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Effect of Sodium-alternative Salts on Physicochemical Properties of Sodium nitrite-cured Salamis

Abstract

To identify the effect of sodium-alternative curing salts on the quality properties of salami through the ripening process, four salami treatments were prepared with different curing salts, T1 (-control, NaCl 1.9%), T2 (+control, NaCl 1.9% + $NaNO_2$ 0.01%), T3 (KCl 1.9% + $NaNO_2$ 0.01%), and T4 ($MgCl_2$ 1.9%+ $NaNO_2$ 0.01%), under 40 days ripening conditions. Sodium-alternative salts (T3 or T4) showed characteristically different quality traits compared with T2. Especially T3 had lower pH, water activity, volatile basic nitrogen, and lipid oxidation after 20 days of ripening period, compare with T2 or T4 (p<0.05). Sodium nitrite had critical impact on increased a* values, and T3 showed higher a* values compared with T2 or T4 (p<0.05). Sodium nitrite reduced initial growth of coliforms but sodium-alternative salts did not affect microbial growth patterns. T2-T4 containing sodium nitrite had higher content of umami nucleotide flavor compounds compared with T1, regardless of the chlorine salt species. The combined use of sodium-alternative curing salts and minimal sodium nitrite was found to be an applicable strategy on development of low sodium salami without a trade-off of the product quality.

Keywords – low sodium salami, sodium-alternative salt, sodium nitrite, physicochemical trait

INTRODUCTION

Sodium chloride (NaCl) not only provides microbial stability due to its capability to reduce water activity, but also helps solubilize myofibrillar proteins and imparts a pleasant salty taste as a flavor enhancer (Martin, 2001). Although NaCl is essential in the human diet, excess sodium intake which may raise the risk of cardiovascular disease with an increase of hypertension (WHO, 2010).

Therefore, possible effects have focused on reducing the level of sodium in meat products (Ruusunen and Puolanne, 2005). Diverse approaches for reducing the sodium level of meat products have been studied, in which sodium chloride was replaced by other chloride salts (KCl, $CaCl_2$ and $MgCl_2$) totally or in part. Especially, KCl was classified as Generally Recognized As Safe (GRAS) by the U.S. FDA (2010) and is also approved by the international regulatory authorities and scientific bodies. The WHO recommended 3.5g of daily dosage for potassium is to be advantageous on keeping blood pressure levels lower (Aburto et al., 2013). A previous study states that the most commonly used sodium-alternative salts, KCl, shows similar functional properties to NaCl. In fermented sausages, the replacement up to 40-50% of NaCl with KCl was adequate to obtain an acceptable meat product, whereas an excessive addition of KCl can lead to flavor and textural defects (Guàrdia et al., 2008). NaCl replacers have their own different amounts of cations and chloride ions. The ionic strength of $MgCl_2$ treatment was higher than that of NaCl, while KCl reduced the ionic strength (Kim et al., 2018).

Thus, the substitution of NaCl to the other chloride salts may delay the reduction of water activity and therefore increasing the post-salting time was needed to acquire similar water activities as compared to the traditional way (Laranjo et al., 2015). Despite the numerous studies in meat products, sodium reduction has been scarcely studied in the fermented meat products. The functions of non-sodium salts such as KCl or $MgCl_2$ with different cations were

not well difined in the fermented meat product of salamis.

Since sodium nitrite is indispensibly used in salamis without significantly affecting the sodium supply, this study was performed to examine the sodium-alternative effects of NaCl by KCl or $MgCl_2$ for manufacturing low sodium salamis containing minimal sodium nitrite during the ripening and drying.

