Impacts of sodium chloride reduction in tomato soup system using potassium chloride and amino acids

Identification Number/DOI: https://doi.org/10.17221/140/2018-CJFS <https://doi.org/10.17221/140/2018-CJFS>

Publisher: CAAS

https://doi.org/10.17221/140/2018-CJFS

Impacts of sodium chloride reduction in tomato soup system using potassium chloride and amino acids

Banu Akgün[1], Seda Genc[2], Qiaofen Cheng[3], Özlem Isik[1]*

[1]*Department of Food Additives and Residues, Central Research Institute of Food and Feed Control, Bursa, Turkey*

[2]*Department of Gastronomy and Culinary Arts, School of Applied Sciences, Yaşar University, İzmir, Turkey*

[3]*Department of Food and Nutritional Sciences, University of Reading, Reading, UK*

**Corresponding author: banu.akgun@tarimorman.gov.tr*

Citation: Akgün B., Genc S., Cheng Q., Isık Ö. (2019): Impacts of sodium chloride reduction in tomato soup system using potassium chloride and amino acids. Czech J. Food Sci., 37: 93–98.

Abstract: Five different salt mixtures were prepared for the aim of lowering the sodium content of tomato soup and effects of using these mixtures on sensory, rheological, microbiological and physico-chemical properties of the final products were evaluated. The results showed that the use of salt substitutes did not affect flow behaviour of soup samples. Sensory profiling revealed that any group could not manage to reach the same saltiness level with the regular salt tomato soup (reference); nevertheless, tomato soups with salt formulation *D* (60% NaCl, 28% KCl, 6% L-lysine hydrochloride and 6% L-glutamic acid) and *E* (60% NaCl, 28% KCl and 12% L-glutamic acid) had the most similar sensory evaluation with the reference. No differences were observed among groups in terms of a_w ($P > 0.05$). On the other hand, the lowest average pH value and the highest aerobic mesophilic counts (87 CFU/g) were observed in the soup with salt formulation *E* ($P < 0.05$). The findings suggest that the partial replacement of 40% sodium chloride (NaCl) by 28% potassium chloride (KCl), 6% L-lysine hydrochloride and 6% L-glutamic acid (salt formulation *D*) seems an alternative approach for reducing the sodium content of tomato soups although it may cause a bit decrease in saltiness and an increase in the number of aerobic mesophilic bacteria (68 CFU/g).

Keywords: KCl; L-lysine hydrochloride; L-glutamic acid; NaCl; salt reduction; tomato soup

Salt (NaCl) is a mineral substance which is used for taste, texture and preservation of foods for many years (Kurlansky 2002). It has been reported that the average daily salt intake by adults in many industrialized countries exceeds the upper level of 5 g/day set by the World Health Organization (WHO 2012), which may lead to a number of health problems including high blood pressure, heart and kidney disease (He & MacGregor 2007). The WHO claims that 2.5 million deaths could be prevented every year if the global sodium consumption would be reduced to the recommended value (WHO 2016). On the other hand, lowering the salt level of high-sodium foods such as bread, meat or soup-base products, without decreasing palatability is not an easy activity (Breslin & Beauchamp 1997; Anonymous 2016).

Different techniques have been used to decrease sodium level in food products (Israr *et al.* 2016). The most common method is to utilize mineral salts with an alternative cation for substituting NaCl but their acceptability is limited owing to their noticeable bitter and metallic tastes (Van Der Klaauw & Smith 1995). KCl is the most popular salt substitute since its physical properties are shown similarity with NaCl. However, owing to the higher molecular weight of cations (K^+), KCl may impart off-tastes (bitter, metallic and acrid) if it is added at high concentration (> 30%) (Bartoshuk 2000; Desmond

Supported by the Ministry of National Education of the Republic of Turkey, Project No. YLSY-2012.

https://doi.org/10.17221/140/2018-CJFS

2006; Waimaleongora-Ek 2006). Although KCl has some disadvantages related to undesirable sensory attributes (bitter/chemical/metallic taste and aftertaste) associated with it, it is still the most desirable alternative for sodium reduction (Kilcast & Den Ridder 2007). Thus, combining KCl with some effective taste improving agents (TIAs) (e.g. mineral salts, umami ingredients, food acids, amino acids, spices, simple carbohydrates or food polymers) emerges as an effective strategy to develop sodium reduced products with satisfactory eating quality (Cepanec *et al.* 2017).

