# 10 畜肉熟成與水產品的美味形成

1. Taste components and conditioning of beef, pork and chicken
2. Taste-active Components of Seafoods with special reference to umami substances





# 15

# Taste Components and Conditioning of Beef, Pork, and Chicken

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| | | |
|---|---|---|
| 熟成之前： | 牛肉屠宰後 4℃貯藏 | 4 日 |
| | 豬肉 | 1 日 |
| | 雞肉 | 0 日 |

## C. Preparation of the Heated Soup

An equal weight of water was added to the minced meat, and the preparation was homogenized. The homogenate was heated in boiling water for 20 min and then subjected to centrifugation to obtain the meat soup.

## D. Preparation of the Synthetic Soup

The synthetic soup was prepared on the basis of the analytical data. The NaCl concentration and the pH of each soup were adjusted to 0.508% and 5.8, respectively.

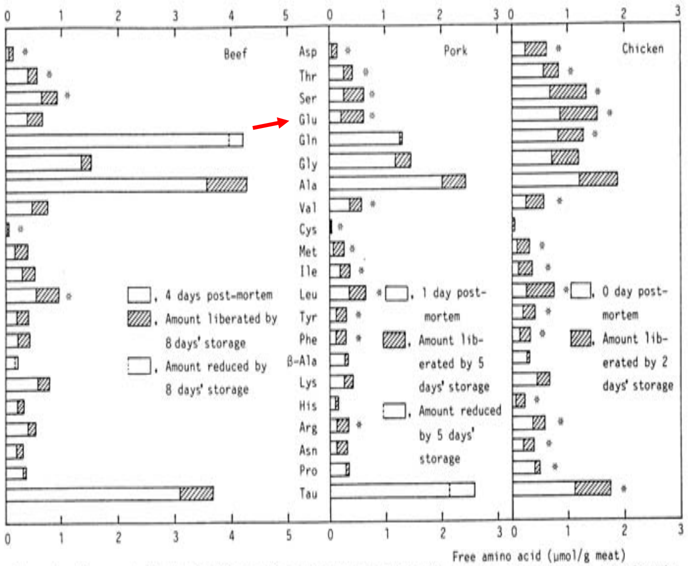




**Table 1.** Effect of Additional Storage on the Intensity of the Brothy Taste of Beef, Pork, and Chicken

| | The no. of samples judged to have a more intense brothy taste: | | | |
|---|---|---|---|---|
| Meat | Before additional storage | After additional storage | $n$ | Difference[a] |
| Beef | 12 | 4 | 16 | NS |
| Pork | 2 | 14 | 16 | * |
| Chicken | 8 | 23 | 31 | * |

[a]NS, not significant; *, significant ($p < 0.05$).




游離胺基酸含量的變化；
＊ 顯著變化

**Figure 1.** Changes in the levels of free amino acids during storage of beef, pork, and chicken. *, Significantly different ($p < 0.05$).





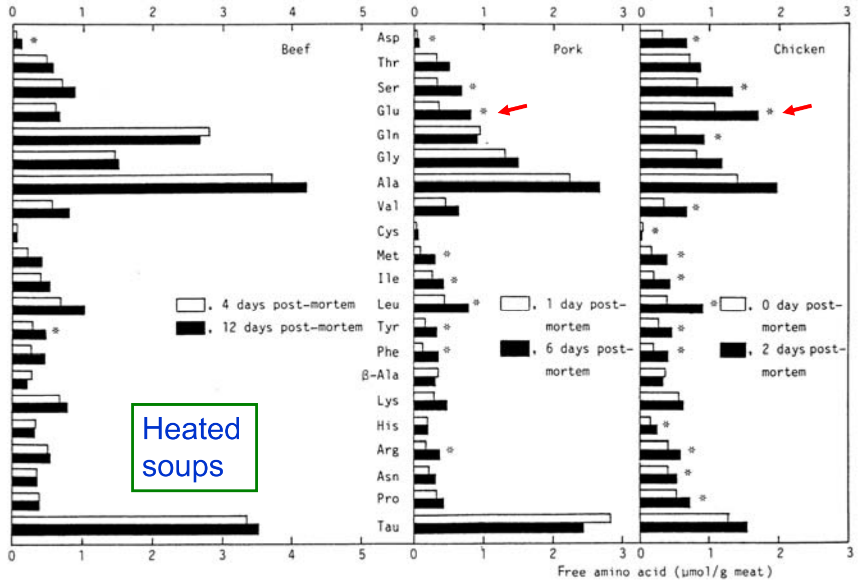



**Figure 2.** Free amino acids contained in heated soup of beef, pork, and chicken before and after additional storage. *, Significantly different ($p < 0.05$).



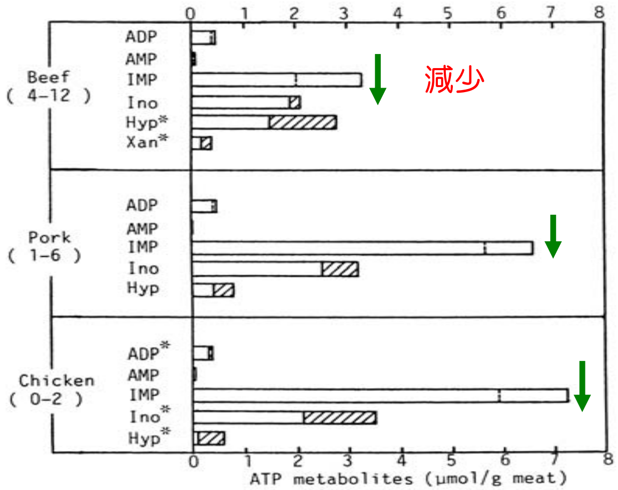



**Figure 3.** Changes in the levels of ATP metabolites during storage of beef, pork, and chicken. ATP metabolites were analyzed by HPLC. (▭) Amount before the additional storage; (▨) amount increased by the additional storage; (▭) amount reduced by the additional storage; *, Significantly different ($p < 0.05$); numbers in parentheses, time post-mortem (days).





In heated soups

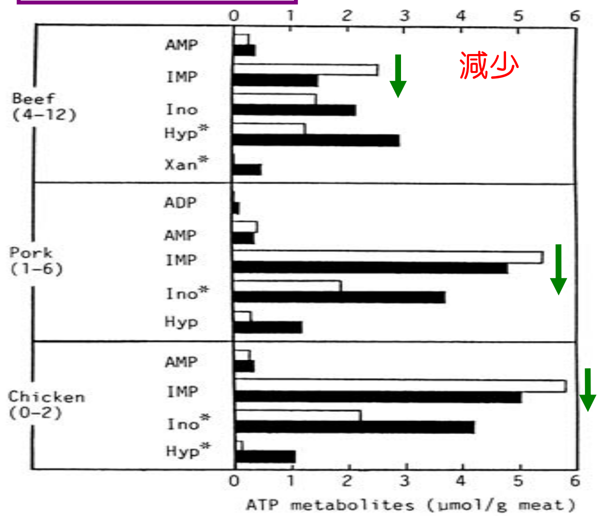
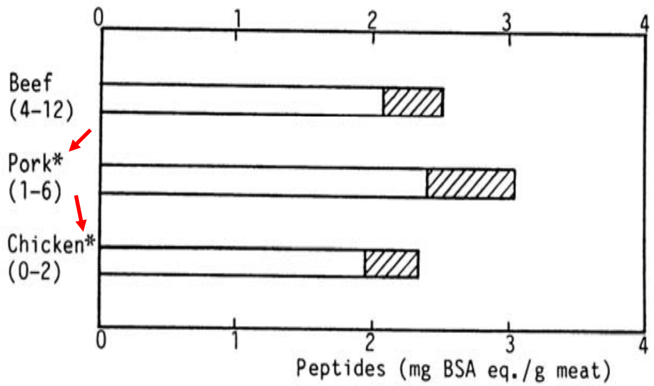



**Figure 4.** Levels of ATP metabolites in heated soup of meat before (▭) and after (▬) additional storage. ATP metabolites were analyzed by HPLC. *, Significantly different ($p < 0.05$); numbers in parentheses, time post-mortem (days).

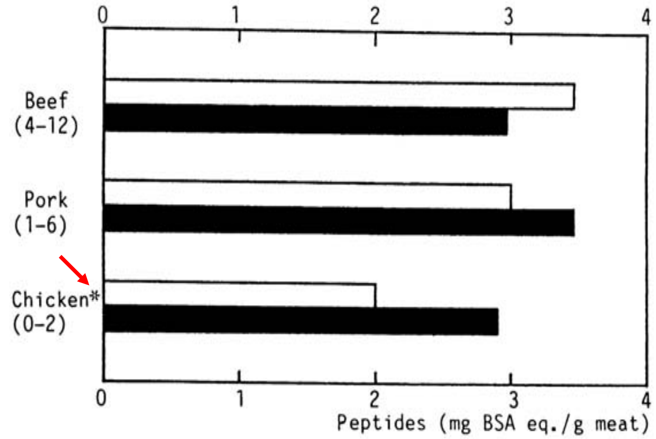



僅牛肉組
無顯著性

**Figure 5.** Changes in the levels of peptides during storage of beef, pork, and chicken. The levels of peptides were obtained from the difference between the values of phenol reagent-positive materials before and after the addition of $Cu^{2+}$ into the phenol reagent. (▭) Amount before additional storage; (▨) amount increased by additional storage; numbers in parentheses, time post-mortem (days).