MATERIALS AND METHODS

Salami manufacture

Refrigerated pork hind leg, beef topside round, and frozen pork backfat were purchased from a domestic meat supplier. After the raw materials were sliced, they stored frozen at -24 °C for 2 days. The batters were made with various curing agents in triplicates (12 batches, in total). The mince of salami consisted of 46% pork hind leg, 30% beef topside round, 20% pork back fat and pork skin, 0.5% garlic, 0.1% monosodium glutamate, 0.4% glucose, and 0.2% starter culture. The added meat starter culture (Lyocarni RBL-73, SACCO, Italy) was containing *Lactobacillus curvatus* and *Staphylococcus xylosus* with 2.5×10^6 Log CFU/g and was used at a level of approximately 6 Log CFU/g. Four salami treatments were prepared with different curing salts, sodium chloride (NaCl), potassium chloride (KCl), or magnesium chloride ($MgCl_2$) at 1.9% (w/w meat batter) with sodium nitrite ($NaNO_2$) at 0.01%. The concentrations of additives were determined by preliminary studies. Only NaCl-added treatment without $NaNO_2$ was prepared as negative control. Therefore, the treatments were T1 (-control, NaCl), T2 (+control, NaCl + $NaNO_2$), T3 (KCl + $NaNO_2$), and T4 ($MgCl_2$ + $NaNO_2$).

Pork, beef and pork backfat were chopped in a bowl chopper (Fujee Co., Seoul, Korea), and mixed for 4 min. Ingredients and starter culture were added and mixed in a mixer (Fujee Co., Seoul, Korea). Using a stuffer (H20E, TALSA Co., Northampton, EU), the mince was stuffed

into fibrous casings (55-mm diameter, Seoul, Korea) using a stuffer (H20E, TALSA Co., Northampton, EU). Then these were soaked in solution of *Aspergillus* spp. (obtained from the Korean Agricultural Culture Collection, RDA) for 2 min. The salami samples were streaked onto 18% Glycerol Agar (Dichloran DG18, Kisanbio, Korea) and then incubated at 25 ºC for 7 days. The fungal colonies were diluted with distilled water for producing *Aspergillus* spp. solution. Samples were dried and aged in a dry-ripening room. The relative humidity and temperature were 80-98% and 16-20 ºC during the ripening. Samples for physicochemical analyses were obtained from each treatment and after 20 and 40 days of ripening.

Physicochemical and microbial analysis

The pH of samples was measured by homogenizing a 10 g sample with 90 mL distilled water with a pH meter (PHM201, Radiometer, Villeurbanne, France). A water activity was measured using a water activity meter (Handheld HP23-AW-A, Rotronic AG, Bassersdorf, Switzerland). Volatile basic nitrogen (VBN) was estimated as the method reported by Conway (1950) then reported as mg/100 g. Lipid oxidation was analyzed in triplicate with minor modification of the method of Witte et al. (1970). The absorbance was measured on a spectrophotometer (X-MA 3000, Human Ltd., Seoul, Korea) at 530 nm. Water holding capacity (WHC) was measured using the modified method of Grau and Hamm (1953). Briefly, a sample weighing 300 mg was placed on Whatman No. 1 filter paper and compressed for 2 min. WHC was calculated as follows: WHC (%) = (1 − total meat area / meat film area) × 100.

Total plate counts, lactic acid bacteria counts, *E. coli.* counts of the samples were analyzed according to the guidelines specified in the Criteria and Ingredient Standard of Livestock Products (QIA, 2013). Color values were determined using a chromameter (CR-410, Minolta Co. Ltd., Tokyo, Japan), at three replicates. A texture analyzer (TA-XT2, Stable Micro Systems,

Godalming, UK) equipped with a load cell was (2,500 N) used on texture profile analysis (Bourne, 1978). The samples were reconstructed to 1.5 cm diameter and 1 cm height. Meat sample was compressed to 50% of their height at 1.0 mm/s, with a 50-mm-diameter plunger. The hardness, springiness, cohesiveness, gumminess and chewiness values were measured. Shear force (kgf) was determined by the method described by the procedure of Bourne (1978).

Nucleotide-related compounds

Meat samples (4 g) were mixed with 20 mL of 0.7 M perchloric acid and homogenized (T25b, Ika Works, Malaysia) for 60 sec at 1,230 g to extract nucleic acids. The extracted nucleic acids were centrifuged (Union 32R, Hanil Co., Ltd., Korea) for 14 min at 2,190 g (5°C) and filtered through Whatman No. 4 filter paper (Whatman Inc., England). The supernatant was then adjusted to pH 7 with 5 N KOH (SevenEasy, Mettler-Toledo Int. Inc., Switzerland). The pH-adjusted supernatant was placed in a volumetric flask and adjusted to a volume of 100 mL with 0.7 M perchloric acid (pH 7). After 25 min of cooling, the mixture was centrifuged (Union 32R) at 2,190 g (5°C) and the supernatant was filtered through a 0.2-μm PVDF syringe filter (Whatman). The filtrate was analyzed using a high-performance liquid chromatography (ACME 9000, Young-Lin, Korea) with a Waters-Atlantis C18 RP column (4.6 × 250 mm, 5 μm particles, Waters Co., USA) and a mobile phase of 0.1 M triethylamine in 0.15 M acetonitrile (pH 7.0). The peaks of individual nucleotides were identified using standards of hypoxanthine, inosine, inosine-5-phosphate (Sigma Chemical Co., St Louis, Mo., USA).

