

Effect of NaCl/Monosodium Glutamate (MSG) Mixture on the Sensorial Properties and Quality Characteristics of Model Meat Products

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Abstract

Sodium chloride is an important ingredient added to most of foods which contributes to flavor enhancement and food preservation but excess intake of sodium chloride may also cause various diseases such as heart diseases, osteoporosis and so on. Therefore, this study was carried out to investigate the effect of monosodium glutamate (MSG) as a salty flavor enhancer on the quality and sensorial properties of the NaCl/MSG complex and actual food system. For characterizing the spray-dried NaCl/MSG complex, surface dimension, morphology, rheology, and saltiness intensity were estimated by increasing MSG (0-2.0%) levels at a fixed NaCl concentration (2.0%). MSG levels had no effect of the characteristics of the NaCl/MSG complex, although the addition of MSG increased the surface dimension of the NaCl/MSG complex significantly ($p < 0.05$). Furthermore, the effect of MSG on enhancing the salty flavor was not observed in the solution of the NaCl/MSG complex. In the case of an actual food system, model meat products (pork patties) were prepared by replacing NaCl with MSG. MSG enhanced the salty flavor, thereby increasing overall acceptability of pork patties. Replacement of NaCl with MSG (<1.0%) did not result in negative sensorial properties of pork patties, although quality deterioration such as high cooking loss was found. Nevertheless, MSG had a potential application in meat product formulation as a salty flavor enhancer or a partial NaCl replacer when meat products were supplemented with binding agents.

Keywords: NaCl, MSG, spray-drying, saltiness, flavor enhancer

Introduction

It has been known that meat products are one of the foods containing high levels of Na. In spite of the recommendation to reduce Na intake, meat products contain about 1.5-2% NaCl in the formulation owing to its functional properties (Song *et al.*, 2013; Takachi *et al.*, 2013; WHO, 2012). NaCl plays key roles in meat products including extraction of salt-soluble proteins, texturization, binding of water molecules, long-term preservation of the products as well as salty flavor generation (Ahn *et al.*, 2013; Noort *et al.*, 2010). Therefore, reduction of NaCl in the formulation is inevitably manifested as a decrease in its qualities.

Processed meat industry has been facing the challenge of reducing Na in the product formulation. Various strate-

gies have been introduced to reduce Na in the meat product formulations. Theoretically two strategies can be applied, i.e., the substitution of NaCl with other ingredients (replacer) and the enhancement of salty flavor of NaCl (enhancer). The former strategy is being attempted by substituting the Na-salt with other salts including K, Ca and Mg-salts. However, these salts also induce flavor or taste modification of the final meat products (Glabert *et al.*, 2003; Gou *et al.*, 1996). The latter strategy is to add a salty taste enhancer such as hydrolyzed amino acids or yeast extracts (Canto *et al.*, 2014; Corral *et al.*, 2013; Horita *et al.*, 2011).

Monosodium glutamate (MSG, $C_5H_8NO_4Na$) is the most abundant naturally occurring non-essential amino acid and the sodium salt of glutamic acid. As a condiment, glutamate components produce a savory taste (umami taste) of foods (Kurihara, 2008). Actually, MSG has been recognized as a food additive with negative effects to consumers. In recent years, physiological and toxicological evaluations were performed by the Food and Drug Administration (FDA) and World Health Organization (WHO),

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and MSG is now classified as 'Generally Recognized As Safe' (GRAS) (WHO, 2012). MSG affects the food taste by harmonizing and providing a balance of tastes. It was identified that the savory taste enhanced overall food flavor or created a synergistic effect among flavors (Ikeda, 2002; Manabe, 2008; Yamaguchi and Takahashi, 1984).

There are five glutamate salts such as sodium glutamate, potassium glutamate, ammonium glutamate, calcium glutamate, and magnesium glutamate which elicited umami in addition to a certain metallic taste due to the other minerals. Among these salts, MSG was the most soluble and palatable, and crystallized easily. The palatability of MSG depends on the presence of NaCl. Manabe (2008) reported that MSG enhanced the salty flavor although the NaCl concentration was reduced. It is likely that the addition of MSG reduces the total amount of NaCl in the meat product formulation (Kurihara, 2008; Yeomans *et al.*, 2008). Therefore, to elucidate the effect of MSG as a salty flavor enhancer, this study investigated sensorial properties and quality characteristics of the NaCl/MSG mixture and model meat products after partially replacing NaCl with MSG.