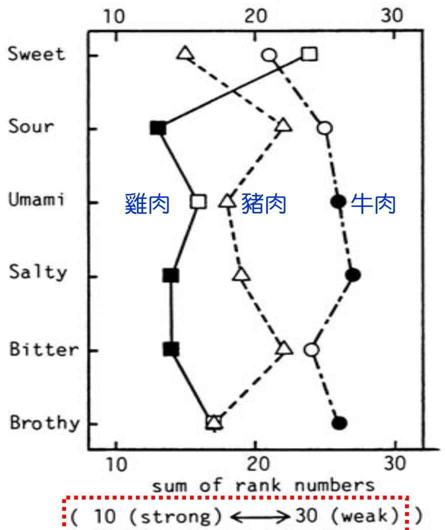



僅雞肉組
顯著增加

**Figure 6.** Peptides contained in heated soup of meat before and after additional storage. Analysis of peptides was the same as in Figure 5. (▭) Before additional storage; (■) after additional storage; *, Significantly different ($p < 0.05$); numbers in parentheses, time post-mortem (days).








Sweet除外的每一種滋味強度，牛肉湯組都比豬肉、雞肉湯組較弱

每種肉湯都具有一特徵的滋味，由基本味彼此間平衡的不同。

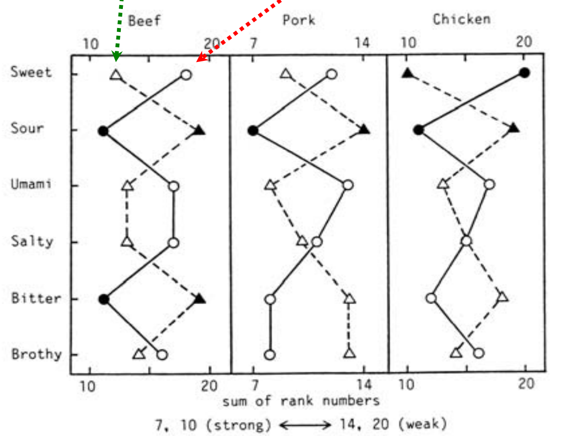
很訝異：牛肉組umami及brothy強度最弱

尋找是哪些成分造成上述之差異

**Figure 7.** Relative strength of each taste among beef, pork, and chicken soups. The NaCl concentration of each soup was adjusted to 0.508%. (○---○) Beef; (△---△) pork; (□—□) chicken. Closed symbols, significantly different from the others ($p < 0.05$).



比較 合成萃取物 和 原汁肉湯 的差異




原汁組的鮮、鹹、肉湯味和合成組幾乎相同，酸味則較弱； 雞肉合成組的甜味也顯著強於原汁組。

游離胺基酸和IMP已知貢獻於鮮味及肉汁味；合成組甜味較強之原因不明，有可能是酸味及苦味的強度更大時，使得可感覺的甜味就較弱。

**Figure 8.** Comparison between authentic and synthetic soups of beef, pork, and chicken. Each soup consisted of IMP and free amino acids. The NaCl concentration of each soup was adjusted to 0.508%. (○—○) Authentic soup; (△---△) synthetic soup. Closed symbols, significantly different from others ($p < 0.05$).

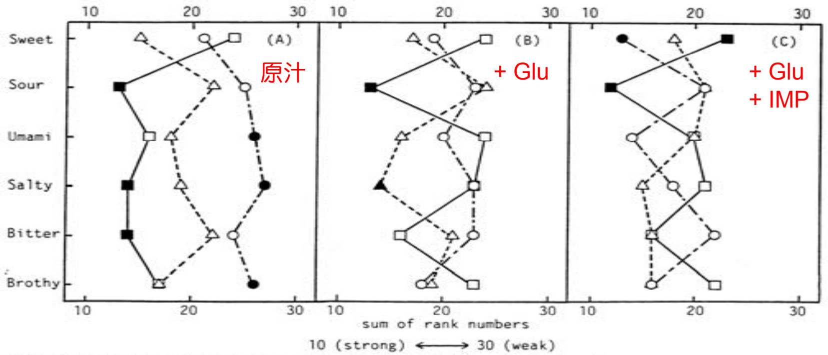



**Figure 9.** Effect of adding glutamic acid (Glu) or Glu + IMP to beef and pork soups at the same level as found in chicken soup. The NaCl concentration of each soup was adjusted to 0.508%. (A) Authentic soup; (B) with addition of Glu to beef and pork soups; (C) with addition of Glu + IMP to beef and pork soups. (○–○) beef; (△---△) pork; (□–□) chicken. Closed symbols, significantly different from others ($p < 0.05$).

牛肉及豬肉湯中再加入Glu 或 Glu + IMP，使濃度等同於雞肉湯中。

牛肉湯組的 umami及brothy 提升至等同或甚強於豬雞肉湯組。表示對於umami及brothy ，Glu扮演很重要的角色。

另一方面，酸味強度未受影響；牛及豬肉湯鹹味強度被增大；牛肉湯的甜味強度也增大。





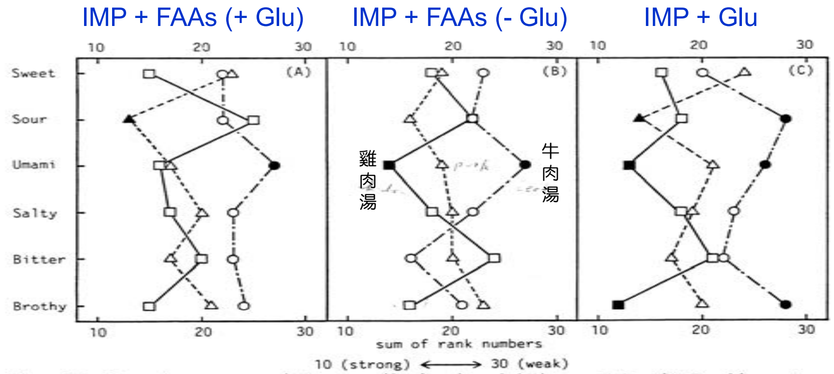



**Figure 10.** Comparison among synthetic soups of beef, pork, and chicken consisting of IMP and free amino acids. The NaCl concentration of each soup was adjusted to 0.508%. (A) IMP + free amino acids (+ Glu); (B) IMP + free amino acids (− Glu); (C) IMP + Glu (○–○) Beef (△---△) pork (□–□) chicken. Closed symbols, significantly different from others ($p < 0.05$).

(A): 合成萃取物由IMP及全部的游離胺基酸組成。三組之中，牛肉湯組umami及brothy最弱。
(B): 欠缺 Glu，umami強度以雞肉組最大，牛肉組最低。欠缺 Glu，則Glu + IMP的相乘作用喪失。
(C): 僅Glu+IMP，雞湯組umami及brothy強度最大，牛肉湯組最低，和在(A)合成萃取物之情形有些類似。





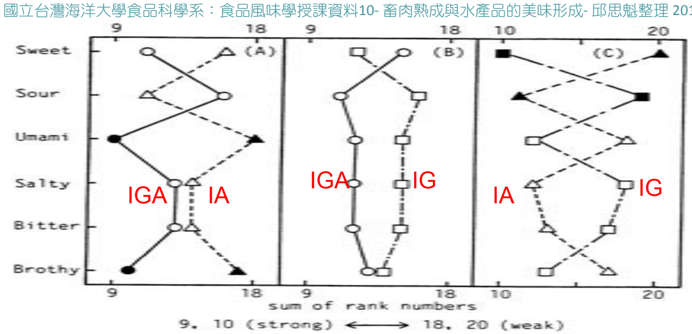



**Figure 11.** Contribution of Glu to each taste quality of chicken synthetic soup consisting of IMP and amino acids. The NaCl concentration of each soup was adjusted to 0.508%. (A) IGA vs. IA; (B) IGA vs. IG; (C) IA vs. IG. (○–○) IGA: IMP + amino acids (+ Glu). (△---△) IA: IMP + amino acids (− Glu). (□–□) IG: IMP + Glu. Closed symbols, significantly different from others ($p < 0.05$).

(A)：IMP + all FAAs (IGA) vs.欠缺 Glu (IA) 。欠缺Glu減弱甜、鮮、肉味等，但鹹及苦味未受影響。
(B)：IGA vs.Glu+IMP (IG) 。全部項目都無顯著差異。IG組的酸、鮮、鹹、苦味等強度較低，似受到Glu以外FAAs的影響。
(C): IA vs. IG。缺少Glu，減弱甜、鮮、肉味，但增強酸、鹹、苦味等。
綜合以上的結果，Glu是貢獻umami及brothy tatse之最重要的成分，其餘的胺基酸也貢獻一部分的鮮味。







明確的回答，實非易事。

本節中，爲避免重複第三章3-6 節內容（魚介類肌肉的萃取物成分），主要僅針對會刺激味覺產生之物質（呈味成分）加以闡述[7~10]。

**4-2-1 主要的呈味成分**

1) **胺基酸** 魚介類，毫無例外地，其所含的游離胺基酸是呈味成分中最爲重要的成分。胺基酸各有其獨特的風味，而到底在食品中發揮怎樣的呈味作用，基本上是受到各胺基酸的閾值及含量，或者和其它成分之間的相互作用等因素所決定。下面就將截至目前爲止，已經報告過而和魚介類的味道有關的主要胺基酸作一敍述。

**麩胺酸** 它的一種鈉鹽（麩胺酸鈉，monosodium glutamate, MSG）帶有鮮味[*]之成分。所有的魚介類，沒有例外，都含有麩胺酸，只是含量大多低於MSG的閾值(0.03%)。可是由於和死後魚肉中所蓄積肌苷酸(IMP)之間具有鮮味的相乘作用，因此於肌苷酸並存的情況下，即使含量低於閾值，仍有助於呈味（參見核苷酸項）。