As mentioned above, amino acids (e.g. L-lysine and L-arginine) are one of the classes of TIAs and they were employed to enhance the saltiness of salt replacers and mask the off-flavours in several studies (Kemmerer 1956; Turk 1992; Waimaleongora-Ek 2006). On the other hand, these amino acids may cause an astringent response (Kilcast & Den Ridder 2007). Many studies examined the effect of partial NaCl replacement by KCl and/or other mineral salts, e.g. magnesium chloride ($MgCl_2$) and calcium chloride ($CaCl_2$), on some quality attributes of various foods (Frye *et al.* 1986; Alino *et al.* 2009, 2010). Nonetheless, in limited studies, amino acids were used as taste-improving ingredients in KCl based salt substitutes. A study conducted by Zasypkin (2007) showed that the most preferred salt composition was as follows: 10–60% KCl, 30–90% NaCl, 0.1–8% of the amino acids (L-lysine, L-arginine, L-aspartic acid, L-glutamic acid (umami substance) or L-histidine), and 0.1–4.5% food acids (citric, lactic, or malic acid). Additionally, Berglund and Alizadeh (1999) found that the mixture of L-lysine hydrochloride and succinic acid can effectively mask off-tastes of KCl.

It should also be considered that salt in the food products not only influences their tastes but also affects their microbiological safety, texture and other quality properties, such as water activity (a_w) and pH (Doyle & Glass 2010; Akgün *et al.* 2018). Hence, before a market launch of the reformulated products, it is necessary to assess how NaCl replacement will impact these properties. The aim of this work was to investigate the effect of sodium reduction by the use of salt substitutes on the quality of home-made tomato soup. Combining KCl with L-lysine hydrochloride and L-glutamic acid was used to replace 40% of NaCl in tomato soup, the quality properties including sensory, rheological, microbiological and physico-chemical (a_w and pH) were measured to evaluate the feasibility of using this salt mixture to develop low salt tomato soup.

MATERIAL AND METHODS

Materials. The ingredients (unsalted butter, wheat flour, unsalted tomato paste, fresh tomato, dried red pepper and mint) used in tomato soup preparation were purchased from the local market in Bursa (Turkey). L-lysine hydrochloride, L-glutamic acid, NaCl, KCl and taste references (sucrose, citric acid monohydrate, caffeine, tannic acid and monosodium glutamate (MSG)) were from ISOLAB (Izmir, Turkey). Maximum recovery diluent (MRD) and plate count agar (PCA) were provided by Merck (Germany).

Preparation of home-made tomato soups. According to Kremer *et al.* (2009), the salt equivalent of regular salt soup averages around 0.90 g per 100 g. By considering this salt ratio, five different tomato soups were prepared: (*A*) tomato soup with 100% NaCl, (*B*) tomato soup with 60% NaCl and 40% KCl, (*C*) tomato soup with 60% NaCl, 28% KCl and 12% L-lysine hydrochloride, (*D*) tomato soup with 60% NaCl, 28% KCl, 6% L-lysine hydrochloride and 6% L-glutamic acid, (*E*) tomato soup with 60% NaCl, 28% KCl and 12% L-glutamic acid. These ratios were determined after several trials.