Materials and Methods

Materials

NaCl (Taeyungsalt Inc., Korea), maltodextrin (MD, 98%, dextrose equivalent: 15-20, Weifang Codi Imp. & Exp. Co., Ltd., China), and MSG (DAE JUNG Co., Korea) were purchased from a local market as food grade products. Pork legs were purchased randomly from three carcasses at 48 h post-mortem. The meat and backfat were separately ground using a 3 mm plate and vacuum packed in a polyethylene pouch. Prior to patty preparation, meat and fat were stored at 4°C (within 3 h).

Preparation of NaCl/MSG complexes

For the NaCl/MSG complex preparation, 20% (w/v) of NaCl and 10% (w/v) MD as a carrier of NaCl matrix were completely dissolved in distilled water by using a magnetic stirrer at a speed of 500 rpm for 30 min. For MSG treatment, 0.5-2.0% (w/w) of MSG was added to the NaCl/MD matrix. Each mixture was dried using a spray-dryer (SD-1000, Eyela, Japan). The selected spray-drying conditions were inlet temperature of 150°C, atomization pressure of 180 kPa, blow rate of 0.6 m³/min, and flow rate of 500 mL/h, which were optimized in a previous study.

Characterization of NaCl/MSG complexes

The surface dimension of the dried NaCl/MSG complex was assessed by a microscope (Olympus CX31, Olympus Corp., Japan) and particle size was measured using the UTHSCSA image tool (USA). More than 100 particles were captured in one image for calculating the average particle size. For the morphological observation, the NaCl and MSG complex was assessed by a scanning electron microscope (FE-SEM, S-4700, Hitachi, Japan). All of the samples were kept in a desiccator for 24 h and then coated for 40 s with platinum using an ion sputter (E-1010, Hitachi, Japan) at a current of 15 mA.

For the determination of rheology, 1% (w/v) spray-dried NaCl/MSG complex was dissolved in water and shear force of the solution was measured by linearly increasing the shear rate from 1/s to 100/s for 500 s using a rheometer (MCR-302, Anton-Paar, USA) fitted with a concentric cylinder for measuring the geometry 303316 (DG26.7/T200/AL). The measurement was conducted at a constant temperature of 25°C.

To determine the saltiness of the complex, the complex solution (1%, w/v) was tempered at an ambient temperature for 2 h. Saltiness intensity was measured using a 5-point hedonic scale. The trained panel test was conducted by 8 panelists who were already trained by testing 12 different concentrations (25 mM to 80 mM) of NaCl solution.

Characteristics of model meat products prepared using MSG

Part of NaCl was substituted with MSG and the mixed powder was directly added in the pork patty formulation. Pork patties were prepared by mixing 80 g of meat, 20 g of fat, and 1.5 g of curing ingredient (NaCl or NaCl/MSG mixture) using a homomixer (5K5SS, Kitchen Aid, USA). As a curing ingredient, powdered NaCl and MSG were mixed in NaCl to MSG ratios of 3:0, 2:1, 1:2 and 0:3 (w/w), respectively. The mixture was shaped manually in the form of a cylinder (2 cm thickness) and placed in a plastic bag. All of the patties were cooked in a 95°C water bath for 30 min and cooled down prior to sensory testing.

For the sensory evaluation, pork patties were cut into 2 cm cubes and tempered at an ambient temperature for 15 min in a plastic bag. The sample cubes were served to 10 panelists trained to test saltiness, juiciness, tenderness, and overall acceptability, and the sensorial intensity of each sample was rated by using the ranking method (Kramer, 1974). The results were analyzed by the rank sum method and differences among means were compared

using the Kramer's statistical chart. In this study, the range of the rank sum test result from 17 to 38 indicated that there was no significant difference among samples ($p < 0.05$) (Kim and Lee, 2001; Kramer, 1974).

