30 $\pm$ 0.02	0.30 $\pm$ 0.02	0.26 $\pm$ 0.02
Manganese	0.11 $\pm$ 0.01 ^a	0.07 $\pm$ 0.01 ^c	0.09 $\pm$ 0.01 ^b
Ratios of fatty acids to total lipids			
Myristic acid (C _{14:0})	0.4 $\pm$ 0.0 ^a	0.3 $\pm$ 0.1 ^b	0.4 $\pm$ 0.1 ^{ab}
Myristoleic acid (C _{14:1})	0.3 $\pm$ 0.0 ^a	0.2 $\pm$ 0.0 ^b	0.3 $\pm$ 0.0 ^a
Palmitic acid (C _{16:0})	11.0 $\pm$ 0.7	8.4 $\pm$ 1.9	11.0 $\pm$ 0.5
Palmitoleic acid (C _{16:1})	5.8 $\pm$ 0.5	4.6 $\pm$ 1.0	6.0 $\pm$ 0.3
Stearic acid (C _{18:0})	3.3 $\pm$ 0.2 ^a	2.3 $\pm$ 0.5 ^b	3.4 $\pm$ 0.1 ^a
Oleic acid (C _{18:1})	17.8 $\pm$ 1.3	13.2 $\pm$ 3.0	18.7 $\pm$ 0.7
Linoleic acid (C _{18:2})	16.9 $\pm$ 1.0 ^a	10.7 $\pm$ 2.6 ^b	16.8 $\pm$ 0.4 ^a
Linolenic acid (C _{18:3})	5.0 $\pm$ 0.3 ^a	3.0 $\pm$ 0.7 ^b	5.5 $\pm$ 0.1 ^a
Arachidonic acid (C _{20:4})	0.8 $\pm$ 0.3	0.3 $\pm$ 0.1	0.6 $\pm$ 0.0

Values are means $\pm$ SE for 3 chickens, and those in each rows with different superscripts^{a-c} are significantly different ($P < 0.05$).

shown in Table 4. Nine fatty acids; myristic, myristoleic, palmitic, palmitoleic, stearic, oleic, linoleic, linolenic and arachidonic acids were detected. Palmitic, oleic and linoleic acids were major ones, and each of them exceeded 10% of total lipids. Sum of the major fatty acids in Hinai-jidori at 8 and 18 weeks and broilers at 8 weeks shared 74.6, 75.1 and 74.2% of total fatty acids, respectively. Sum of unsaturated fatty acid contents of Hinai-jidori at 8 and 18 weeks and broilers at 8 weeks shared 76.0, 74.4 and 76.4% of total fatty acids, respectively. While, the amount of the identified 9 fatty acids in Hinai-jidori and broilers at 8 weeks shared 61.4 and 62.6% of total lipid content. That of Hinai-jidori at 18 weeks was 43.0% of total lipid contents, which was lower than that of Hinai-jidori and broilers at 8 weeks. However, there were no significant differences in the proportion of each fatty acid

to the total 9 fatty acids of the meat of the both strains.

Discussions

The water, protein and lipid contents obtained in this study were similar to those of Fukunaga *et al.*⁸⁾ In their study on 3 chicken strains, they found that there were no significant differences in the contents of these 3 components among the strains. In this study, though there were significant differences in water and protein contents between Hinai-jidori and broilers, these differences seems to be too small to distinguish the difference in the taste by sensory test. Lipid and ash contents of meat were not significantly different between Hinai-jidori and broilers. The lipid contents of broilers obtained in this study were lower than those in the Standard Tables of Food Composition in Japan²¹⁾, where

the edible fraction including subcutaneous fat was used for the analysis. However, in this study, fat pad was removed from the meat before analysis. This might be one of the reasons why the lipid contents of meat were lower than those of edible fraction and whole body. Leeson and Summers¹⁷⁾ reported that the body lipids increased with advancing age. However, there were no significant difference in lipid content between Hinai-jidori of 18 weeks and broilers of 8 weeks. The results suggested that the increases of lipid contents of edible fraction and whole body were affected by the contents of lipid accumulated in parts other than muscle. The increase of lipid content in the edible fraction and whole body with advancing age was considered to be the results of the increase of the accumulated subcutaneous fat.

Fatty acid is widely believed to relate with the taste, odor and flavor characters such as mildness, continuity, complexity and fullness, etc.¹⁶⁾. However, the 9 fatty acids identified in this study may not be related with the difference in chicken meat taste of both strains, because there was no appreciable difference in the patterns of 9 fatty acids. It may be possible that other fatty acids not detected in this study relate the taste of Hinai-jidori. However, the effect of other fatty acids is small, if any, because chicken meat taste is almost completely changed by the mixture of amino acids, ATP metabolites and minerals without fatty acids in the previous report⁷⁾. According to Standard Tables of Food Compositions in Japan²¹⁾, chicken meat contains 2.4 g lipid per 100 g meat, which is lower than pork and beef, whose lipid contents are 30.8 and 16.3 g lipid per 100 g meat, respectively. Low lipid content is one of the characteristics of chicken meat. Therefore, the effect of fatty acids and lipid on the taste of chicken meat is considered to be lesser than those of other livestock meat. In any way, the present results indicated that it is difficult to explain the difference in the taste between the

strains by the difference in the contents of lipid and in fatty acid compositions.