To prepare tomato soup, the butter (30 g) was melted in a pan and wheat flour (9 g) was added and stirred on low heat until it was a sandy texture. Tomato paste (20 g) and chopped tomatoes (500 g) were added and stirred. Then, boiling water (600 ml) was poured and whisked to keep smooth. It was simmered for about 30 min until the tomatoes were well softened. Later, red pepper (0.5 g), mint (0.5 g), NaCl, KCl and/or amino acids were added according to above formulations. The mixture was pureed in a blender (Braun, Turkey) at the highest speed for 2 minutes. The recipe for soup was taken from an unpublished survey of homemade tomato soup.

Sensory profiling analysis. Sensory profiling analysis was performed on 5 tomato soup samples according to ISO 6564:1985. The method was used to determine the major flavours in the regular salt home-made tomato soup and the impact of salt reduction on the flavour intensity of tomato soup. The panel including eight assessors – 4 males and 4 females in the age range of 30 to 40 were selected and trained. Assessors were personnel at the Central Research Institute of Food and Feed Control in Bursa (Turkey), all of whom had past sensory experience. A trained sensory panel developed a consensus vocabulary of 6 attributes over 3 tasting sessions. During panel training, the taste standards were served to the assessors to provide reference points for

https://doi.org/10.17221/140/2018-CJFS

taste intensity ratings. Samples (30 ml) were presented monadically in a balanced order with three digit random codes in paper containers and they were asked to rinse their palates between samples with water (Pınar, Turkey). Evaluation of each term (saltiness, bitterness, umami, sourness, sweetness and astringency) was performed individually using 10 cm unstructured line scales (scaled 0–100).

Rheological measurement of tomato soup. The rheological measurements were made on tomato soups by using MCT 302 Rheometer (Anton Paar GmbH, Germany) in the system of concentric cylinder (diameter 27 mm) at room temperature of 25°C and serving temperature of 60°C for shear rate range of 0.1 to 100 s^{-1}. The graph (shear stress versus shear rate) is plotted on a log-log scale and they were fitted to the power law model (Equation 1). Values of consistency coefficient (k) and flow behavior index (n) were found by studying the flow behavior of the tomato soups (Steffe 1996).

$$\sigma = k\,(\ddot{y})n \qquad (1)$$

where: σ – shear stress (Pa); k – consistency coefficient; $\ddot{y}$ – shear rate (s^{-1}); n – flow behavior index

Microbiological analysis. In order to evaluate the microbiological safety of soup products, the numbers of total aerobic mesophilic microorganisms were determined according to ISO 4833-1:2013. Ten grams of a homogenized sample was added to 90 ml of MRD within a stomacher bag and the mixture was homogenized by using a stomacher (AES Chemunex, France). Serial dilutions (10^{-1}, 10^{-2} and 10^{-3}) were prepared with MRD. The inoculation procedure was performed by pour plate technique and petri dishes were incubated at 30°C for 3 days.

pH and a_w analysis. The pH was measured using a digital pH meter (Mettler Toledo, Germany) according to AOAC No. 981.12 (1996). The water activity of soups was measured at 25°C with a water activity meter (AquaLab LITE, USA) as described by AOAC No. 978.18 (1995). Three measurements were taken on the same samples.

Statistical analysis. SPSS 21 (IBM SPSS Statistics 21) was used for statistical analysis. ANOVA was used to decide whether there are any significant differences amongst the viscosity measurements, pH, a_w values and bacterial counts of soup samples. Duncan's Multiple Range Test was used for mean separation for all data at the 5% significance level.

RESULTS AND DISCUSSION

Sensory profiling of tomato soup samples. Six sensory attributes of five tomato soups were evaluated. The sensory panel found that perceived salty, bitter, sour, umami and astringent tastes differed significantly among the evaluated samples ($P < 0.05$) and use of different salt mixtures caused no significant effect on sweet taste ($P > 0.05$) (Table 1). The soup with salt formulation B was found more bitter, astringent and sour but less salty than the reference (A) ($P < 0.05$). Similarly, a study by FSAI (2005) suggested that blending NaCl and KCl (about 50 : 50) in solution caused a considerable rise in bitter and astringent taste and a decrease in salty taste. A much higher saltiness, lower bitterness and astringency value were perceived in the soup with salt formulation C, D and E compared to the soup with salt formulation B. Unfortunately, any reformulated tomato soups could not reach the same level of saltiness with

