Evaluation of the meat from Hinai-jidori chickens and broilers: Analysis of general biochemical components, free amino acids, inosine 5′-monophosphate, and fatty acids

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Primary Audience: Researchers, Producers, Consumers

SUMMARY

The Hinai-dori is a breed of chicken native to the Akita Prefecture in northern Honshu, Japan. A cross between the Hinai-dori and Rhode Island Red breeds has been commercialized as the Hinai-jidori chicken, and is one of the most popular brands in Japan. The meat of the Hinai-jidori chicken is considered much more palatable than that of typical broilers. To identify the candidate substances influencing the palatability of chicken meat, quantitative analyses were performed on the general biochemical components, free amino acids, inosine 5′-monophosphate (IMP), and fatty acids in the thigh meat of Hinai-jidori and broiler chickens. Hinai-jidori chickens and broilers were fed the same diet for 8 and 22 wk and were reared under the same conditions. The levels of free amino acids and glutamic acid in the meat of 8-wk-old broilers were significantly higher than those of 22-wk-old Hinai-jidori chickens. In addition, the IMP levels in 22-wk-old Hinai-jidori chickens were significantly higher than those of 8-wk-old broilers, whereas no significant difference in IMP levels was observed between 22-wk-old Hinai-jidori chickens and broilers. These data suggest that IMP content reflects a difference in the ages (weeks) of the chickens rather than a difference between the strains. However, a significant difference in arachidonic acid content was observed between Hinai-jidori chickens and broilers, suggesting that the high arachidonic acid content is a characteristic feature of Hinai-jidori chicken meat. Further studies are needed to elucidate the relationship between arachidonic acid content and the palatability of Hinai-jidori chicken meat.

Key words: arachidonic acid, free amino acid, glutamic acid, Hinai-jidori chicken, inosine 5′-monophosphate

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DESCRIPTION OF PROBLEM

Globally, chicken meat is obtained from a few fast-growing broiler strains, which are provided by commercial breeding companies that use intensive fattening systems to ensure high yields of meat. Some Japanese consumers are willing to pay a high retail price for better qual-

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ity chicken meat, known as "Jidori" chicken in Japanese. Because such birds require a relatively long grow-out time, the production cost increases considerably, and the retail price of these chickens can be up to 2 to 5 times more than that of broilers. In Japan, most of the high-quality chickens were initially bred by crossing native Japanese breeds with highly selected lines that showed a rapid growth rate or relatively high egg production. The Hinai-jidori chicken, a cross between Hinai-dori (a chicken breed native to the Akita Prefecture of Japan) sires and Rhode Island Red dams, is a popular brand of Jidori chicken in Japan.

Several studies have been conducted to investigate factors affecting the palatability of chicken meat. The texture of the meat is an important factor because most consumers in Japan believe that a tough texture is characteristic of Jidori meat [1]. Other key factors are the presence of free amino acids (**FAA**), such as glutamic acid, and purine compounds, such as inosine 5′-monophosphate (**IMP**). Nishimura et al. [2] analyzed the chemical components in meat and suggested that FAA are responsible for improving the taste of meat during storage. Studies performed in the past 2 decades have compared the contents of FAA, including glutamic acid, and IMP in Jidori and broiler meat. Karasawa et al. [3] reported that glutamic acid content and total FAA content in thigh meat obtained from 3 types of Jidori chickens were significantly higher than those in thigh meat from broilers, whereas subsequent studies have reported no significant differences in FAA content between Jidori chickens and broilers [4–6]. Moreover, Matsuishi et al. [1] reported that soup prepared with broiler meat had a significantly higher FAA content than that prepared with meat from a Jidori breed, and that the broiler chicken soup tended to be more delicious than Jidori chicken soup. Fujimura et al. [5] reported that IMP content of meat from Hinai-jidori chickens was significantly higher than IMP content of broiler meat, whereas other studies have not revealed a significant difference in IMP content between Jidori and broiler chicken meat [3, 4]. Taken together, these studies suggest that the FAA, glutamic acid, and IMP contents are correlated with the palatability of chicken meat; however, whether the differences in FAA, glutamic acid, and IMP contents are actually correlated with the palatability of Jidori chicken has not yet been elucidated. In addition, the experimental design in most of these studies has not considered the influence of environmental factors. For example, Matsuishi et al. [1], Fukunaga et al. [4], and Fujimura [5] compared the palatability of broiler and Jidori chicken meat without controlling for the fattening period and feed content between the 2 strains, whereas Karasawa et al. [3] compared the palatability of meat from broilers and Jidori chickens that were fed the same diet for the same duration.