Potassium ion has been recognized to be one of the taste-active components in chicken meat⁷⁾ and seafood^{9,16)}. Potassium content was not significantly different between the strains in the present study. This indicated that potassium content may not be a major factor in increasing the palatability of Hinai-jidori meat. Sodium ion has also been reported to be taste-active in seafood^{9,16)}. However, it has not been recognized as a taste-active component in chicken meat extract. From the Standard Tables of Food Composition in Japan²¹⁾, sodium contents in meat of scallop and crab are 2.0 and 2.7 mg per g meats, respectively. The sodium content of meat of Hinai-jidori was 0.37 mg per g, which was only about 18.5% that of scallops. The content is considered to be lower than the threshold value¹²⁾.

There were no significant differences in each amino acid content of Hinai-jidori and broilers. The values except methionine and cystine were similar to those of the Standard Tables of Food Composition in Japan²¹⁾. In acid hydrolysis, sulfur containing amino acid and Trp are not measurable⁴⁾. For the determination of sulfur amino acid the protein sample is treated with performic acid, and for Trp, the sample is hydrolyzed with alkaline solution. Since sulfur containing amino acid and Trp were not measured exactly, the amounts of amino acids were less than protein contents. Free glutamic acid was recognized as one of the taste-active components in chicken meat^{7,11)}. However, no difference was found in Glx contents in meat hydrolyzate of both strains.

Unfortunately, as described above, the difference of the taste between Hinai-jidori and broiler meats at marketing age could not be explained by the differences in the compositions and levels of water, protein, lipid, ash, major 16 amino acids, 9 minerals and 9 fatty acids. Typical differences were not found in

the above components. Therefore, the components analyzed in the present study were not considered to be a reliable indicator for detecting taste difference between the strains. Therefore, other parameters related to the taste such as ATP metabolites have to be analyzed to clarify the differences between the strains. We reported previously that IMP, free Glu and K^+ were taste-active components in the chicken meat extract⁷⁾, and there was a difference in the IMP contents in meat extract of both strains⁵⁾. From the sensory test, it has been suggested that the synergistic effect of IMP and free Glu give rise to the deliciousness of meat of Hinai-jidori⁵⁾. Therefore, the difference in the taste of meat between Hinai-jidori and broilers is considered to be due to the difference in the total of the meat extract. Present results suggested the importance of other taste relating components, especially of Glu and IMP, in enhancing the taste of Hinai-jidori meat.

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同週齢あるいは出荷週齢時における比内地鶏とブロイラーの胸肉の 水分、タンパク質、脂質、灰分、アミノ酸、無機質 および脂肪酸の比較

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比内地鶏は、古くから美味しい鶏とされてきた。そして官能試験によってもその味がブロイラー肉に有意に優ることが確認された。そこで本研究においては比内地鶏肉の味に影響する成分を明らかにするために、肉の一般成分つまり水分、タンパク質、脂質、灰分を分析するとともに、アミノ酸、無機質、脂肪酸に注目し、出荷適期の鶏種間での比較検討を行った。供試鶏は、8週齢のブロイラーとそれと同週齢ならびに出荷適期の18週齢比内地鶏とし、それぞれの栄養要求量に則した配合飼料を給与して育成した。成分分析には浅胸筋を供試した。その結果、出荷期の週齢の比内地鶏肉はブロイラーに比較して水分含量が1.2%少なく、タンパク質含量が0.7%多かった。脂質、灰分には差は認められなかった。アミノ酸組成にも差は認められなかった。無機質においては、リン、マグネシウムはブロイラーよりも比内地鶏肉が多かったが、前報においてカリウムイオンが呈味有効成分と認められたが、カリウム含量に鶏種間差は見られなかった。脂肪酸は9成分を検出したが、両種とも8週齢時において差は認められなかった。18週齢の比内地鶏においてはリノール酸、リノレイン酸、ミリスチン酸、ミリストレイン酸、ステアリン酸に差が見られたものの、加齢によって各脂肪酸バランスの変動は見られず、8から18週齢にかけて比内地鶏に特異的な脂肪酸は認められなかった。これらの成分の差の有無や差の程度を検討したところ、上記の分析した成分の中で比内地鶏とブロイラー肉の味の差に明確に影響する成分は特定されなかった。

日畜会報, 67 (6) : 541-548, 1996

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