Table 1. The taste strength of five tomato soups with different salt substitutes

	Formulation				
	A	B	C	D	E
Saltiness	$59.38^{a} \pm 6.23$	$29.75^{c} \pm 7.05$	$35.25^{c} \pm 7.29$	$43.75^{b} \pm 8.48$	$45.25^{b} \pm 3.73$
Bitterness	$10.13^{b} \pm 4.16$	$20.88^{a} \pm 8.11$	$11.50^{b} \pm 3.51$	$12.75^{b} \pm 4.20$	$13.13^{b} \pm 5.51$
Astringent	$12.63^{b} \pm 2.50$	$17.50^{a} \pm 2.07$	$14.88^{ab} \pm 3.64$	$12.25^{b} \pm 4.13$	$12.75^{b} \pm 1.67$
Sweetness	$23.88^{a} \pm 6.27$	$23.50^{a} \pm 3.96$	$24.75^{a} \pm 5.09$	$24.13^{a} \pm 5.17$	$26.63^{a} \pm 3.07$
Sourness	$20.88^{b} \pm 4.19$	$26.75^{a} \pm 7.38$	$26.25^{ab} \pm 4.23$	$26.00^{ab} \pm 5.63$	$26.38^{ab} \pm 3.46$
Umami	$19.63^{bc} \pm 3.02$	$16.50^{c} \pm 2.62$	$19.25^{bc} \pm 5.90$	$23.00^{ab} \pm 2.62$	$25.00^{a} \pm 3.21$

A – 100% NaCl; B – 60% NaCl and 40% KCl; C – 60% NaCl, 28% KCl and 12% L-lysine hydrochloride; D – 60% NaCl, 28% KCl, 6% L-lysine hydrochloride and 6% L-glutamic acid; E – 60% NaCl, 28% KCl and 12% L-glutamic acid. Values are mean ± standard deviation ($n = 8$); different letters in the same line represent significant different arithmetic means ($P < 0.05$)

https://doi.org/10.17221/140/2018-CJFS

the reference one ($P < 0.05$). However, it should be considered that commercial soups sold in different countries may contain salt content lower than 0.9% NaCl. Hence, these alternative salt formulations could be acceptable for those countries. It was also observed that the use of 12% L-glutamic acid increased umami taste of soup ($P > 0.05$). This is an expected result since it is known that L-glutamic acid can elicit the umami taste response (Lindemann *et al.* 2002). Tomato soups with D and E salt formulations seem more appropriate as they presented the most similar sensory profile with the reference apart from slight saltiness difference. Likewise, Kim *et al.* (2015) invented an alternative seasoning comprising L-glutamic acid and L-lysine with no sodium ingredient and it had excellent sensory properties with regard to saltiness and umami.

Rheological behaviour of tomato soup. Flow behaviour characteristic of tomato soups at 60°C was shown in Figure 1. The relation between shear stress–shear rate was nonlinear, indicating that tested tomato soups exhibited a typical non-Newtonian shear-thinning flow behaviour. The power law model was used for describing the flow behaviour of soups since R^2 values were higher than 0.94. In this study, flow index (n) values for each sample were found to be less than unity (0.163–0.270). Thus, tomato soups can be characterized as a pseudoplastic (shear thinning) fluid, and changes in salt and amino acid content or temperature did not alter the rheological class of tomato soup. Additionally, it was seen that the power-law index (n) was not materially affected by salt and amino acid content and temperatures. Similar findings have been reported by other authors (Heikal & Chhinnan 1990; Yilmaz *et al.* 2010). Consistency index (k) gives information about the viscous nature of a food system. Table 2 demonstrated that k changed with salt and amino acid content but