Reflecting on past studies, we conclude that to determine the palatability of chicken meat, it is necessary to define candidate substances related to differences between broilers and Jidori chickens in characteristics of the meat. The objective of the present study was to compare meat quality traits of Hinai-jidori chickens with those of broilers to confirm whether Hinai-jidori chickens have developed unique quality characteristics. In the present study, broilers and Hinai-jidori chickens were reared with a focus on the effects of environmental factors.

MATERIALS AND METHODS

Raw Materials

Hinai-jidori chickens were reared in the Livestock Experiment Station of the Akita Prefectural Agriculture Forestry and Fisheries Research Center. Broilers were obtained from a local trading company [7]. The Hinai-jidori and broiler chickens hatched on the same day in the same incubator. Thirty-six female individuals (18 Hinai-jidori chickens and 18 broilers) were reared under identical environmental conditions in the same open-sided poultry shed, with chickens having access to a grass paddock and being fed the same diet. The commercial diet for first-stage grower chicks up to the first 2 wk of age contained 22% CP and had an ME content of 3,050 kcal/kg, whereas the diet for second-stage grower chicks, aged between 3 and 22 wk, contained 17% CP and had an ME content of 3,250 kcal/kg. Feed and water were provided ad libitum. The experimental animals were divided into groups of 1) 8-wk-old broilers, 2) 22-wk-old broilers, and 3) 22-wk-old Hinai-jidori chickens because broiler chickens and Hinai-jidori chickens are generally slaughtered at 8, 22, and 22 wk of age, respectively, in Japan.

Five chickens from each group were randomly selected, fasted for 18 h, weighed, and slaughtered. The chickens were bled and plucked, and their carcasses were manually eviscerated and washed, immediately cooled in ice-cold water until the temperature reached 8°C, and then removed from the water and allowed to drain for 30 min. The carcasses were dissected, the thigh meat was deboned after removing the skin, and the meat was immediately minced using a domestic meat chopper. Subsequently, the meat samples were stored at −30°C until further analysis.

General Biochemical Components of Meat

Moisture content of the meat samples was determined by oven-drying at 135°C for 2 h. Crude protein content was determined using an automatic Kjeldahl nitrogen determination system [8]. Crude fat content was determined by the ether extraction method using an automated analyzer [9].

IMP Content and FAA Content of Meat

To measure IMP content, 5 g of meat was homogenized with 15 mL of distilled water for 2 min. The homogenate was centrifuged at 10,000 × *g* at 4°C for 20 min, and the supernatant was filtered through a 0.45-μm membrane filter. The filtrate was analyzed by HPLC [10].

To measure FAA content, 5 g of meat was homogenized with 22.5 mL of 0.1% 2-mercaptoethanol and 3 mL of 50% (wt/vol) trichloroacetic acid. The homogenates were allowed to stand for more than 3 h and then centrifuged at 10,000 × *g* for 20 min at 4°C. The supernatant was recovered and filtered through filter paper [11]. The pH of the filtrate was adjusted to 2.3, and the FAA in the meat samples were analyzed using an amino acid analyzer [12].

Fatty Acid Composition of Meat

To determine the fatty acid composition, lipids were extracted from approximately 3 g of each meat sample by using 80 mL of chloroform:methanol (2:1, vol/vol) according to the method of Folch et al. [13]; the lipids thus obtained were methylated with a 20% boron trifluoride-methanol complex in methanolic solution [14]. The fatty acid methyl esters were quantified by gas chromatography [15] using the protocol described by Rikimaru et al. [16], and chromatograms were recorded using a computing integrator [17]. The fatty acids were identified by comparing the relative retention times of the fatty acid methyl esters with those standards, and the relative proportions of these esters were determined in terms of percentages of the total peak areas.

Statistical Analyses

All the statistical analyses were performed using Excel-Statistics 2006 software [18]. Comparisons among the treatment means were assessed by performing Tukey's, Bonferroni's, and Scheffé's multiple-comparison tests using the software. Differences between the groups were considered significant when the *P*-values were less than 0.05 in all the multiple-comparison tests.

RESULTS

General Biochemical Components of Meat

Moisture, CP, and crude fat contents of the thigh meat samples from the 3 test groups are shown in Table 1. Moisture content in 8-wk-old broilers was significantly higher than that in 22-wk-old broilers and 22-wk-old Hinai-jidori chickens. Crude protein content in 22-wk-old Hinai-jidori chickens was significantly higher than that in 8- and 22-wk-old broilers. Crude fat content in 22-wk-old broilers was significantly higher than that in 8-wk-old broilers and 22-wk-old Hinai-jidori chickens.