**甘胺酸** 爲帶有爽快甜味之胺基酸。無脊椎動物，特別是甲殼類及海扇貝貝柱中的含量高，其大部份的甜味即來自甘胺酸。蝦類的美味與甘胺酸的含量之間也關係密切。

* 以麩胺酸鈉(MSG)及肌苷酸(IMP)、鳥嘌呤核苷單磷酸(GMP)等核苷酸鈉鹽所表現出來的味稱爲鮮味。雖然曾有以基本味如甜味、酸味、苦味及鹹味可合成出鮮味之說法，但最近味覺心理學的研究顯示，鮮味乃是上述基本味所無法合成之另一種獨立的味。另外，現在已經知道對麩胺酸鈉具有特異感應之受容體(receptor)，也存在於鯉魚及老鼠的化學感覺器官中，因此，將鮮味視爲基本味之一，乃更爲妥當之看法，此在國際上已逐漸得到認同。
鮮味並非本身即是鮮美的味道，而是鮮味的成分具有提高美味的作用；所以，將鮮味與美味予以區別，有其必要性。「鮮味」(日語爲「うま味」一詞，爲日本人所創，外語中找不到適當的譯詞，所以外國的專家們也就直接使用該詞的日語發音"umami"。



**丙胺酸** 爲帶有弱苦味之甜味胺基酸。其含量大抵低於甘胺酸，但無脊椎動物中則含相當多的量，在慈愛蟹(snow crab)及海扇貝已確知係提供甜味之成分。

**組胺酸** 紅肉魚肉中蓄積有多量的這種胺基酸，但有的報告指出它和呈味有關，有的則認爲無關，因此尚未獲得明確的結論。不過有報告指出鰹柴魚中含量很高的組胺酸，和並存的多量的乳酸與磷酸二氫鉀($KH_2PO_4$)共同地提高緩衝能，而有增強呈味之作用。由於和組胺酸一樣具有異吡唑基(imidazole group)之鵝肌肽(anserine)，鰹柴魚中亦含有多量，今後，這些成分的呈味作用有必要再詳細地探討。

**精胺酸** 爲帶有苦味之胺基酸。因而富含精胺酸的魚介類往往被認爲味道不佳，但相反地，含多量精胺酸的無脊椎動物則大多具有美味。探討慈愛蟹及海扇貝貝柱合成萃取物的結果，發現精胺酸並沒發出苦味，反而可增強風味的複雜性及濃厚性，具有提高整體美味之作用。

**甲硫胺酸** 它雖係苦味的胺基酸，卻是現出海膽的特有風味所不可欠缺的成分。而且有報告指出微量的甲硫胺酸能夠使麩胺酸鈉的呈味感覺更加濃厚。

**纈胺酸** 報告指出它與海膽特有的苦味有關。

**脯胺酸** 是帶有苦味之甜味胺基酸。因此有記載稱它對脯胺酸含量豐富的魚貝類的風味有所助益；但是在慈愛蟹合成萃取物的官能試驗結果，即使在每100mℓ中含163mg脯胺酸這種相當多量情況下，對美味仍未能有所幫助。附帶地說，L-脯胺酸的刺激閾值高達0.3%。

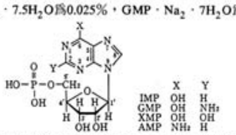
2) **胜肽** 肌肽(carnosine)被認爲與牛肉萃取物的美味有關；而鰻魚肌肉中亦含有多量之此雙胜肽，但它與鰻魚的風味之間的關係尚無人探討。在鼠鯊肉合成萃取物中研究鵝肌肽(anserine)的結果，加入該胜肽可稍增強酸味及引出濃厚感。Balenine在鰮鯨肉合成萃取物中的官能試驗結果，被認爲具有增強鮮味及濃厚感之作用。由於這3種胜肽在中性酸鹼度附近均具有

苷強緩衝能，其所以引出濃厚感，可能與此性質有關。

**3) 核苷酸** 爲探討鰹柴魚煮汁的鮮味成分，1913年小玉氏分離得到肌苷酸組胺酸鹽，之後並了解其鈉鹽可以呈現相同強度的鮮味。鳥嘌呤核苷單磷酸爲天然食品的鮮味成分一事，係由國中氏於1960年研究香菇的呈味成分時最早發現的，鳥嘌呤核苷單磷酸在乾香菇及松茸中的含量高，魚介類中亦有少量存在。

國中氏的研究並闡明核苷酸的化學構造與鮮味產生之間的關係，即嘌呤基的第6位置上結合羥基和核糖的5'位置上接上磷酸酯，乃產生鮮味之必要條件。肌苷酸、鳥嘌呤核苷單磷酸及5'-黃苷酸(xanthylic acid; XMP)都能符合這個必要件，而腺苷酸(adenylic acid; AMP)則因第6位置上鍵結胺基而幾乎無味。

核苷酸的閾值，$IMP \cdot Na_2 \cdot 7.5H_2O$爲0.025%，$GMP \cdot Na_2 \cdot 7H_2O$爲0.0125 %，都相當低，和麩胺酸鈉所不同的是其鮮味強度不因用量增加而有明顯的提高。是故以核苷酸作爲呈味成分之意義，應是考慮其與麩胺酸鈉之間所產生的鮮味相乘效果。該兩成分的相乘作用可以$y = u + 1200uv$關係式來表示，$u$及$v$分別代表混合液中麩胺酸鈉及肌苷酸的濃度，$y$則是具有和混合液相同的風味強度之麩胺酸鈉單獨的濃度（g／dℓ）。



| | X | Y |
|---|---|---|
| IMP | OH | H |
| GMP | OH | $NH_2$ |
| XMP | OH | OH |
| AMP | $NH_2$ | H |

麩胺酸鈉和核苷酸間的相乘作用所產生的鮮味，構成魚貝類的主要風味：但有趣的是本身幾乎無味的腺苷酸也能夠增強麩胺酸鈉的鮮味。雖異於蓄積肌苷酸之魚肉，這個事實足以說明蓄積腺苷酸之無脊椎動物肌肉爲何也具有強鮮味之原因。像這樣的麩胺酸鈉和核苷酸間的相乘作用，不僅是人類的感覺，從老鼠的味神經感應也獲得證明，亦即核苷酸結合於味受容膜之後，可提高麩胺酸鈉對受容體的親和力之故。

**4) 次黃嘌呤** 爲具有苦味之嘌呤鹽基，由肌苷酸分解而生成。一般認爲它是造成冰藏鱈魚肉產生苦味之原因。

**5) 甘胺甜菜鹼(glycinebetaine)** 因具有甜味，一般認爲它有助於含量豐富之無脊椎動物肌肉甜味的產生。但是以慈愛蟹肉合成萃取物（100 mℓ中含357mg甘胺甜菜鹼）所作的官能試驗，雖承認它對甜味有所助益，但在其含量降爲179mg時，其效果卻沒有太大的影響。另外，在海扇貝貝柱合成萃取物的官能試驗結果，於100mℓ含237mg甘胺甜菜鹼時，其呈味效果並不顯著，惟有趣的是合成萃取物中若再加入甘胺甜菜鹼，則會引出水產物般的香味(seafood-like flavor)。

**6) 氧化三甲基胺** 因具有甜味，一般認爲它能夠對含量高的魚貝類提供甜味，但在慈愛蟹肉合成萃取物（100mℓ中含169mg氧化三甲基胺, TMAO）的官能試驗中，被斷定不具呈味效果：而在鼠鯊肉合成萃取物（100mℓ中含1.12g氧化三甲基胺）的官能試驗中，報告指出氧化三甲基胺之加入可稍增強甜味。從上述的實驗結果，可知氧化三甲基胺唯有存在相當多量時，始能顯現出呈味效果。

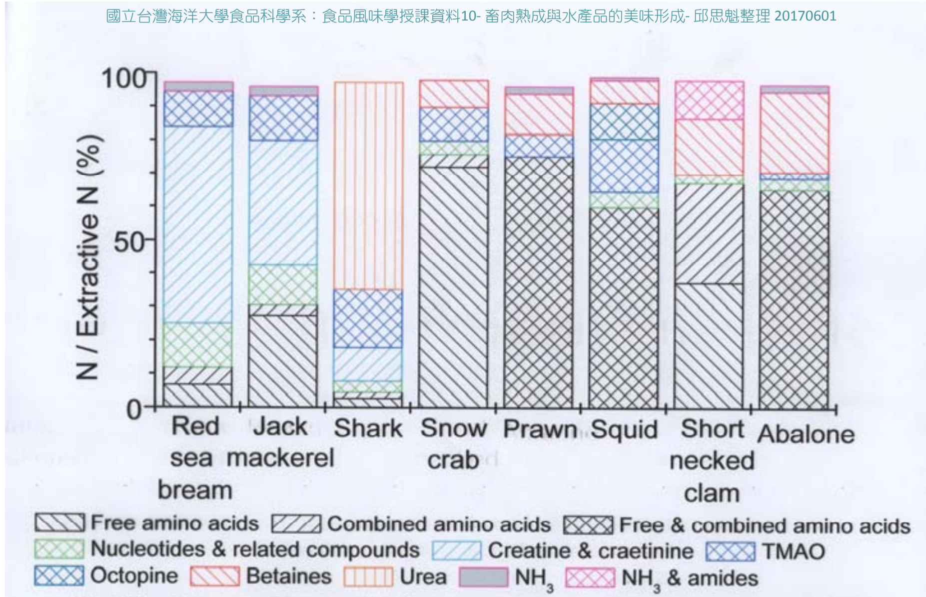
**7) 有機酸** 琥珀酸在蜆、蜊、海扇貝等貝類中的含量多，一直被認爲是貝類的重要呈味成分。但琥珀酸係貝類死後或在嫌氣狀態下活存時所蓄積的，剛捕獲的貝類含量低。由於這樣的試料一定就不鮮美，故琥珀酸在呈味上的作用有待檢討。乳酸在鰹柴魚煮汁中係提高緩衝能之要因，一般認爲有增強味道的作用。