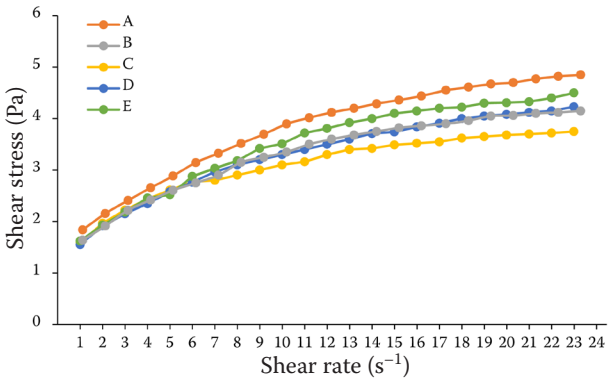

Figure 1. Flow curves of tomato soups at 60°C

Table 2. Rheological parameter of tomato soups at 2 different temperatures

Temperature (°C)	Formulation	Consistency index (k)	Power law index (n)	R^2
	A	4.266	0.165	0.98
	B	4.046	0.191	0.98
25	C	4.217	0.163	0.98
	D	4.560	0.175	0.98
	E	4.487	0.188	0.97
	A	1.982	0.270	0.94
	B	1.862	0.257	0.97
60	C	1.774	0.225	0.98
	D	2.113	0.220	0.96
	E	1.991	0.239	0.94

*For abbreviations see Table 1

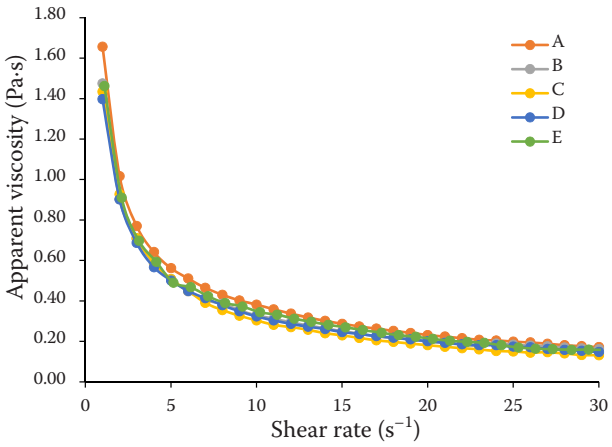

Figure 2. Effect of shear rate on the apparent viscosity of tomato soups at 60°C

there were no consistent trends. Also, a negative correlation was found between k and temperature. As can be seen from Figure 2, the viscosity of tomato soup declined with increasing shear rate. These results were consistent with findings of Ibanoglu (1998).

Microbiological analyses. The numbers of total mesophilic aerobic bacteria of five soup samples were given in Table 3. The counts ranged from 10 to 87 CFU/g. It was seen that a decrease in NaCl concentration led to an increase in total aerobic mesophilic count. Similarly, Laranjo *et al.* (2016) reported that NaCl has an inhibitory effect on mesophilic bacteria. The reason behind is that salts may cause microbial cells (various spoilage or pathogenic bacteria) to experience osmotic shock with a drastic loss of water (Durack *et al.* 2013). Moreover, it was seen that higher numbers of organisms grew in soups

https://doi.org/10.17221/140/2018-CJFS

Table 3. Total aerobic mesophilic counts (CFU/g) of tomato soup samples

Formulation	Total aerobic mesophilic counts
A	$10^{d} \pm 2.8$
B	$29^{c} \pm 4.2$
C	$19^{cd} \pm 1.4$
D	$68^{b} \pm 6.4$
E	$87^{a} \pm 4.9$

Values are mean ± standard deviation (n = 2); different letters in the same column represent significant different arithmetic means (P < 0.05)

containing L-glutamic acid. It is probably because amino acids can be utilized as a primary nitrogen sources by bacteria (Middelboe *et al.* 1995).