Statistical analysis

The experiment was designed and statistically analyzed in factorial (curing agents × ripening time). All the variables measured was analyzed on their variance using the General Linear

Model (GLM) procedure. To determine the differences among the treatment means, the Duncan's multiple range test was used with significance level of $p<0.05$. The SAS statistical software package was utilized (SAS, 2002)

RESULTS AND DISCUSSION

Physicochemical characteristics

The effect of different sodium-alternative curing agents on the physicochemical traits of salamis during ripening is presented in Table 1. After 20 d of ripening of salamis, pH was the highest in T3 but the lowest in T4 ($p<0.05$). The pH values were higher in KCl treatment and lower in $MgCl_2$ than that of NaCl treatments during the ripening period ($p<0.05$). These results are consistent with results of previous report (Kim et al., 2018). This difference was related to the inhibitory action of NaCl substitution by KCl towards the growth of coliforms, which metabolized basic nitrogen compounds leading to pH changes in dry-cured bacons (Alinõ et al. 2010). Gimeno et al. (1999) also reported that NaCl was replaced by a mixture of 44.5 % NaCl, 24.5% KCl, 20.6% $CaCl_2$, and 10.4% $MgCl_2$, and a more decrease in pH on the mixture than NaCl-only formulation. A pattern similar to this was reported for a partial NaCl decrease by a chloride salts mixture (NaCl 10 g/kg and KCl 5.5 g/kg) (Gimeno et al., 2001). During aging and drying of salamis, their pH significantly declined at 20 and 40 days compared to 0 day. After 20 days of ripening, all treatments had pH below 4.9. This rapid decline in pH is vital for inhibiting pathogenic microorganisms, increasing the safety of fermented sausages (Leroy et al., 2006).

As shown in Table 1, there were no significant differences of water activities among the treatments even though T4 had lower A_w than the others at 20 and 40 d. Initial A_w was reduced from around 0.98-0.99 to 0.84-0.86 during the process of ripening and drying. A_w gradually

declined during the ripening of the salamis (p<0.05). These A_w results coincide with the results in salami (Horita et al., 2014).

During ripening and drying, T3 had significantly lower VBN than the other treatments during ripening (p<0.05) (Table 2). These results may be due to the replacement of NaCl by KCl, since the replacement was found to decrease the quantity of salt-tolerant flora and inhibit the growth of coliforms (Alinõ et al. 2010). During the ripening time, the VBN of salamis continuously increased (p<0.05). Our study showed that T3 samples containing KCl and $NaNO_2$ had a positive effect on VBN in salamis during aging.

TBA-reactive substance (TBARS) level is used to set an acceptable limit for rancidity for fresh meat (Ockerman, 1985). As presented in Table 2, T3 had significantly lower TBA than the other treatments at 20 and 40 days (p<0.05). On the other hand, T2 had significantly higher TBA at 20 and 40 days. In general, TBA can be affected by salt concentration (Choi et al., 2016). Low salt concentration tended to reduce lipid oxidation and had a less pro-oxidant effect during aging (Andrés et al., 2004). In this case, it appears that KCl induced slower lipid oxidation than the other curing salts. The TBARS levels increased throughout ripening (p<0.05), which is related to the oxidation by the salt that can be favored by the metallic ions contained as impurities in added curing salts (Lorenzo et al., 2015). KCl may have less impurities acerbating lipid oxidation, which could affect the shelf-life of the salami.