**8) 無機成分** 第三章中曾述及無機成分並不屬於一般的萃取物成分，然而鈉、鉀、氯、磷酸根等的離子，特別是鈉及氯離子對於風味的產生非常重要，將於下節舉例說明。

### 4-2-2 數種魚介類的風味組成

自食品中製造其萃取物，詳細分析其中的組成成份及其含量之後，依照分析結果之組成，混合高純度的試劑，這樣就能夠得到充分再現該食品

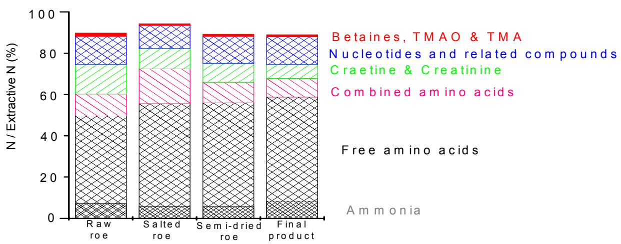
國立台灣海洋大學食品科學系：食品風味學授課資料10- 畜肉熟成與水產品的美味形成- 邱思魁整理 20170601



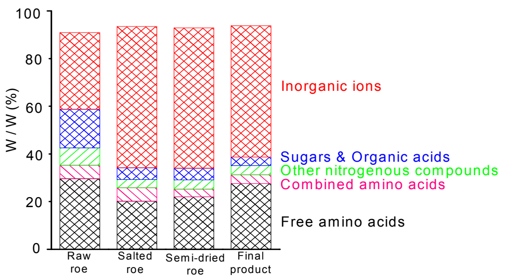

Distribution of nitrogen in the muscle extract of fish and shellfish



國立台灣海洋大學食品科學系：食品風味學授課資料10- 畜肉熟成與水產品的美味形成- 邱思魁整理 20170601



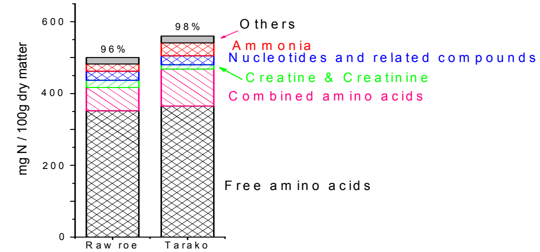

Distribution of nitrogen in the extracts at different stages of dried mullet roe processing.



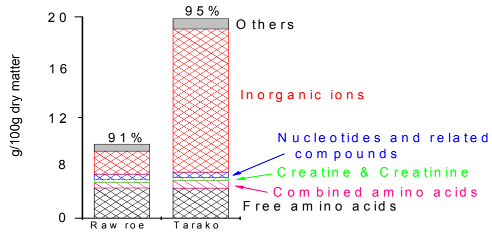

Distribution of various components in the extracts at different stages of the dried mullet roe processing.



國立台灣海洋大學食品科學系：食品風味學授課資料10- 畜肉熟成與水產品的美味形成- 邱思魁整理 20170601




Nitrogen distribution in the extract of raw and salted Alaska pollack roes (Tarako). The figures at the top of the columns indicate the recovery on nitrogen basis.




Distribution of various components in the extracts of raw and salted Alaska pollack roes (Tarako). The figures at the top of the columns indicate the recovery on weight basis.

# 8 Taste-active components of seafoods with special reference to umami substances

S. FUKE

## 8.1 What are umami and umami substances?

### *8.1.1 Introduction*

From the age of Aristotle or earlier, many scientists have tried to analyse the taste of foods especially in western Europe, and advocated sweetness, sourness, saltiness, bitterness, astringent, metallic and other tastes as fundamental elements contributing to food taste. Henning systematically summarized these tastes and proposed the famous taste tetrahedron theory, in which four basic tastes (sweetness, sourness, bitterness and saltiness) were located on each apex of the tetrahedron and other tastes were located somewhere on the surface (Komata, 1986). This tetrahedron theory has been very influential and has been supported by many food scientists.

At the beginning of this century, Ikeda (1909) isolated monosodium glutamate (MSG) as a substance responsible for the palatable taste of sea tangle which had been used popularly in Japan to prepare savoury soup. He noticed that the taste of MSG was a new type of taste, different from the conventional basic tastes and designated it as umami. Since then the concept of umami has been widely accepted in Japan and many works on umami substances have been conducted. Kodama (1913) identified inosine 5′-monophosphate (IMP) in dried skipjack and Kuninaka (1964) recognized guanosine 5′-monophosphate (GMP) in black mushroom as umami substances. In Europe and America, umami substances have been believed to be only flavour potentiators or enhancers, and umami has not been accepted as one of the basic tastes. In recent years however, new psychometric and neurophysiological approaches to recognize umami as one of the basic tastes have been developed. The multidimensional scaling method, applied to measure the distances between the conventional four basic tastes represented by sucrose, tartaric acid, sodium chloride and quinine sulphate, respectively, found that umami was independent of the other four tastes (Yamaguchi, 1987). The occurrence in mice of glossopharyngeal nerve responding strongly to umami substance but not to the other substances (Ninomiya and Funakoshi, 1987) also supported the

From: “Seafoods- Chemistry, Processsing and Quality” (F. Shahidi and J.R. Botta eds.), 1994, pp. 115-139, Chapman & Hall, London.





# What are umami and umami substances?

- The taste of foods
  Taste tetrahedron theory: 4 basic tastes (sweetness, sourness, bitterness and saltiness)
  "Umami" substances:
    Monosodium glutamate (MSG) - sea tangle
    Inosine 5'-monophosphate - dried skipjack
    Guanosine 5'-monophosphate - black mushroom
    Flavor potentiators or enhancers

- A substances to be labeled as having umami should fulfill the following conditions:

1. it should stimulate neurofibres specific to umami substances;
2. in the multidimentional scaling analyses, it should be located in a different dimension from the other tastes;
3. it should show a synergistic taste effect in coexistence with monosodium glutamate.





## Free L-glutamte in natural foods (mg/100g)

| | |
|---|---|
| Kelp | 2240 |
| Parmesam cheese | 1200 |
| Green tea | 668 |
| Seaweed | 640 |
| Sardine | 280 |
| Fresh tomato juice | 260 |
| Champignon | 180 |
| Cuttlefish | 146 |
| Tomato | 140 |
| Oyster | 137 |
| Potato | 102 |
| Chinese cabbage | 100 |
| Fresh shiitake mushroom | 67 |
| Soybean | 66 |
| Sweet potato | 60 |
| Dried sardine | 50 |
| Prawn | 43 |
| Clam | 41 |
| Chicken bones | 40 |
| Cabbage | 37 |
| Carrot | 33 |
| Bonito flakes | 26 |
| Pork fillet | 23 |





## 5'-inosinate in natural foods (mg/100g)

| | |
|---|---|
| Dried sardine | 886 |
| Bonito flake | 687 |
| Bonito | 285 |
| Horse mackerel | 265 |
| Mackerel pike | 242 |
| Sea bream | 215 |
| Mackerel | 215 |
| Sardine | 193 |
| Tuna | 188 |
| Pork | 122 |
| Beef | 107 |
| Prawn | 92 |
| Chicken | 76 |
| Cod | 44 |

## 5'-guanylate in natural foods (mg/100g)

| | |
|---|---|
| Dried shiitake mushroom | 156.5 |
| Matsutake | 64.6 |
| Enokitake mushroom | 21.8 |
| Fresh shiitake mushroom | 16-45 |
| Truffle mushroom | 5.8 |
| Pork | 2.5 |
| Beef | 2.2 |
| Chicken | 1.5 |

# Synergistic Taste Effect

- *MSG with 5'-ribonucleotides (IMP or GMP)*

  Model system

  Soup of various foods

**Table 8.2** Relative intensity of synergism between MSG and various 5′-ribonucleotides[a]

| Substances (disodium salt) | Relative intensity |
|---|---|
| 5′-IMP·7.5$H_2O$ | 1 |
| 5′-GMP·7$H_2O$ | 2.3 |
| 5′-XMP·3$H_2O$ | 0.61 |
| 5′-AMP | 0.18 |

[a]Abbreviations used: IMP, inosine monophosphate; GMP, guanine monophosphate; XMP, xanthine monophosphate; AMP, adenine monophosphate.





**Table 8.3** Effect of subthreshold amount of various amino acids and succinic acid on lowering the threshold value of IMP

| Substances[a] | IMP added[b] | Significance[c] | Ratio[d] |
|---|---|---|---|
| Aspartate | 0.0025 | *** | |
| | 0.00125 | * | 1/20 |
| Glutamate | 0.0004 | *** | |
| | 0.0003 | ** | 1/83 |
| Aminoadipate | 0.0050 | *** | |
| | 0.0025 | *** | 1/10 |
| Oxyglutamate | 0.0002 | ** | |
| | 0.0001 | * | 1/250 |
| Homocysteinate | 0.0005 | *** | |
| | 0.00025 | * | 1/100 |
| Succinic acid | 0.030 | *** | |
| | 0.020 | * | 1/1 |

[a]Substances used were all sodium salts at the concentration of 0.1 g/dl in 1% sodium chloride solution except succinic acid whose concentration was 0.05 g/dl in the same solution.
[b]Disodium salt of 5′-IMP was used.
[c]***, ** and *: Significant at 0.1, 1 and 5% levels, respectively.
[d]The concentration ratio of each substance against the threshold value of IMP, 0.025%.