Water activity and pH. The pH and a_w of soups were measured at 25°C. The pH values of soup samples were found between 4.55 ± 0.03 and 4.74 ± 0.02. No statistically significant differences were found between pH values of the reference and soup with salt formulation B and C. This is due to the fact that univalent salts (NaCl or KCl) have similar impact on the pH of food (Ichikawa & Shimomura 2007). On the other hand, it was observed that L-glutamic acid addition slightly decreased pH value of the soup. This situation comes from the acidic characteristic of L-glutamic acid (Ophardt 2003). The water activity values of the samples were found between 0.97 ± 0.01 and 0.98 ± 0.01. Similarly, Schweitzer (2013) stated water activity level of tomato soup as 0.96. It was not seen any significant effect of salt replacement on the water activity value of the soup samples (P > 0.05). Accordingly, a study conducted by Campagnol *et al.* (2011) indicated that there was no difference in terms of a_w values between sausages with 100% NaCl and 50% NaCl + 50% KCl.

CONCLUSIONS

The present study has shown the feasibility of a sodium reduction by the use of KCl and amino acids in tomato soup. Under the studied condition, tomato soup with salt formulation D exhibited similar microbiological, physico-chemical, and sensory properties with the reference, whereas a small drop in salty taste perception and an increase in aerobic bacteria count occurred. Considering that reformulation of food products to reduce sodium content has been a central strategy for achieving the population level salt reduction, the current findings should encourage manufacturers to decrease salt concentration in soup products by the incorporation of careful reformulation of KCl and certain amino acids. Future research may need to examine the application of salt reduction strategies in different soup varieties.

Acknowledgement. The authors would like to thank Central Research Institute of Food and Feed Control and the University of Reading for allowing us to use their laboratories, and DYO Çiğli R&D center for rheological analyses.

References

Akgün B., Genç S., Arıcı M. (2018): Tuz: Gıdalardaki Algısı, Fonksiyonları ve Kullanımının Azaltılmasına Yönelik Stratejiler. Akademik Gıda, 16: 361–370.

Alino M., Grau R., Fuentes A., Barat J.M. (2009): Influence of low-sodium mixtures of salts on the post-salting stage of dry-cured ham process. Meat Science, 83: 423–430.

Alino M., Grau R., Toldra F., Blesa E., Pagan M.J., Barat J.M. (2010): Physicochemical properties and microbiology of dry-cured loins obtained by partial sodium replacement with potassium, calcium and magnesium. Meat Science, 85: 580–588.

Anonymous (2016): Türkiye Aşırı Tuz Tüketiminin Azaltılması Programı 2017–2021. T.C. Sağlık Bakanlığı: Ankara.

Bartoshuk M. (2000): Comparing sensory experiences across individuals: recent psychophysical advances illuminate genetic variation in taste perception. Chemical Senses, 25: 447–460.

Berglund K.A., Alizadeh H.: Composition and method for producing a salty taste. U.S. Patent No 5897908, 1999.

Breslin P.A.S., Beauchamp G.K. (1997): Salt enhances flavour by suppressing bitterness. Nature, 387: 563.

Campagnol P.C.B., Santos B.A.D., Wagner R., Terra N.N., Pollonio M.A.R. (2011): The effect yeast extract addition on quality of fermented sausages at low NaCl content. Meat Science, 87: 290–298.

Cepanec K., Vugrinec S., Cvetkovic T., Ranilovic J. (2017): Potassium chloride-based salt substitutes: a critical review with a focus on the patent literature. Comprehensive Reviews in Food Science and Food Safety, 16: 881–894.

Desmond E. (2006): Reducing salt: A challenge for the meat industry. Meat science, 74: 188–196.

Doyle M.E., Glass K.A. (2010): Sodium reduction and its effect on food safety, food quality, and human health. Comprehensive Reviews in Food Science and Food Safety, 9: 44–56.

Durack E., Alonso-Gomez M., Wilkinson M.G. (2013): The effect of salt reduction on the growth of food spoilage

https://doi.org/10.17221/140/2018-CJFS

bacteria in model broth systems and salt-adjusted ready meals. Journal of Food Safety, 33: 302–312.