IMP Content and FAA Content of Meat

Free amino acid and IMP contents in the meat samples are shown in Table 2. Total FAA content in 8-wk-old broilers was significantly higher than that in 22-wk-old broilers and 22-wk-old Hinai-jidori chickens. Among the amino acids detected, the contents of serine, glutamine, proline, valine, methionine, isoleucine, leucine, tyrosine, phenylalanine, and arginine in 8-wk-old broilers were significantly higher than the

Table 1. Mean values and SD for BW and general components (moisture, CP, and crude fat) in the thigh meat of broilers and Hinai-jidori chickens

Strain	Broilers	Broilers	Hinai-jidori chickens
Age, wk	8	22	22
n	5	5	5
BW, g	2,632.4 ± 251.9^{b}	5,778.0 ± 491.7^{a}	2,188.0 ± 119.0^{c}
Moisture, g/100 g	74.1 ± 1.3^{a}	70.8 ± 1.6^{b}	71.3 ± 0.3^{b}
CP, g/100 g	19.4 ± 0.4^{b}	19.8 ± 0.9^{b}	21.0 ± 0.4^{a}
Crude fat, g/100 g	5.5 ± 1.2^{b}	8.5 ± 1.8^{a}	6.3 ± 0.5^{b}

$^{a-c}$Within a row, means without a common superscript are significantly different ($P < 0.05$).

corresponding values in 22-wk-old broilers and 22-wk-old Hinai-jidori chickens. In addition, the contents of asparagine, glycine, and alanine in 8-wk-old broilers were significantly higher than the corresponding values in 22-wk-old Hinai-jidori chickens. No significant differences were observed in the concentrations of asparagine, glycine, and alanine between 8- and 22-wk-old broilers and between 22-wk-old broilers and 22-wk-old Hinai-jidori chickens. Glutamic acid content was highest in 8-wk-old broilers and lowest in 22-wk-old broilers. Inosine 5′-monophosphate content in 22-wk-old Hinai-jidori chickens was significantly higher than that in 8-wk-old broilers, whereas there were no significant differences in IMP content between 8- and 22-wk-old broilers and between 22-wk-old broilers and 22-wk-old Hinai-jidori chickens.

Fatty Acid Composition of Meat

Fatty acid compositions of the meat samples are shown in Table 3. Contents of arachidonic acid (**ARA**) and docosahexaenoic acid in 22-wk-old Hinai-jidori chickens were significantly higher than the corresponding values in 8- and 22-wk-old broilers. However, α-linolenic acid content in 22-wk-old Hinai-jidori chickens was significantly lower than that in 8- and 22-wk-old broilers. Myristic acid content in 22-wk-old broilers was significantly higher than that in 8-wk-old broilers and 22-wk-old Hinai-jidori chickens, whereas palmitoleic acid content in 8-wk-old broilers was significantly higher than that in 22-wk-old broilers and 22-wk-old Hinai-jidori chickens. Heptadecanoic acid content in 22-wk-old broilers was significantly higher than that in 8-wk-old broilers; however, there were no significant differences in heptadecanoic acid content between 8-wk-old broilers and 22-wk-old Hinai-jidori chickens or between 22-wk-old broilers and 22-wk-old Hinai-jidori chickens. Eicosatrienoic acid content in 8-wk-old broilers was significantly higher than the corresponding value in 22-wk-old Hinai-jidori chickens; however, there were no significant differences in eicosatrienoic acid content between 8- and 22-wk-old broilers or between 22-wk-old broilers and 22-wk-old Hinai-jidori chickens.

DISCUSSION

Typically, as an animal ages, the composition of the body and muscle changes, with protein and fat content increasing and moisture content decreasing [19]. Fanatico et al. [20] reported that CP content in meat from a slow-growing chicken strain was higher than in meat from a fast-growing chicken strain. In the present study, the moisture content of meat samples from 8-wk-old broilers was higher than in meat samples from 22-wk-old broilers, the crude fat content in 22-wk-old broilers was higher than that in 8-wk-old broilers, and the CP content in 22-wk-old Hinai-jidori chickens was higher than that in 8-wk-old broilers. The changes in levels of these variables may be related to age.