- *$\alpha$-Amino dicarboxylates and L-homocysteinate with IMP*

IMP·2Na和 $\alpha$-Amino dicarboxylates (aspartate·Na, D,L-threo-$\beta$-hydroxy- glutamate·Na, D,L-$\alpha$-aminoadipate·Na, MSG 及 L-cysteinate·Na)之間的滋味相乘效應

閾值（水中）：aspartate 0.16%, hydroxyglutamate 0.03%, MSG 0.03%, IMP 0.025%

**Table 8.3** Effect of subthreshold amount of various amino acids and succinic acid on lowering the threshold value of IMP

| Substances[a] | IMP added[b] | Significance[c] | Ratio[d] |
|---|---|---|---|
| Aspartate | 0.0025 | *** | |
| | 0.00125 | * | 1/20 |
| Glutamate | 0.0004 | *** | |
| | 0.0003 | ** | 1/83 |
| Aminoadipate | 0.0050 | *** | |
| | 0.0025 | *** | 1/10 |
| Oxyglutamate | 0.0002 | ** | |
| | 0.0001 | * | 1/250 |
| Homocysteinate | 0.0005 | *** | |
| | 0.00025 | * | 1/100 |
| Succinic acid | 0.030 | *** | |
| | 0.020 | * | 1/1 |

[a]Substances used were all sodium salts at the concentration of 0.1 g/dl in 1% sodium chloride solution except succinic acid whose concentration was 0.05 g/dl in the same solution.
[b]Disodium salt of 5′-IMP was used.
[c]***, ** and *: Significant at 0.1, 1 and 5% levels, respectively.
[d]The concentration ratio of each substance against the threshold value of IMP, 0.025%.





## The taste of free amino acids

**Table 8.4** Comparison of the predominant taste of L-amino acids reported by several authors

| Amino acids | A[a] (1989) | B (1977) | C (1982) | D (1985) |
|---|---|---|---|---|
| Gly | sw[b] | sw | sw | sw |
| Ala | sw | sw | sw | sw |
| Ser | sw | sw | fl/sw | fl/sw |
| Pro | sw | sw/bi | – | fl |
| Lys | sw/ot | sw/bi | – | fl |
| His | bi/tl | bi | fl/bi | fl |
| Arg | bi | bi | – | fl |
| Ile | bi | bi | fl/bi | fl |
| Val | bi/sw | bi | tl | fl |
| Leu | bi | bi | fl/bi | bi |
| Met | bi | bi | fl/bi | su/mt/bi |
| Trp | bi | bi | fl/bi | bi |
| Asp | so | – | fl/so | fl |
| Glu | tl | nt | fl/sw/mt | – |

[a]A, B, C and D: Cited from Birch and Kemp (1989), Wieser *et al.* (1977), Shiffman *et al.* (1982) and Solms *et al.* (1965).
[b]Abbreviations used: sw, sweet; bi, bitter; fl, flat; tl, tasteless; ot, other taste; mt, meaty; su, sulphurous, so, sour; nt, neutral.

**Table 8.5** Contribution of basic tastes to the tastes of free amino acids (%)

| | Sweet | Salt | Sour | Bitter | Umami | Others |
|---|---|---|---|---|---|---|
| Gly[a] | 83.0 | 0.4 | 8.4 | 4.6 | 5.3 | 0.2 |
| Ala | 75.1 | 1.3 | 2.7 | 8.3 | 13.1 | 1.0 |
| Thr | 87.9 | 0.4 | 4.4 | 2.7 | 3.9 | 0.8 |
| Ser | 64.7 | 2.0 | 5.6 | 7.2 | 19.1 | 1.4 |
| Pro | 51.6 | 0.4 | 3.4 | 42.8 | 2.2 | 0 |
| Lys·HCl[b] | 38.6 | 8.7 | 7.9 | 28.8 | 10.5 | 5.5 |
| Gln | 41.8 | 0.3 | 1.5 | 10.2 | 26.0 | 10.9 |
| Phe | 0 | 0.7 | 0 | 98.7 | 0 | 0.7 |
| His | 7.2 | 1.0 | 8.5 | 64.1 | 11.5 | 7.8 |
| Arg | 2.1 | 0.4 | 1.2 | 85.9 | 1.5 | 8.9 |
| Val | 16.1 | 0.4 | 3.8 | 73.5 | 1.8 | 4.4 |
| Leu | 3.0 | 1.4 | 2.0 | 87.0 | 3.0 | 1.6 |
| Met | 7.4 | 0.2 | 4.0 | 61.6 | 16.6 | 9.4 |
| Trp | 1.6 | 0 | 2.2 | 95.0 | 0.2 | 1.0 |
| Asp | 1.7 | 3.1 | 81.1 | 4.3 | 8.5 | 1.6 |
| Glu | 5.0 | 5.4 | 60.0 | 3.8 | 24.8 | 1.0 |
| Asp·Na[b] | 5.3 | 43.5 | 8.6 | 4.8 | 35.5 | 2.3 |
| Glu·Na[b] | 9.8 | 13.3 | 3.4 | 1.7 | 71.4 | 0.4 |

[a]All amino acids (L-form except Gly) were tasted in powder.
[b]Lys·HCl; lysine hydrochloride, Asp·Na; monosodium aspartate, Glu·Na; monosodium glutamate.





- *Synergistic taste effect among three compounds*

The strength of umami giving by the mixtures in 1% NaCl solution comprising 2 or 3 out of 3 elements (amino acids, 低於刺激閾值; nucleotides, 0.01% IMP/GMP; 0.1% MSG), was evaluated and compared with that of the 1% NaCl solution containing either the same amount of amino acid only or the same amounts of nucleotides and MSG.

各種胺基酸(濃度低於閾值)溶液中

Exp 1: 加入 Glu•Na 或 Asp•Na

Exp 2: 加入 IMP/GMP

Exp 3: 加入 Glu•Na or Asp•Na/IMP/GMP





Exp 1: + Glu•Na or Asp•Na; Exp 3: + Glu•Na or Asp•Na/IMP/GMP
Exp 2: + IMP/GMP;

**Table 8.6** Taste enhancing effect of α-amino acids

| | Threshold (g/dl) | Tested (g/dl) | Exp. 1 | Exp. 2 | Exp. 3 |
|---|---|---|---|---|---|
| Gly | 0.11 | 0.10 | – | – | ** |
| Ala | 0.06 | 0.05 | – | – | ** |
| Thr | 0.26 | 0.20 | – | – | * |
| Ser | 0.15 | 0.10 | – | – | ** |
| Pro | 0.30 | 0.20 | – | – | ** |
| Lys·HCl | 0.05 | 0.04 | – | – | – |
| His | 0.02 | 0.01 | – | – | – |
| His·HCl | 0.0005 | 0.004 | – | – | ** |
| Arg | 0.01 | 0.008 | – | – | – |
| Arg·HCl | 0.03 | 0.02 | – | – | – |
| Ile | 0.09 | 0.09 | – | – | – |
| Val | 0.15 | 0.15 | – | – | ** |
| Cys | NG | 0.05 | – | – | ** |
| DL-Tyr | 0.02 | 0.15 | – | – | ** |
| Tyr | NG | 0.10 | – | – | – |
| Met | 0.03 | 0.03 | – | – | ** |
| Phe | 0.15 | 0.05 | – | – | – |
| Asp | 0.003 | 0.003 | – | – | * |
| Asp·Na | 0.10 | 0.10 | NA | ** | NA |
| Glu·Na | 0.03 | 0.02 | NA | ** | NA |

Exp. 1: Enhancing effect of amino acids on sodium salt of Glu or Asp.
Exp. 2: Enhancing effect of amino acids on 5′-ribonucleotides.
Exp. 3: Enhancing effect of amino acids on mixtures of 5′-ribonucleotides and sodium salt of Glu or Asp.
** and *: Significant at 1% and 5% levels, respectively. –: Insignificant. NA, not analysed.
NG, value was not given.





- *Sulphur-containing compounds as flavor enhancers*

The addition of 0.1 and 0.4% freeze-dried garlic extract to Chinese or curry soup, respectively, improved their flavor, especially "kokumi" flavor.

**Table 8.7** Enhancing effect of freeze-dried garlic extract on 'Kokumi' flavour

| Test solutions | Effect |
|---|---|
| Water | – |
| 0.05% MSG | + |
| 0.05% IMP | + |
| 3.1% MSG | ++ |
| 0.05% MSG + 0.05% IMP | ++ |

++ and +: Significant at 0.1% and 1% levels, respectively. –: Insignificant.

**Table 8.8** Effect of sulphur compounds in garlic on 'kokumi' flavour of umami solution

| Components | Effect |
|---|---|
| Alliin | +++ |
| Cycloalliin | + |
| MeCSO | ++ |
| GAC | ++ |
| GACSO | + |
| Glutathione | +++ |
| Cys | + |
| Met | + |

Abbreviations used: MeCSO, (+)-*S*-methyl-L-cysteine sulphoxide; GAC, γ-L-glutamyl-*S*-allyl-L-cysteine; GACSO, γ-glutamyl-*S*-allyl-L-cysteine sulphoxide.
+++, ++ and +: Enhancing effect is very strong, strong, and a little, respectively.





- *Methyl xanthines and IMP*

Methyl xanthines such as **caffeine, theobromine and theophylline** enhance the taste of compounds which is not enhanced by IMP, and conversely IMP enhances the taste of compounds which are not enhanced by methyl xanthines.

The panelist's tongue was adapted to one of the methyl xanthines at concentrations ranging from $10^{-5}$ to $10^{-2}$ M and then the stimulus to be tested was introduced to the tongue.





(1) The tastes of 6 sweeteners ($10^{-5}$ M acesulfame-K, 3.00 x $10^{-5}$ to $10^{-4}$ M neohesperidin dihydrochalcone, 1.47 x $10^{-2}$ M D-tryptophan, 2.78 x $10^{-5}$ M thaumatin, 1.17 x $10^{-3}$ M stevioside and 1.87 x $10^{-3}$ M sodium saccharin) were potentiated by either of the methyl xanthines.