Cooking loss and compression test of pork patties were carried out as quality indicators of the treatments. The cooking loss in pork patties was determined by measuring the value of exudation after thermal treatment. Each pork patty was weighed before and after cooking at 95°C for 30 min, and cooking loss was expressed as a percentage of the initial weight. After measuring the cooking loss, double cycled compression test (texture profile analysis) was conducted using a texture analyzer (CT3 Texture Analyzer, BROOKFIELD, USA) equipped with a probe (TA43 sphere 25.4 mm D, BROOKFIELD, USA) under the conditions of target value of 10 mm, trigger load of 20 g, test speed of 0.50 mm/s, target type of 10 mm distance, and 2 cycles.

Statistical analysis

Completely randomized block design was adopted to estimate the effects of MSG levels on the characteristics of the NaCl/MSG complex or on the quality characteristics of pork patties. Analysis of variance was conducted and the means were separated by Duncan's test using the software SPSS 20.0 (SPSS Institute, USA) when the main effect (MSG concentration) was significant ($p < 0.05$).

Results and Discussion

Characteristics of the NaCl/MSG complex

Surface dimensions of the NaCl/MSG complex are presented in Fig. 1. Addition of MSG increased the surface dimension of the NaCl/MSG complex. Mean surface dimension of NaCl without MSG was 25 μm^2 at 60% cumulative distribution. Addition of MSG increased the surface dimension of the complex significantly ($p < 0.05$). The dimension of the NaCl/MSG complexes was largest with 0.5% MSG addition and smallest with 1.0% MSG addition, however, the dimensions of all NaCl/MSG complexes were not significantly different. As expected, MSG was absorbed on the surface of NaCl/MD matrix, which made the NaCl/MSG complex larger than the control (Frascarelli *et al.*, 2012; Kha *et al.*, 2010; Rai *et al.*, 1985; Sivasadas *et al.*, 2008). With respect to morphology (Fig. 1), all of the complexes exhibited a round shape with varying particle size distribution. The particle shape appeared to be uniform with increasing MSG concentration, while aggregated particles were observed with 0.5% MSG addi-

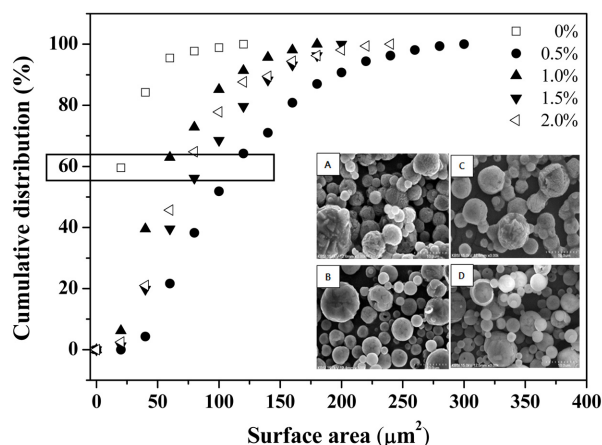


Fig. 1. Surface area of NaCl complexes with the addition of various concentrations of MSG and morphological image of NaCl complexes with the addition of various concentrations of MSG by scanning electron microscope $\times 3000$ magnification (A: 0.5%, B: 1.0%, C: 1.5%, and D: 2.0%).

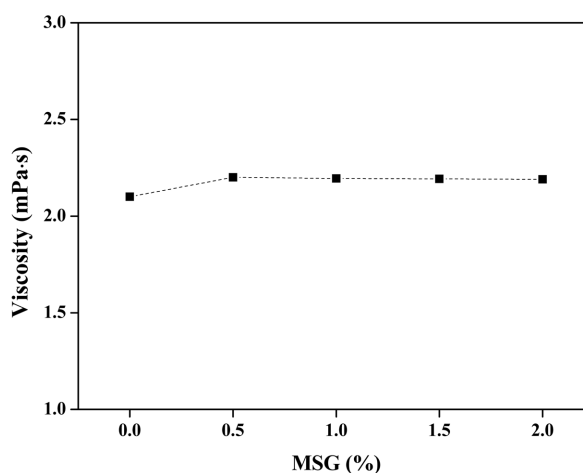


Fig. 2. Saltiness evaluation of the NaCl/MSG complex with addition of various concentrations of MSG.