Frye C.B., Hand L.W., Calkins C.R., Mandigo R.W. (1986): Reduction or replacement of sodium chloride in a tumbled ham product. Journal of Food Science, 51: 836–837.

He F.J., MacGregor G.A. (2007): Dietary salt, high blood pressure and other harmful effects on health. In: Kilcast D., Angus F. (eds): Reducing Salt in Foods. Cambridge, Woodhead Publishing: 18–54.

Heikal Y.A., Chhinnan M.S. (1990): Rheological characterisation of tomato puree at different temperatures using two types of viscometers. Engineering and Food: Physical Properties and Process Control, 133–142.

Ichikawa T., Shimomura M. (2007): Effects of sodium chloride and other salts on the properties of diluted egg white sols and gels. Food Science and Technology Research, 13: 173–177.

Israr T., Rakha A., Sohail M., Rashid S., Shehzad A. (2016): Salt reduction in baked products: Strategies and constraints. Trends in Food Science & Technology, 51: 98–105.

Ibanoglu S., Ibanoglu E. (1998): Rheological characterization of some traditional Turkish soups. Journal of Food Engineering, 35: 251–256.

Kemmerer K.S.: Dietary seasoning composition. U.S. Patent 2829056A, 1956.

Kremer S., Mojet J., Shimojo R. (2009): Salt reduction in foods using naturally brewed soy sauce. Journal of Food Science: 74: 55–62.

Kilcast D., Den Ridder C. (2007): Sensory issues in reducing salt in food products. In: Kilcast D., Angus F. (eds): Reducing salt in foods. Cambridge, Woodhead Publishing: 201–220.

Kim Y., Kang K.K., Han M.H., Park D., Oh J., Park B.: Amino acid seasoning compositions comprising L-glutamic acid and L-lysine. US 20150086692 A1, 2015.

Kurlansky M. (2002): Salt: A World History. London, Jonathan Cape: 1–24.

Laranjo M., Gomes A., Agulheiro-Santos A.C., Potes M.E., Cabrita M.J., Garcia R., Fraqueza M.J. (2016): Characterisation of 'Catalão' and 'Salsichão' Portuguese traditional sausages with salt reduction. Meat science, 116: 34–42.

Lindemann B., Ogiwara Y., Ninomiya Y. (2002): The discovery of umami. Chemical Senses, 27: 843–844.

Middelboe M., Borch N.H., Kirchman D.L. (1995): Bacterial utilization of dissolved free amino acids, dissolved combined amino acids and ammonium in the Delaware Bay estuary: effects of carbon and nitrogen limitation. Marine Ecology Progress Series, 128: 109–120.

Ophardt C.E. (2003): Characteristics and properties of amino acids. Available at http://chemistry.elmhurst.edu/vchembook/561aminostructure.html (accessed May 20, 2018).

Schweitzer K. (2013): Hearts Tomato Soup. Available at http://www.slideshare.net/kristineschweitzer/hearts-tomato-soup (accessed May 15, 2018).

Steffe J.F. (1996): Rheological Methods in Food Processing Engineering (2nd Ed). Michigan, Freeman Press: 131.

Turk R.: Metal free and low metal salt substitutes containing lysine. European Patent 0582036A1, 1992.

Van Der Klaauw N.J., Smith D.V. (1995): Taste quality profiles for fifteen organic and inorganic salts. Physiology & Behavior, 58: 295–306.

Waimaleongora-Ek P. (2006): Sensory characteristics of salt substitute containing L-arginine. [Diploma thesis]. Thammasat University, Thailand.

Yılmaz M.T., Sert D., Demir M.K. (2010): Rheological properties of tarhana soup enriched with whey concentrate as a function of concentratıon and temperature. Journal of Texture Studies, 41: 863–879.

Zasypkin D.V.: Reduced sodium salty taste composition, process for its preparation and food systems containing such composition. U.S. Patent 2009104330A1, 2007.

Received: 2018–05–23
Accepted after corrections: 2019–04–05