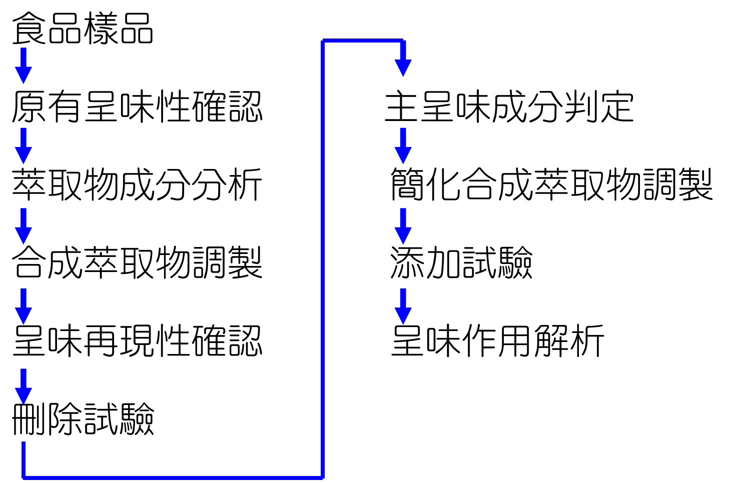
(2) The tastes of aspartmate, sucrose, fructose and sodium clclomate were not enhanced by methyl xanthines.

(3) The same effect was observed for amino acids (enantiomers of Phe, His, Arg, Ala and Asn) except for enantiomers of Glu which were potentiated by IMP.

(4) The tastes of quinine hydrochloride, KCl, NaCl and urea were enhanced by methyl xanthines as well.








水產食品呈味機制之解析流程

**Table 8.10** Extractive components in snow crab (mg/100 g)

| | | | | | |
|---|---|---|---|---|---|
| Tau | 243 | Phe | 17 | Ino | 13 |
| Asp | 10 | Orn | 1 | Gua | 1 |
| Thr | 14 | Lys | 25 | Cyt | 1 |
| Ser | 14 | His | 8 | Bet | 357 |
| Sar | 77 | τ-MeHis | 3 | TMAO | 338 |
| Glu | 19 | Trp | 10 | Hom | 63 |
| Pro | 327 | Arg | 579 | Glc | 17 |
| Gly | 623 | CMP | 6 | Rib | 4 |
| Ala | 187 | AMP | 32 | Lac | 100 |
| α-Abu | 2 | GMP | 4 | Suc | 9 |
| Val | 30 | IMP | 5 | $Na^+$ | 191 |
| Met | 19 | ADP | 7 | $K^+$ | 197 |
| Ile | 29 | Ade | 1 | $Cl^-$ | 336 |
| Leu | 30 | Ado | 26 | $PO_4^{3-}$ | 217 |
| Tyr | 19 | Hyp | 7 | | |

Abbreviations used: Sar, sarcosine; α-Abu, α-aminobutyric acid; Orn, ornithine; τ-MeHis, τ-methylhistidine; Ade, adenine; Ado, adenosine; Hyp, hypoxanthine; Ino, inosine; Gua, guanine; Cyt, cytosine; Hom, homarine; Glc, glucose; Rib, ribose; Lac, lactic acid; Suc, succinic acid.





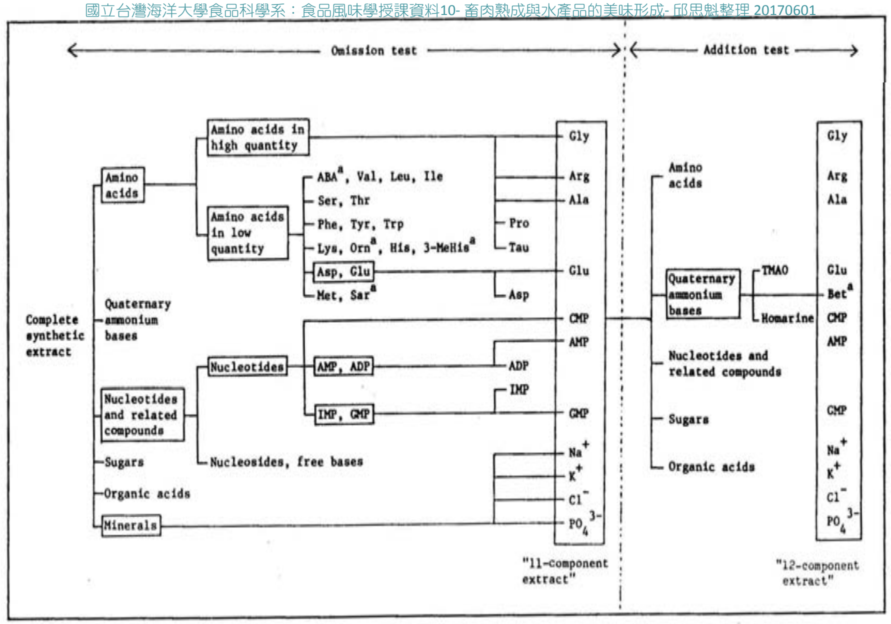
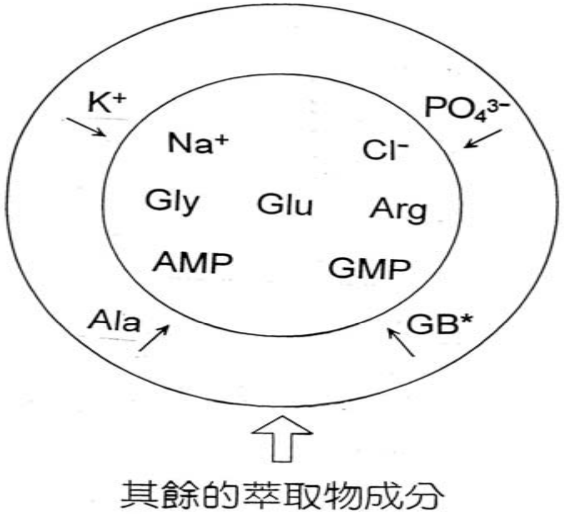



*Fig. 1—Summary of omission and addition tests. The components enclosed in boxes were judged to contribute to the taste of snow crab. (aABA, α-amino-n-butyric acid; Orn, ornithine; 3-MeHis, 3-methylhistidine; Sar, sarcosine; Bet, glycine betaine.)*






慈愛蟹(snow crab)肉呈味的構成模式

(GB*: glycine betaine)





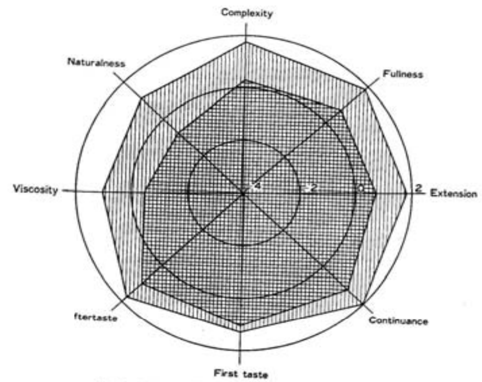



Fig. 3. Taste profiles according to the secondary qualities. Vertical lines, natural extract; horizontal lines, synthetic extract.

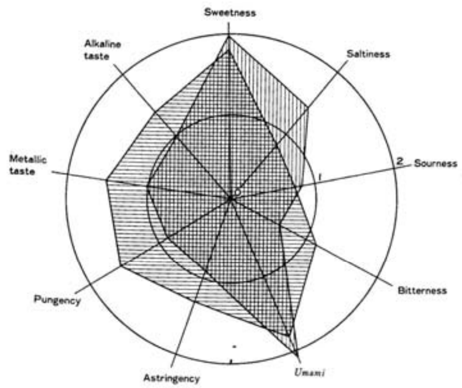



Fig. 2. Taste profiles according to the primary qualities. Vertical lines, natural extract; horizontal lines, synthetic extract.

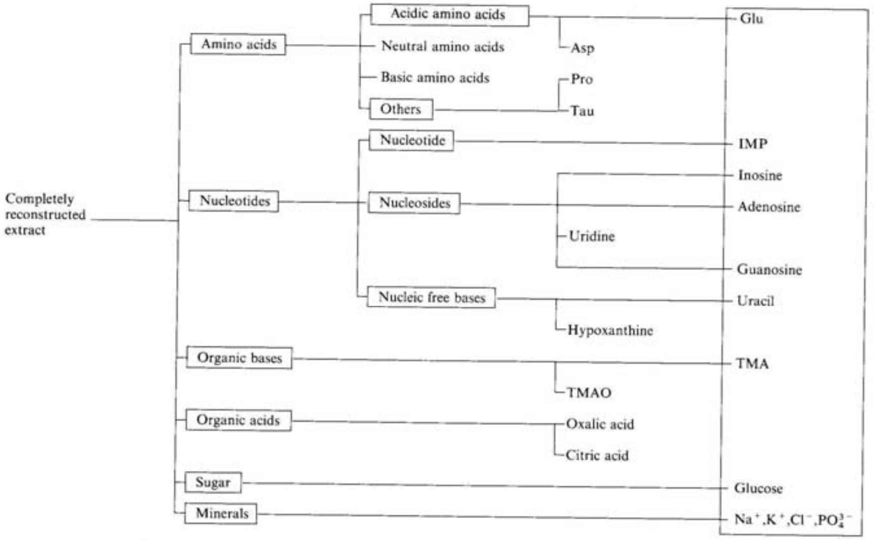



**Fig 1.** Summary of sensory omission test. The components enclosed in boxes were judged to contribute to the characteristic taste of ikura.