tion, reflecting a larger surface dimension of 0.5% MSG as described above. The evidence of aggregation was also observed after 1.0% MSG addition, although the intensity of aggregate formation was considerably decreased compared to that after 0.5% MSG addition. Rheological properties of the NaCl/MSG solution showed a Newtonian fluid behavior (Fig. 2). Viscosity of the solution tended to increase with MSG addition, in particular, the solution with 0.5% MSG addition had the highest viscosity among the others. Nevertheless, the difference was not significant, and the viscosity of the solution ranged from 2.0-2.2 mPa·s. The results indicated that the addition of MSG in

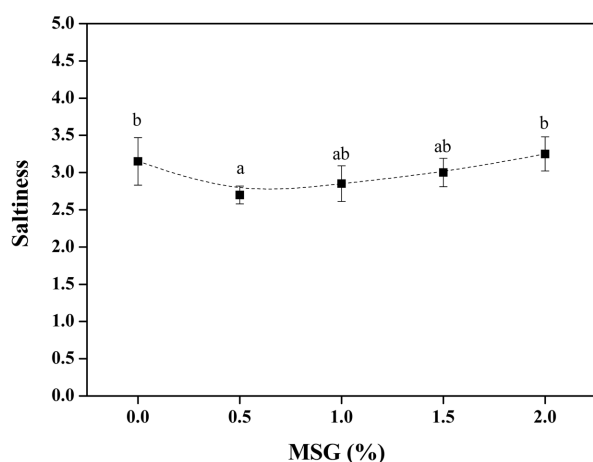


Fig. 3. Viscosity of the solution of NaCl mixed with various concentrations of MSG.

meat product formulation would not lead to rheological and textural modification.

Fig. 3 indicates the saltiness of the NaCl/MSG complex solution. In contrast to the previous expectation, the NaCl/MSG complex with addition of 0.5% MSG showed lower saltiness than that in the control ($p < 0.05$). The saltiness of the NaCl/MSG complex containing more than 1.0% MSG did not differ from that of the control. Although, MSG was expected to be a salty flavor enhancer, the sensorial properties of the NaCl/MSG complex were likely to depend on the food systems. Based on the definition of umami (savory+salty), low level of MSG reduced the salty flavor because of its savory taste (Ikeda, 2002; Manabe, 2008; Yamaguchi and Takahashi, 1984). Therefore, it is essential to use MSG in the actual meat products such as pork patties.

Characteristics of pork patties prepared using MSG

Replacement of NaCl with MSG resulted in poor water binding properties of pork patties. As depicted in Fig. 4A, replacing 0.5% NaCl with the corresponding amount of MSG increased the cooking loss of pork patties from 28% to 39% ($p < 0.05$). With respect to MSG addition, there was no significant difference in cooking loss for pork patties prepared using different MSG concentrations. The results were manifested by less salt-soluble protein extraction caused due to reduction of NaCl in the formulation (Keever, 2011). MSG did not seem to affect the water-binding properties of meat products. Meanwhile, textural properties of pork patties were not affected by MSG levels (Fig. 4B). As found in our preliminary study (data were not shown), reducing the NaCl level resulted in moisture loss

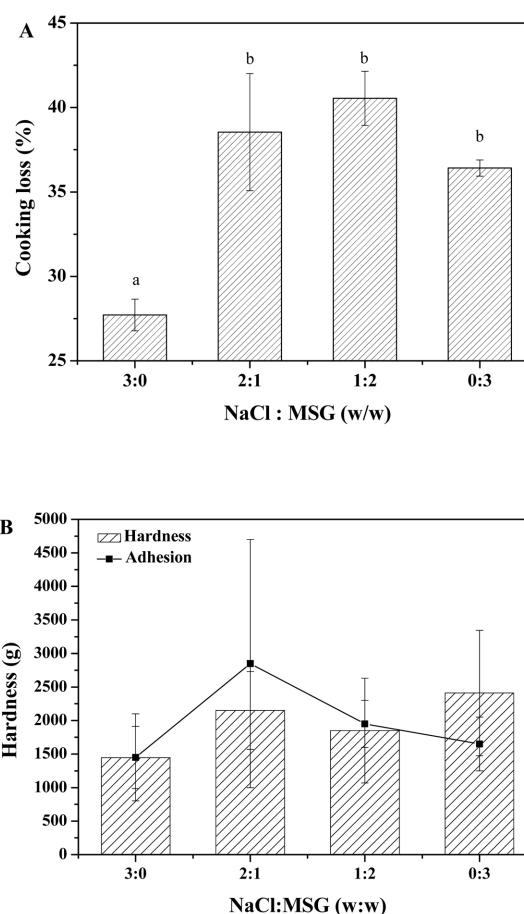


Fig. 4. Cooking loss (A) or texture analysis (B) of pork patties after addition of various MSG concentrations.

