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# Evaluation of taste compounds in water-soluble extract of a *doenjang* (soybean paste)

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**Abstract**

Fractions isolated by gel filtration chromatography from the water-soluble extract of a *doenjang* (soybean paste) were subjected to sensory analysis and chemical analysis in order to elucidate the contribution of taste compounds to their sensory properties. Saltiness was the predominant taste. Next, astringency and umami taste were moderately present. There were also slight notes of sourness, sweetness and bitterness. Saltiness, umami taste and sourness may be directly related to particular taste compounds (NaCl and KCl for saltiness; glutamic acid and aspartic acid for umami taste; lactic acid for sourness) at higher concentrations than their respective reported thresholds. Umami taste may also be directly related to umami peptides. Astringency may be directly related to the presence of phenolics.

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## 1. Introduction

*Doenjang* is a fermented soybean paste used primarily as soup base and as a dipping agent for vegetables and meat in Korea.

It is anticipated that the water-soluble fraction of traditional *doenjang* contains the majority of the taste compounds, e.g. salts, amino acids and peptides, produced during proteolysis. However, no taste components seem to have been analyzed and related to the taste of traditional *doenjang* except for some amino acids and/or organic acids which were determined and overall preference tests were performed (Joo, Kim, & Oh, 1992; Yang, Choi, Kim, & Chung, 1992).

In the present study, fractions were obtained by gel filtration chromatography of the water-soluble extract of a *doenjang* and their chemical composition was related to sensory data to evaluate the contribution of identified compound(s) to the taste of each fraction.

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## 2. Materials and methods

### 2.1. Reagents

HPLC grade water, obtained with a Milli-Q water purification system (Millipore Corp., Bedford, MA), was used throughout the study. All the chemicals were of analytical grade (Sigma, St. Louis, MO).

### 2.2. Preparation of extract

One hundred grammes of a *doenjang* from Suh-Won Nong-San (Korea) was homogenized with 400 ml of pure water. The homogenates were heated to boiling, held for 10 min and left to cool for 50 min while stirring. The mixture was centrifuged at 2000 *g* and at 4 °C for 30 min and the resulting supernatants were filtered through cheese-cloth and freeze-dried. The freeze-dried material (15.5 g) was dissolved in 50 ml of pure water, centrifuged at 105,000 *g* and at 4 °C for 30 min, and filtered with Whatman No. 1 filter paper. The filtered water-soluble extract (WSE) was then stored at −20 °C until used.

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### 2.3. Gel filtration chromatography

WSE (10 ml) was applied onto a XK (Pharmacia Biotech) column (5.0×90 cm) filled with Sephadex G-25. The elution was achieved at a flow rate of 7.5 ml $min^{-1}$ at room temperature with water as the mobile phase to allow sensory evaluation of the recovered fractions. Eluted compounds were detected at 254 nm, 9.0 ml fractions being collected. According to the profile (Fig. 1), eleven fractions were constituted and stored at −20 °C until use.

### 2.4. Analytical methods

The amino acids in the WSE and in each fraction and peptides in the WSE were analyzed before and after hydrolysis to determine amino acid and peptide compositions. When necessary, they were hydrolyzed in 6 M HCl at 110 °C under nitrogen for 24 h. Amino acid composition was determined by a Waters AccQ-Tag Amino Acid Analysis System (1993). Sodium, potassium, phosphorus and calcium ions were determined by inductively coupled plasma atomic emission spectroscopy (Jobin-yvon 138 ultrace, Jobin-yvon, Paris, France). Lactate and chloride were estimated by diagnostic kits (Sigma, St. Louis, MO). Total phenolics were assayed with Folin-Ciocalteu reagent according to the method of Slinkard and Singleton (1997), using ρ-cinnamic acid as a standard.

### 2.5. Sensory analyses

#### 2.5.1. Sensory panel

Three panellists, previously trained to recognize basic tastes (bitterness, saltiness, acidity, sweetness and umami) and astringency, and also known for their accurate sensory evaluation abilities, were recruited from the Food Materials Team of the Korea Food Research Institute.