**Table 8.9** Extractive components in abalone muscle (mg/100 g)

| | | | |
|---|---|---|---|
| Tau | 946 | Tyr | 57 |
| Asp | 9 | Phe | 26 |
| Thr | 82 | Trp | 20 |
| Ser | 95 | His | 23 |
| Glu | $\boxed{109}$ | Lys | 76 |
| Pro | 98 | Arg | 299 |
| Gly | $\boxed{174}$ | Bet | $\boxed{975}$ |
| Ala | 98 | AMP | $\boxed{90}$ |
| Val | 37 | ADP | 12 |
| Met | 12 | TMAO | 3.2 |
| Ile | 18 | TMA | 1.1 |
| Leu | 24 | $NH_3$ | 8 |

Abbreviations used: Tau, taurine; Bet, glycine betaine; TMAO, trimethylamine oxide: TMA, trimethylamine.



Extractive components in the adductor muscle of scallop (mg/100g)

| | | | | | |
|---|---|---|---|---|---|
| Free amino acids | | Tyrosine | - | Organic bases | |
| Taurine | 784 | Phenylalanine | 2 | Glycine betaine | 339 |
| Aspartic acid | 4 | β-Alanine | 2 | TMAO | 20 |
| Threonine | 16 | β-Aib | 3 | TMA | 19 |
| Serine | 8 | Ornithine | 1 | Homarine | 79 |
| Glutamic acid | 140* | Lysine | 5 | Trigonelline | 32 |
| Proline | 51 | Histidine | 2 | Organic acids | |
| Glycine | 1925* | Arginine | 323* | Succinic acid | 10 |
| Alanine | 256* | Ammonia | 4 | Inorganic ions | |
| Valine | 8 | Nucleotides etc. | | $Na^+$ | 73* |
| Cystine | 8 | AMP | 172* | $K^+$ | 218* |
| Methionine | 3 | Inosine | 14 | $Ca^{2+}$ | + |
| Cystathionine | 4 | Hypoxanthine | 2 | $Mg^{2+}$ | + |
| Isoleucine | 2 | | | $Cl^-$ | 95* |
| Leucine | 3 | | | $PO_4^{3-}$ | 213 |

β-Aib, β-aminoisobutyric acid; TMAO, trimethylamine oxide; TMA, trimethylamine. - ,not detected; + ,trace amount.





Extractive components in short-necked clam (mg/100g)

| | | | | | |
|---|---|---|---|---|---|
| Free amino acids | | Phenylalanine | 3 | TMA | 4 |
| Taurine | 555* | β-Alanine | 2 | TMAO | 3 |
| Aspartic acid | 18 | β-Aib | 1 | Organic acids | |
| Threonine | 5 | Ornithine | 2 | Oxalic acid | 119 |
| Serine | 7 | Trypyophan | 3 | Succinic acid | 65* |
| Glutamic acid | 90* | Lysine | 6 | Sugars | |
| Proline | 3 | Histidine | 3 | Mannose | 3 |
| Glycine | 180* | Arginine | 53* | Glucose | 3 |
| Alanine | 74 | Ammonia | 1 | Inorganic ions | |
| Valine | 4 | Nucleotides etc. | | $Na^+$ | 378* |
| Methionine | 3 | ADP | 9 | $K^+$ | 273* |
| Cystathionine | 2 | AMP | 28* | $Ca^{2+}$ | 52 |
| Isoleucine | 3 | Inosine | 11 | $Mg^{2+}$ | 40 |
| Leucine | 5 | Organic bases | | $Cl^-$ | 452* |
| Cystine | - | Glycine betaine | 42 | $PO_4^{3-}$ | 72 |

β-Aib, β-aminoisobutyric acid; TMAO, trimethylamine oxide; TMA, trimethylamine.

**Table 8.11** Extractive components in dried skipjack 'Katsuobushi' (mg/100 g)

| | | | | | |
|---|---|---|---|---|---|
| Tau | 32 | Trp | 15 | Gyl | 17 |
| Gly | 26 | Orn | 5 | Ara | 1 |
| Ala | 50 | Arg | 5 | Rib | 2 |
| His | $\boxed{1992}$ | $(Cys)_2$ | 26 | Man | 5 |
| Asp | 2 | β-Ala | 1 | Glc | 6 |
| Glu | $\boxed{23}$ | π-MeHis | 1 | For | 13 |
| Leu | 25 | Ans | 1250 | Ace | 52 |
| Lys | $\boxed{29}$ | Car | $\boxed{107}$ | Prp | 3 |
| Met | 17 | AMP | 52 | Suc | 96 |
| Thr | 11 | IMP | $\boxed{474}$ | Lac | $\boxed{3415}$ |
| Ser | 12 | Ino | $\boxed{186}$ | $Na^+$ | $\boxed{434}$ |
| Pro | 5 | Hyp | 12 | $K^+$ | $\boxed{688}$ |
| Val | 16 | TMA | 19 | $Ca^{2+}$ | 39 |
| Ile | 8 | TMAO | 5 | $Mg^{2+}$ | 124 |
| Tyr | 20 | Cre | 540 | $Cl^-$ | $\boxed{1600}$ |
| Phe | 15 | Crn | $\boxed{1150}$ | $PO_4^{3-}$ | 545 |

Abbreviations used: $(Cys)_2$, cystine; β-Ala, β-alanine; π-MeHis, π-methylhistidine; Ans, anserine; Car, carnosine; Cre, creatine; Crn, creatinine; Gyl, glycerol; Ara, arabinose; Man, mannose; For, formic acid; Ace, acetic acid; Prp, propionic acid.





Extractive components of salted salmon eggs* (mg/100g)

| | | | | | |
|---|---|---|---|---|---|
| Free amino acids | | Tyrosine | 5.6 | Hypoxanthine | 3.4 |
| Taurine | 13.6 | Phenylalanine | 7.6 | Organic bases | |
| Aspartic acid | 12.4 | Lysine | 9.0 | TMA | 1.7* |
| Threonine | 6.6 | Histidine | 2.1 | TMAO | 62.3 |
| Serine | 14.0 | Carnosine | 2.8 | Organic acids | |
| Glutamic acid | 23.5* | Arginine | 6.6 | Oxalic acid | 0.2 |
| α-AAA | 0.6 | Nucleotides etc. | | Citric acid | 0.5 |
| Proline | 3.2 | IMP | 2.7* | Sugars | |
| Glycine | 4.0 | Uridine | 5.1 | Glucose | 8.4* |
| Alanine | 8.9 | Inosine | 7.8* | Inorganic ions | |
| Valine | 9.6 | Adenosine | 4.2* | $Na^+$ | 1165* |
| Methionine | 3.1 | Guanosine | 4.3* | $K^+$ | 191* |
| Isoleucine | 8.6 | Cytosine | 25.1 | $Cl^-$ | 1055* |
| Leucine | 11.7 | Uracil | 3.1* | $PO_4^{3-}$ | 33.3 |

*Only the components used to prepare the synthetic extract are shown.
α-AAA, α-aminoadipic acid; TMAO, trimethylamine oxide; TMA, trimethylamine.





Taste-active components in five kinds of seafoods (mg/100g)

| | Abalone | Sea-urchin | Snow crab | Scallop | Short-neck clam |
|---|---|---|---|---|---|
| Glu | *109* | *103* | *19* | *140* | *90* |
| Gly | *174* | *842* | *623* | *1925* | *180* |
| Ala | 98 | *261* | *187* | *256* | 74 |
| Val | 37 | *154* | 30 | 8 | 4 |
| Met | 13 | *47* | 19 | 3 | 3 |
| Arg | 299 | 316 | *579* | *323* | *53* |
| Tau | 946 | 105 | 243 | 784 | *555* |
| AMP | *90* | 10 | *32* | *172* | *28* |
| IMP | - | 2 | 5 | - | - |
| GMP | - | 2 | *4* | - | - |
| Bet | *975* | 7 | *357* | 339 | 42 |
| Suc | - | 1.2 | 9 | 10 | *65* |
| $Na^+$ | NA | NA | *191* | *73* | *244* |
| $K^+$ | NA | NA | *197* | *218* | *273* |
| $Cl^-$ | NA | NA | *336* | *95* | *322* |
| $PO_4^{3-}$ | NA | NA | *217* | 213 | 74 |





Taste-active components in dried skipjack and salted salmon eggs (mg/100g)

| | Dried skipjack | Salted salmon eggs | | Dried skipjack | Salted salmon eggs |
|---|---|---|---|---|---|
| Glu | *23* | *18.6* | TMA | 19 | *2* |
| Lys | *29* | 9 | Creatinine | *1150* | - |
| His | *1992* | 2.1 | Lactic acid | *3415* | - |
| Carnosine | *107* | 2.8 | Glucose | 6 | *8.4* |
| IMP | *474* | *2.7* | $Na^+$ | *434* | *117* |
| HxR | *186* | *7.8* | $K^+$ | *688* | *19* |
| Adenosine | - | *4.2* | $Cl^-$ | *1600* | *106* |
| Guanosine | - | *4.3* | $PO_4^{3-}$ | 545 | *33* |
| Uracil | - | *3.1* | | | |

**Table 8.14** Effect of omission of each component on the flavour of synthetic extract

| | Sea-urchin | Snow crab | Scallop | Short-necked clam | Dried skipjack |
|---|---|---|---|---|---|
| Glu | um sw | um sw sf | um sw pl | um sw pl | um sw |
| Gly | sw sf **bi** | um sw | sw pl | sw | – |
| Ala | sw **bi** | sw | sw | – | – |
| Arg | **um sw** | sf pl | sf | sf | – |
| IMP | um at | – | – | – | um sw pl |
| AMP | – | um | um sw pl | um sw pl | – |
| $Na^+$ | NA | sw um sf | um sf pl | sw um sa | sa sf pl |
| $Cl^-$ | NA | tl | sw um pl | sw um sa pl | sa sf pl |

Abbreviations used: um, umami; sw, sweetness; bi, bitterness; sf, specific flavour of the seafood; at, aftertaste; pl, palatability; sa, saltiness; –, no effect. Bold letters signify an increase, others a decrease in the specified items.