Unlike in the United States, Japanese consumers eat less breast meat than thigh meat. The market price of breast meat is lower than that of thigh meat, and the demand for breast meat is low [21]. Contents of FAA, glutamic acid, and IMP are thought to be correlated with the palatability of chicken meat [1–3]; however, the contents of FAA and glutamic acid in breast meat are higher than those in thigh meat [3, 22] and the IMP content of breast meat is higher than that in thigh meat [3, 23, 25]. In the pres-

Table 2. Mean values and SD for contents of free amino acids and inosine 5'-monophosphate in the thigh meat of broilers and Hinai-jidori chickens

Item	Broilers	Broilers	Hinai-jidori chickens
Age, wk	8	22	22
n	5	5	5
Free amino acid, mg/100 g			
Aspartic acid	27.6 ± 5.3	26.4 ± 6.8	22.6 ± 1.5
Threonine	11.0 ± 2.6	8.6 ± 1.7	7.8 ± 1.9
Serine	31.2 ± 9.6[a]	20.0 ± 1.2[b]	18.0 ± 2.1[b]
Asparagine	8.2 ± 1.8[a]	6.2 ± 1.3[ab]	5.0 ± 0.7[b]
Glutamic acid	38.8 ± 4.9[a]	23.6 ± 5.0[c]	31.2 ± 1.3[b]
Glutamine	92.0 ± 20.0[a]	66.4 ± 5.5[b]	57.4 ± 6.7[b]
Proline	6.2 ± 1.9[a]	4.0 ± 0.0[b]	3.4 ± 0.5[b]
Glycine	22.2 ± 6.0[a]	18.2 ± 2.3[ab]	13.8 ± 2.3[b]
Alanine	35.2 ± 9.9[a]	27.6 ± 3.3[ab]	22.0 ± 1.9[b]
Valine	6.4 ± 1.7[a]	4.2 ± 0.4[b]	4.2 ± 0.4[b]
Cysteine	—[1]	—	—
Methionine	3.6 ± 0.9[a]	2.0 ± 0.0[b]	2.0 ± 0.0[b]
Isoleucine	4.4 ± 1.1[a]	2.4 ± 0.5[b]	2.0 ± 0.0[b]
Leucine	9.0 ± 2.1[a]	4.6 ± 0.5[b]	4.4 ± 0.5[b]
Tyrosine	5.6 ± 1.1[a]	2.6 ± 0.5[b]	3.8 ± 0.4[b]
Phenylalanine	4.4 ± 1.1[a]	2.6 ± 0.5[b]	2.2 ± 0.4[b]
Histidine	5.8 ± 1.1	5.4 ± 0.5	4.6 ± 0.5
Lysine	18.0 ± 7.7	11.0 ± 1.0	10.4 ± 1.1
Tryptophan	—	—	—
Arginine	12.2 ± 5.7[a]	6.8 ± 1.5[b]	5.8 ± 0.8[b]
Total free amino acids, mg/100 g	341.8 ± 66.3[a]	242.6 ± 16.6[b]	220.6 ± 13.0[b]
Inosine 5'-monophospate, mg/100 g	131.2 ± 19.8[b]	143.6 ± 9.5[ab]	156.6 ± 8.4[a]

[a–c]Within a row, means without a common superscript are significantly different ($P < 0.05$).

[1]A dash (—) indicates below measurable limits.

ent study, the meat quality traits of thigh meat were analyzed because 1) thigh meat is undeniably preferred over breast meat in Japan, and 2) a key substance corresponding to the preference of Japanese consumers may be predominant in thigh meat.

Davidek and Khan [23] and Chow and Jacobson [24] reported that IMP content in chicken meat increases as the age of the chicken increases, and we observed a similar tendency in the IMP content of broiler meat. This is the first report showing a significant difference in IMP content between Hinai-jidori chickens and broilers at marketing age, although Fujimura et al. [5] reported that IMP content was significantly higher in the meat of 8-wk-old Hinai-jidori chickens than in the meat of 8-wk-old broilers. The difference in IMP content between Hinai-jidori chickens and broilers at marketing age may simply reflect the age of the bird because there were no significant differences in IMP content between 22-wk-old Hinai-jidori chickens and 22-wk-old broilers.

In contrast to IMP and FAA contents, ARA content in thigh meat is higher than that in the breast meat, and it decreases linearly with increasing weight of the chickens [26]. In the present study, we found that ARA content of 22-wk-old Hinai-jidori chickens was significantly higher than that of 8- and 22-wk-old broilers. Our data suggest that ARA content in Hinai-jidori chicken meat is significantly higher than that in broiler meat, and this is the first study to identify ARA content as a characteristic feature of meat from Hinai-jidori chickens. Fujimura et al. [6] observed no significant differences in contents of 9 major fatty acids, including ARA, between 8-wk-old broilers and 8- and 18-wk-old Hinai-jidori chickens. Dietary fatty acids, including ARA, may directly affect the fatty acid profile of the meat. In the study by Fujimura et al. [6], broilers were fed a diet containing 6.5% fishmeal from 6 to 8 wk of age, whereas Hinai-jidori chickens were fed diets containing 4.0% fishmeal from 6 to 10 wk of age and a diet containing 0.5% fishmeal from 11 to 18 wk of