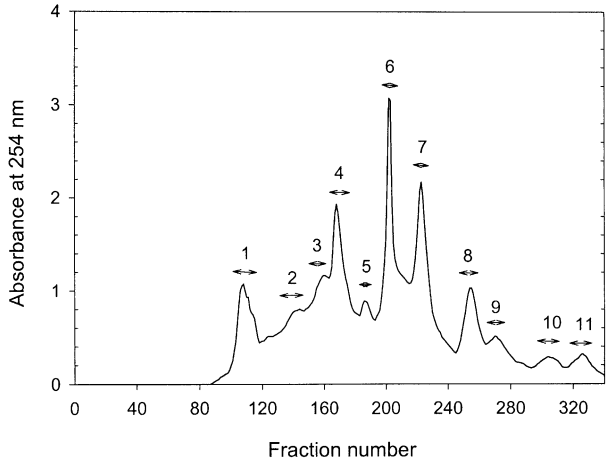


Fig. 1. Sephadex G-25 gel filtration chromatogram of the water-soluble extract of a *doenjang*.

#### 2.5.2. Taste dilution analysis (TDA)

The procedure of Frank, Ottinger, and Hofmann (2001) was followed. Briefly, 1.0 ml each of 11 fractions from gel filtration chromatography was stepwise 1 + 1-diluted with water. The dilutions were judged in a triangle test. The dilution at which a taste difference between the diluted fraction and two blanks (water) could just be detected was defined as the taste dilution (TD) factor.

#### 2.5.3. Taste description and evaluation of the taste intensity

Fractions 1 and 8–11 from gel filtration chromatography could not be differentiated from water in the TDA. Therefore, only the fractions 2–7 were considered for analysis in the current section. The fractions were concentrated five times by freeze-drying and dissolving in one fifth of the original volume of water. The panel was asked to describe the taste in decreasing order of intensity.

## 3. Results and discussion

The composition of the water-soluble extract of the *doenjang* is given in Table 1.

Following gel filtration chromatography of the water-soluble extract of the *doenjang*, 11 fractions were collected as illustrated in Fig. 1. It should be noted that pure water was used as eluent to allow sensory evaluation of the fractions and, therefore, the separation was not exclusively based upon molecular size.

Sensory and chemical analyses were performed on each fraction and they were related to evaluate the contribution of identified compound(s) to the taste of each fraction. As mentioned previously in the Methods section, fractions 1 and 8–11 from gel filtration chromatography, could not be differentiated from water in the taste dilution analysis. Therefore, only the fractions 2–7 were considered further. The results obtained for the taste dilution analysis, taste description and evaluation of the taste intensity of the gel filtration fractions for the

Table 1
Composition of the water-soluble extract of a *doenjang* (g/100 ml)

| | |
|---|---|
| Sodium | 4.41 |
| Potassium | 0.73 |
| Calcium | 0.05 |
| Chloride | 9.35 |
| Phosphorus | 0.19 |
| Lactate | 0.78 |
| Phenolics | 5.98 |
| Amino acids | 2.30 |
| Peptides | 2.89 |

Table 2
Taste dilution (TD) factors and sensory analysis of the Sephadex G-25 gel filtration fractions obtained from the water-soluble extract of a *doenjang*

| Fractions | TD factor | Taste descriptor[a] |
|---|---|---|
| 2 | 1 | Umami |
| 3 | 2 | Astringent |
| 4 | 2 | Umami, sour, astringent |
| 5 | 2 | Salty, umami |
| 6 | 8 | Salty, umami, sweet |
| 7 | 1 | Astringent, bitter |

[a] The taste is described in the decreasing order of intensity.

Table 3
Concentration of the non-nitrogenous compounds identified in each tasted Sephadex G-25 gel filtration fraction obtained from the water-soluble extract of a *doenjang*

| Parameters (mg $l^{-1}$) | Fractions | | | | | | Taste threshold value in water (mg $l^{-1}$)[a] |
|---|---|---|---|---|---|---|---|
| | 2 | 3 | 4 | 5 | 6 | 7 | |
| $Na^+$ (NaCl) | 20 | 0 | 0 | 730 | 3800 | 38 | 0.45–1.4×$10^3$ (NaCl) |
| $K^+$ (KCl) | 0 | 0 | 0 | 53 | 570 | 6 | 1.3×$10^3$ (KCl) |
| $Ca^{2+}$ ($CaCl_2$) | 0 | 0 | 0 | 53 | 14 | 0 | 0.85–1.1×$10^3$ ($CaCl_2$) |
| $Cl^-$ | 40 | 50 | 50 | 170 | 1300 | 60 | |
| P ($H_3PO_4$) | 10 | 0 | 10 | 170 | 13 | 0 | |
| Lactic acid | 14 | 7 | 86 | 250 | 30 | 12 | |
| Phenolics | 170 | 420 | 610 | 360 | 260 | 890 | |

[a] Stahl (1978).