which might account for hard texture of meat products. Consequently, it was clear that reducing the NaCl level negatively affected the quality characteristics of meat products. Meanwhile, it may be possible that the quality deterioration is minimized when the meat products are finely ground to form emulsion-type products because of the presence of fat. In this study, the pork patty was adopted as a model meat product, and a fat-free product was prepared initially. The impact of NaCl reduction was more significant in this kind of meat products (Keever, 2011).

Sensorial properties of pork patties prepared using varying MSG concentrations are presented in Fig. 5. Replacing NaCl with MSG up to 1.0% did not affect the saltiness of pork patties and significantly low saltiness was found in the sample prepared using 1.5% MSG (no NaCl) ($p < 0.05$). Because MSG was not classified as a salty taste generator but as a flavor enhancer, MSG alone could not provide the salty flavor of the product. Meanwhile, it was intriguing to note that 1.0% MSG addition caused no difference in the saltiness intensity of pork patties compared

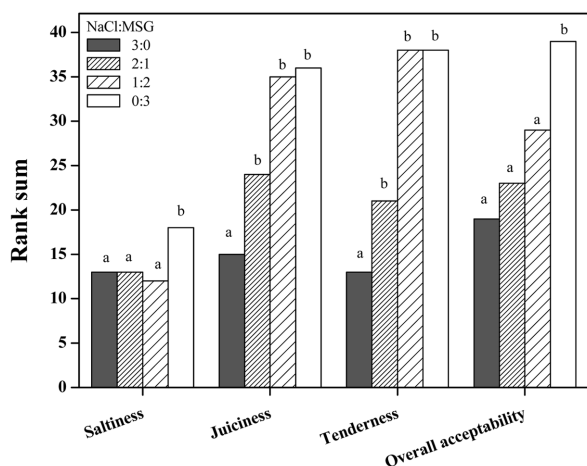


Fig. 5. Effect of MSG concentration on sensory properties of pork patties.

to that in the control. Unlike that in the NaCl/MSG complex, MSG enhanced the salty flavor in the actual meat product. Therefore, it was confirmed that MSG has a potential to replace partial amount of NaCl in the meat product formulation. However, juiciness and tenderness of pork patties prepared using all MSG concentrations were lower than those of the control ($p < 0.05$). Juiciness and tenderness were not different among pork patties prepared using MSG, reflecting that a strategy for improving the processing characteristics has to be applied with the usage of MSG. Alternatively, the addition of MSG up to 1.0% with reduction in NaCl level did not affect the overall acceptability of pork patties. Low acceptability of a pork patty was observed when 1.5% MSG (no NaCl) was added ($p < 0.05$). Therefore, the results supported the possible application of MSG as a salty flavor enhancer of meat products. Although, a technique to prevent the quality loss caused due to reduction in the NaCl level is necessary, MSG (<1.0%) enhanced the salty flavor thereby reducing the NaCl level without causing deterioration of sensorial properties of meat products.

Conclusion

This study explored the effects of MSG as a salty flavor enhancer on the quality and sensorial properties of the NaCl/MSG complex and the actual meat product. It was found that MSG-induced enhancement of salty flavor was better in actual foods than in the simple NaCl/MSG mixture. Although, the mechanisms involved in salty flavor enhancement caused by MSG are still obscure, the present study demonstrated that the addition of MSG was effective

in reducing the NaCl level in the meat product formulation.