## Effect of omission of each component on the flavor of synthetic extract

| | 海膽 | 慈愛蟹 | 扇貝柱 | 蜊 | 鰹柴魚 |
|---|---|---|---|---|---|
| Glu | 鮮 / 甜 | 鮮 / 甜 / SF | 鮮 / 甜 / 美味性 | 鮮 /甜 / 美味性 | 鮮 / 甜 |
| Gly | 甜 / 苦 SF | 鮮 / 甜 | 甜 / 美味性 | 甜 | — |
| Ala | 甜 / 苦 | 甜 | 甜 | — | — |
| Arg | 鮮 / 甜 | SF 美味性 | SF | SF | — |
| IMP | 鮮 / 餘味 | — | — | — | 鮮 /甜 / 美味性 |
| AMP | — | 鮮 | 鮮 / 甜 / 美味性 | 鮮 /甜 / 美味性 | — |
| Na+ | ／ | 鮮 /甜 / SF | 鮮 / SF / 美味性 | 甜 / 鮮 / 鹹 | 鹹 / SF 美味性 |
| Cl- | ／ | 鮮 / 甜 / 美味性 | 甜 / 鮮 / 美味性 | 甜 / 鮮 / 鹹 美味性 | 鹹 / SF 美味性 |

紅字表示增強；一表示no effect。SF: specific flavor the seafood；美味性 palatability.





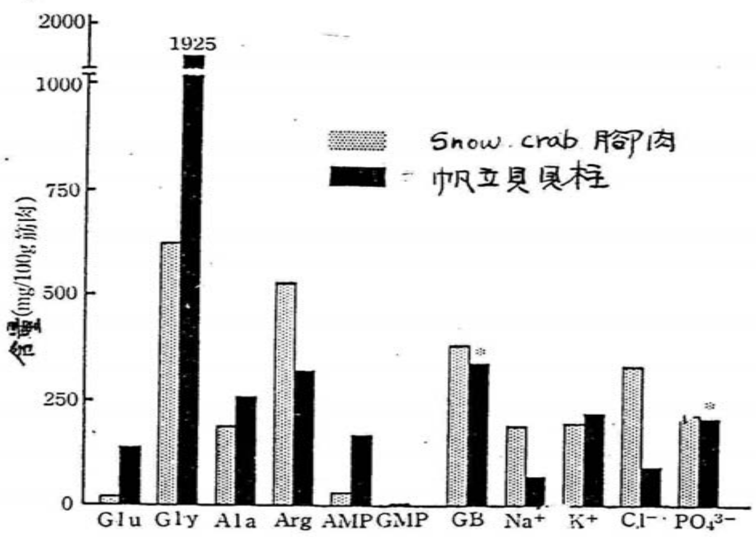



図 8·2 ズワイガニとホタテガイの呈味有効成分の含量の比較
＊：呈味無効と判定されたもの





Nippon Suisan Gakkaishi 55(9), 1599–1603 (1989)

### The Effects of Phosphatase Treatment of Yellowtail Muscle Extracts and Subsequent Addition of IMP on Flavor Intensity

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(Received March 31, 1989)

**Table 1.** Effects of acid phosphatase treatment on flavor score of the boiled muscle extract

| Flavor attributes | Flavor score |
|---|---|
| Umami | $-1.93 \pm 0.19^{+3}$ |
| Sourness | $1.43 \pm 0.20^{+3}$ |
| Thickness | $-1.86 \pm 0.14^{+3}$ |
| Fresh fish flavor | $-1.14 \pm 0.40^{+1}$ |
| Overall taste quality | $-1.93 \pm 0.19^{+3}$ |

The original boiled muscle extract was presented as control.
$+1$, $p < 0.05$; $+3$, $p < 0.001$.

White muscle extract: 0.5 g/mL Dark muscle Extract: 0.33 g/mL

**Table 2.** Effects of the addition of IMP to the enzyme-treated extract on flavor score

| Flavor attributes | IMP added (μmol/ml) | | |
|---|---|---|---|
| | 0.125 | 0.25 | 0.5 |
| Umami | 1.21±0.37$^{+1}$ | 0.93±0.07$^{+3}$ | 1.29±0.19$^{+3}$ |
| Sourness | −0.21±0.29 | −0.21±0.31 | −1.07±0.23$^{+2}$ |
| Thickness | 0.21±0.33 | 1.21±0.37$^{+1}$ | 1.14±0.14$^{+3}$ |
| Fresh fish flavor | 0.14±0.40 | 0.36±0.36 | 0.86±0.14$^{+3}$ |
| Overall taste quality | −0.29±0.34 | 0.36±0.28 | 1.00±0.01$^{+3}$ |

The enzyme-treated extract was presented as control. +1, $p<0.05$; +2, $p<0.01$; +3, $p<0.001$.





**Table 3.** Effect of the high level addition of IMP to the enzyme-treated extract on flavor score

| Flavor attributes | IMP added (μmol/ml) | | | |
|---|---|---|---|---|
| | 1.5 | 2 | 2.5 | 4.0 |
| Umami | −0.71±0.15$^{+2}$ | −0.21±0.29 | 0.21±0.33 | 0.14±0.40 |
| Sourness | 0.71±0.19$^{+2}$ | −0.36±0.32 | −0.36±0.36 | −0.29±0.29 |
| Thickness | −1.00±0.01$^{+3}$ | −0.29±0.36 | −0.21±0.29 | −0.29±0.36 |
| Fresh fish flavor | −0.71±0.19$^{+2}$ | −0.21±0.29 | 3.36±0.32 | 0 ±0.31 |
| Overall taste quality | −1.00±0.01$^{+3}$ | −0.29±0.34 | −0.29±0.34 | −0.29±0.36 |

The original boiled muscle extract was presented as control. +2, $p<0.01$; +3, $p<0.001$.





**Table 4.** Effects of the addition of IMP and Glu to the boiled muscle extracts on flavor score

| Muscles | IMP added | Glu added |
|---|---|---|
| White (15-days storage) | 0.21±0.29 | −0.29±0.29 |
| Dark (1-day storage) | 1.86±0.01$^{+3}$ | 0.14±0.31 |

The original boiled muscle extracts were presented as control.
+3, $p<0.001$.





*From:*

Nippon Suisan Gakkaishi 56(4), 697 (1990)

**Changes in Flavor Profile in Boiled Muscle Extracts of Yellowtail *Seriola quinqueradiata* Stored in Ice**

Michiyo Murata,*[1] Morihiko Sakaguchi,*[1] Tetsuji Shimizu,*[2] and Hajime Eguchi*[3]

(Received July 21, 1989)

**Table 1.** Changes in flavor score of the yellowtail white and dark muscle extracts during ice storage

| | Storage period (days) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | 0 | 2 | 4 | 8 | 12 | 16 | 22 | |
| WHITE MUSCLE | | | | | | | | |
| Umami | 0 | 0.3 ±0.29 | −0.1 ±0.46 | 0.1 ±0.26 | 0.1 ±0.26 | 0.1 ±0.36 | −0.3 ±0.29 | |
| Sourness | 0 | −0.7 ±0.36 | −0.7 ±0.42 | −0.7 ±0.47 | −0.6 ±0.37 | −0.6 ±0.43 | −0.1 ±0.40 | |
| Thickness | 0 | 0.4 ±0.37 | 0.3 ±0.29 | 0.4 ±0.20 | 0.1 ±0.34 | −0.3 ±0.36 | −0.1 ±0.34 | |
| Astringency | 0 | 0 ±0.22 | 0.1 ±0.26 | 0.3 ±0.19 | 0.3 ±0.29 | 0.1 ±0.34 | 0 ±0.00 | *ns* |
| Off-odor | 0 | 0.1 ±0.26 | −0.3 ±0.29 | 0 ±0.22 | −0.1 ±0.40 | −0.1 ±0.46 | 0 ±0.22 | |
| pH | 5.9 | 6.1 | 6.0 | 6.1 | 6.1 | 6.0 | 6.1 | |
| DARK MUSCLE | | | | | | | | |
| Umami | 0 | −0.9 ±0.26*1 | −1.0 ±0.31*1 | −1.0 ±0.38*1 | −1.0 ±0.34*1 | −1.0 ±0.28*1 | −1.3 ±0.28*1 | |
| Sourness | 0 | −0.1 ±0.34 | −0.4 ±0.37 | 0 ±0.43 | −0.4 ±0.37 | −0.3 ±0.19 | −0.1 ±0.34 | *ns* |
| Thickness | 0 | −0.6 ±0.37 | −1.1 ±0.34*1 | −1.3 ±0.36*1 | −1.5 ±0.30*2 | −1.0 ±0.43 | −1.3 ±0.29*2 | |
| Astringency | 0 | −0.1 ±0.26 | −0.1 ±0.26 | −0.1 ±0.26 | 0.4 ±0.30 | 0.9 ±0.26*1 | 0.4 ±0.26 | |
| Off-odor | 0 | −0.6 ±0.43 | −0.3 ±0.20 | −0.3 ±0.36 | −0.4 ±0.48 | 1.1 ±0.14*3 | 1.3 ±0.19*3 | |
| Bitterness | 0 | −0.4 ±0.30 | −0.4 ±0.30 | −0.1 ±0.26 | 0.1 ±0.26 | 1.3 ±0.29*2 | 0.7 ±0.36 | |
| pH | 6.2 | 6.3 | 6.3 | 6.2 | 6.3 | 6.2 | 6.3 | |

flavor score, mean ± SEM.
Symbols: *1, significant at the 95% level; *2, significant at the 99% level; *3, significant at the 99.9% level.