Table 4
Concentration of free amino acids identified in each tasted Sephadex G-25 gel filtration fraction obtained from the water-extract of a *doenjang*

| Amino acids (mg/l) (Vt, ml)[a] | Fractions | | | | | | Threshold value (mg/l) and taste of free amino acids in water[b] | |
|---|---|---|---|---|---|---|---|---|
| | 2 (167) | 3 (105) | 4 (152) | 5 (79) | 6 (98) | 7 (117) | | |
| Asp (Na) | 0 | 0 | 24 | 36 | 4 | 2 | 1000 | Umami |
| Ser | 1 | 2 | 2 | 61 | 13 | 2 | 1500 | Sweet |
| Glu (Na) | 1 | 0 | 150 | 65 | 10 | 2 | 300 | Umami |
| Gly | 1 | 0 | 5 | 16 | 4 | 1 | 1300 | sweet |
| His | 1 | 0 | 2 | 27 | 3 | 1 | 200 | Bitter |
| Thr | 1 | 1 | 4 | 67 | 12 | 0 | 2600 | Sweet |
| Arg | 1 | 1 | 2 | 19 | 14 | 0 | 500 | Bitter |
| Ala | 1 | 1 | 4 | 120 | 13 | 0 | 600 | Sweet |
| Pro | 0 | 2 | 9 | 98 | 8 | 2 | 3000 | Sweet, bitter |
| Cys | 0 | 18 | 150 | 18 | 0 | 5 | nd | |
| Tyr | 0 | 3 | 11 | 2 | 2 | 50 | nd | Bitter |
| Val | 0 | 1 | 6 | 82 | 9 | 0 | 400 | Bitter |
| Met | 1 | 3 | 4 | 0 | 6 | 0 | 300 | Bitter |
| Lys | 1 | 3 | 82 | 27 | 6 | 2 | 500 | Sweet, bitter |
| Ile | 1 | 2 | 9 | 70 | 11 | 1 | 900 | Bitter |
| Leu | 1 | 1 | 3 | 120 | 18 | 2 | 1900 | Bitter |
| Phe | 0 | 1 | 1 | 1 | 22 | 25 | 900 | Bitter |
| Total | 11 | 39 | 468 | 829 | 155 | 95 | | |

[a] Vt = Total volume of the fractions obtained after chromatography of 10 ml water-soluble extract.
[b] Kato, Rhue, and Nishimura (1989).

*doenjang* are shown in Table 2. Non-nitrogenous compounds, such as mineral salts, lactic acid, and phenolics were quantified in each fraction (Table 3). Free amino acids were analyzed in each fraction (Table 4). It should be noted that each fraction was concentrated five times for taste description and evaluation of taste intensity.

Saltiness was the predominant taste in the *doenjang*, as observed in fractions 5 and 6, especially in fraction 6 (Table 2), and may be directly related to the presence of NaCl and KCl in these fractions at higher concentrations than their respective thresholds (Table 3).

Next, astringency and umami taste were moderately present in the *doenjang*. Astringency was present in fractions 3, 4, and 7 (Table 2), and may be directly related to the presence of phenolics in these fractions (Table 3). Presence of phenolics (phenolic acids and isoflavones) in *doenjang* was reported by Lee and Cheigh (1997). Besides tannins, it has been demonstrated that the astringent sensation can also be produced by small molecules, e.g. 5-O-caffoylquinic acid (Naish, Clifford, & Birch, 1993) and monomeric flavonols (Ding, Kuhr, & Engelhardt, 1992; Kallithraka, Bakker, & Clifford, 1997; Thorngate & Noble, 1995).

Umami taste was present in fractions 2, 4, 5, and 6 (Table 2). Umami taste in fractions 4 and 5 may be directly related to glutamic acid and aspartic acid in these fractions at higher concentrations than their respective thresholds (Table 4) and possibly to umami peptides, which may also explain the umami taste of fractions 2 and 6. Umami peptides in *doenjang* have yet to be identified.

There was a slight note of sourness, sweetness and bitterness in the *doenjang* (Table 2). Acidity was observed in fraction 4 and may be directly related to the presence of lactic acid in this fraction at a higher concentration than its threshold (Table 3). It should be noted that there was no sourness detected in fraction 5, though it contained more lactic acid than fraction 4. This may be explained by the decrease of sourness by saltiness (Brannan, Setser, & Kemp, 2001) in fraction 5.

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