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References

- Ahn, S., Park, S., Kim, J. M., Han, S. N., Jeong, S. B., and Kim, H. K. (2013) Salt content of school meals and comparison of perception related to sodium intake in elementary, middle, and high schools. *Nutr. Res. Pract.* **7**, 59-65.
- Canto, A. C. V. C. S., Lima, B. R. C. C., Suman, S. P., Lazaro, C. A., Monteiro, M. L. G., Conte-Junior, C. A., Freitas, M. Q., Cruz, A. G., Santos, E. B., and Silva, T. J. P. (2014) Physicochemical and sensory attributes of low-sodium restructured caiman steaks containing microbial transglutaminase and salt replacers. *Meat Sci.* **96**, 623-632.
- Corral, S., Salvador, A., and Flores, M. (2013) Salt reduction in slow fermented sausages affects the generation of aroma active compounds. *Meat Sci.* **93**, 776-785.
- Frascareli, E. C., Silva, V. M., Tonon, R. V., and Hubingera, M. D. (2012) Effect of process conditions on the microencapsulation of coffee oil by spray drying. *Food Bioprod. Process.* **90**, 413-424.
- Gelabert, J. Gou, P., Guerrero, L., and Arnau, J. (2003) Effect of sodium chloride replacement on some characteristics of fermented sausages. *Meat Sci.* **65**, 833-839.
- Gou, P., Guerrero, L., Gelabert, J., and Arnau, J. (1996) Potassium chloride, potassium lactate and glycine as sodium substitutes in fermented sausages and in dry-cured pork loins. *Meat Sci.* **42**, 37-48.
- Horita, C. N., Morgano, M. A., Celeghini, R. M. S., and Polonio, M. A. R. (2011) Physico-chemical and sensory properties of reduced-fat mortadella prepared with blends of calcium, magnesium and potassium chloride as partial substitutes for sodium chloride. *Meat Sci.* **89**, 426-433.
- Ikeda, K. (2002) New Seasonings. *Chem. Senses* **27**, 847-849.
- Keever, B. D. (2011) Salt concentration and species affects protein extractability and processed meat characteristic. M.D. thesis, University of Illinois, Urbana Champaign, United States.
- Kha, T. C., Nguyen, M. H., and Roach, P. D. (2010) Effects of spray drying conditions on the physicochemical and antioxidant properties of the Gac (*Momordica cochinchinensis*) fruit aril powder. *J. Food Eng.* **98**, 385-392.
- Kim, G. O. and Lee, Y. C. (2001) Sensory evaluation of food products. HakYeonSa. Seoul, Korea, pp. 326-329. (in Korean)
- Kramer, A., Cooper, G. K., and Papavasiliou, D. A. (1974) A non-parametric ranking method for the statistical evaluation of sensory data. *Chem. Senses* **1**, 121-133.
- Kurihara, K. (2009) Glutamate: from discovery as a food fla-

- vor to role as a basic taste (umami). *Am. J. Clin. Nutr.* **90**, 719S-722S.
14. Manabe, M. (2008) Saltiness enhancement by the characteristic flavor of dried bonito stock. *J. Food Sci.* **73**, 321-325.
 15. Noort, M. W. J., Bult, J. H. F., Stieger, M., and Hamer, R. J. (2010) Saltiness enhancement in bread by inhomogeneous spatial distribution of sodium chloride. *J. Cereal Sci.* **52**, 378-386.
 16. Rai, G., Lavernia, E., and Grant, N. J. (1985) Powder size and distribution in ultrasonic gas atomization. *JOM.* **37**, 22-26.
 17. Sivadas, N., O'Rourke, D., Tobin, A., Buckley, V., Ramtoola, Z., Kelly, J. G., Hickey, A. J., and Cryan, S. A. (2008) A comparative study of a range of polymeric microspheres as potential carriers for the inhalation of proteins. *Int. J. Pharm.* **358**, 159-167.
 18. Song, H. J., Cho, Y. G., and Lee, H. J. (2013) Dietary sodium intake and prevalence of overweight in adults. *Metabolism.* **62**, 703-708.
 19. Takachi, R., Ishihara, J., Iwasaki, M., Ishii, Y., and Tsugane, S. (2013) Self-reported taste preference can be a proxy for daily sodium intake in middle-aged Japanese adults. *J. Acad. Nutr. Diet.* **144**, 781-787.
 20. WHO (2012) Guideline: Sodium intake for adults and children, in: W.H.O. (WHO) (Ed.).
 21. Yamaguchi, S. and Takahashi, C. (1984) Interactions of monosodium glutamate and sodium chloride on saltiness and palatability of a clear soup. *J. Food Sci.* **49**, 82-85.
 22. Yeomans, M., Gould, N., Mobini, S., and Prescott, J. (2008) Acquired flavor acceptance and intake facilitated by monosodium glutamate in humans. *Physiol. Behav.* **93**, 958-966.

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