Table 3. Mean values and SD for fatty acid composition of the thigh meat of broilers and Hinai-jidori chickens

Item	Broilers	Broilers	Hinai-jidori chickens
Age, wk	8	22	22
n	5	5	5
Fatty acid, % of total analyzed fatty acids			
Myristic acid (C14:0)	0.68 ± 0.04^b	0.90 ± 0.07^a	0.72 ± 0.04^b
Myristoleic acid[1] (C14:1)	0.08 ± 0.08	—[2]	—
Palmitic acid (C16:0)	21.56 ± 0.80	21.46 ± 0.74	20.68 ± 0.83
Palmitoleic acid (C16:1)	4.14 ± 0.54^a	2.80 ± 0.07^b	3.02 ± 0.43^b
Heptadecanoic acid (C17:0)	0.14 ± 0.05^b	0.24 ± 0.05^a	0.20 ± 0.00^{ab}
Heptadecenoic acid[1] (C17:1)	—	0.16 ± 0.05	0.06 ± 0.09
Stearic acid (C18:0)	7.12 ± 0.53	7.52 ± 0.34	7.80 ± 0.66
Oleic acid (C18:1)	43.26 ± 1.32	43.24 ± 0.77	43.72 ± 1.11
Linoleic acid (C18:2)	17.06 ± 1.56	18.06 ± 0.59	17.48 ± 1.23
α-Linolenic acid (C18:3)	1.16 ± 0.15^a	1.26 ± 0.13^a	0.94 ± 0.05^b
Eicosenoic acid (C20:1)	0.40 ± 0.00	0.32 ± 0.04	0.42 ± 0.04
Eicosadienoic acid (C20:2)	0.26 ± 0.05	0.20 ± 0.00	0.20 ± 0.00
Eicosatrienoic acid (C20:3)	0.26 ± 0.05^a	0.18 ± 0.04^{ab}	0.16 ± 0.05^b
Arachidonic acid (C20:4)	1.42 ± 0.27^b	1.26 ± 0.33^b	1.92 ± 0.04^a
Docosatetraenoic acid (C22:4)	0.32 ± 0.04	0.24 ± 0.05	0.30 ± 0.00
Docosapentaenoic acid[1] (C22:5n-6)	0.24 ± 0.05	0.02 ± 0.04	—
Docosapentaenoic acid[1] (C22:5n-3)	—	0.12 ± 0.11	0.20 ± 0.00
Docosahexaenoic acid (C22:6)	0.20 ± 0.07^b	0.24 ± 0.11^{ab}	0.38 ± 0.04^a
Unidentified fatty acids	1.70 ± 0.20	1.78 ± 0.24	1.80 ± 0.12

[a, b]Within a row, means without a common superscript are significantly different ($P < 0.05$).

[1]Differences among means were not analyzed because the data were not suitable for multiple-comparison tests.

[2]A dash (—) indicates below measurable limits.

age. In the present study, Hinai-jidori chickens and broilers were fed the same grain-based diet throughout the experimental period. Thus, we suggest that ARA in meat is biosynthesized from linoleic acid in the grain and that the difference in ARA content between Hinai-jidori chickens and broilers reflects a difference between the strains. Further studies are needed to clarify the reason for the difference in ARA content between Hinai-jidori chickens and broilers.

Because ARA content was identified as a characteristic feature of Hinai-jidori chicken meat, ARA may be related to the palatability of the meat. A patent report showed that slightly autoxidized ARA has a flavor similar to the flavor of cooked chicken meat [27], and recent studies have proposed relationships between the levels of polyunsaturated fatty acids, including ARA, and the palatability of food [28, 29]. In short, when foods such as fried potatoes, Chinese noodle soup, and Salisbury steak were cooked in vegetable oil containing ARA, the palatability index of the foods increased. These findings suggest that ARA may be associated with both the flavor and the palatability of chicken. However, further studies are warranted to elucidate the relationship between ARA content and the palatability of Hinai-jidori chicken meat.

CONCLUSIONS AND APPLICATIONS

1. This is the first report showing that a high ARA content is a characteristic feature of Hinai-jidori chicken thigh meat.
2. Further research is needed to better understand the relationship between ARA content and the palatability of Hinai-jidori chicken meat.

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