WHC of samples continuously decreased during the ripening and drying phases (Table 2). At 20 and 40 days, T1 showed higher WHC than that of the other samples (p<0.05). The result is supported by Kim et al. (2018) finding highest water-holding capacity could be expected at ionic strength 1.0-1.5 with high pH and the substitution by KCl reduced the ionic strength. As the level of NaCl was reduced, the amount of soluble myofibrillar proteins decreased (Gordon & Barbut, 1992). As a results of reducing ionic strength or changing in charge density by using

different salts, the water-holding capacity and the gel strength could be changed (Whiting, 1984).

The microbiological characteristics using different curing agents are presented in Table 2. No significant differences among treatments were observed regarding total plate counts, lactic acid bacteria counts ($p>0.05$). These reports are in agreement with Alino et al. (2010) and Aaslyng et al. (2014) who did not find significant differences among the chloride salts used. LAB showed a strong increase above 8.0 Log CFU/g after 20 days without changes until the end of manufacturing. This result was similar to that reported by Campagnol et al. (2011). Coliforms were not detected in the sodium nitrite-added treatment groups in comparison of the only sodium-added treatments at 0 day, which was because the bacteria have low resistance to acidification (González-Fernández et al., 2006). From this result, the growths of total plate count and LAB were not affected by use of sodium-alternative curing salts.

The influence of curing agents on the salami meat color during ripening is shown in Table 3. T3 samples showed a higher redness value (a*) than the other samples, while T1 showed lowest value ($p<0.05$). Treatments with sodium-nitrite had higher redness value (a*) compared with T1 (only NaCl-added). Thus, sodium nitrite showed more favorable red color in salami.

T1 samples exhibited a higher yellowness (b*) value than the other samples, while T4 showed a significantly lower value. Choi et al. (2016) showed KCl-added sausages were redder than those made with NaCl. The L*, a*, and b* values in all samples continuously declined during the aging ($p<0.05$), and the results were same as that from another study (Papadima and Bloukas, 1999). A reduction in a* values of the sausages can be attributed to the oxidation of nitrosylmyoglobin to nitrate and brown metmyoglobin (Gøtterup et al., 2008).

198 **Texture profiles**

199 T1 samples had a lower shear force than the other samples (p<0.05, Table 4). In addition, T1
200 lower springiness, cohesiveness, and gumminess values, whereas T4 showed a significantly
201 higher values. The higher texture parameters might be partly attributed to the reduction of
202 bound water during aging (Horita et al., 2014). In addition, NaCl reduction in sausages could
203 destroy the texture-profile of sausages due to the reduced ionic strength and charge density,
204 which causes a decrease in the soluble myofibrillar proteins (Toldrá 1998). Previous researches
205 have indicated that $MgCl_2$ or $CaCl_2$ can increase hardness because of negative attribution of
206 divalent salt (Ca^{2+}) to water-binding capacity (Horita et al., 2014). The present study showed
207 an similar trend in texture profiles at the end of aging. Campagnol et al. (2011) reported that
208 the NaCl replacement or reduction could decrease the textural properties of salamis. Lücke
209 (1998) attributed this to the ability of NaCl to solubilize and diffuse muscle myofibrillar
210 proteins forming gel between the meat and fat particles, thus favoring slicing and improving
211 the juiciness and texture of the product. All texture parameters in all samples increased
212 continuously and steadily during the ripening (p<0.05), by the lower moisture content. This
213 findings was similar to that reported by Lorenzo et al. (2015) who reported that shear force
214 showed a marked rise during aging.

215

216 **Nucleotide-related compounds**

217 A further basic taste sensation called 'umami' has been expressed as the taste of monosodium-
218 glutamate (MSG), guanosine 5-monophosphate (GMP), and inosine 5-monophosphate (IMP)
219 (Mateo et al., 1996). The role of IMP for the generation of meat odor and flavor has been
220 demonstrated in sensory studies (Aristoy and Toldrá, 2009). As shown in Table 5, treatments
221 with sodium-nitrite had higher contents of GMP and IMP compared with T1 (only NaCl-added)

(p<0.05). Thus, sodium nitrite showed desirable umami flavor-enhancing activities in salami ripening. The results show that sodium nitrite might possibly affect more directly the formation of nucleotides-related flavor compounds rather than chloride salts. However, little effect was found on the nucleotides and nucleotides degradation products in cured meat products owing to the antioxidant effect of sodium nitrite (Feng et al., 2017).

CONCLUSION

Sodium-alternative salts (KCl or $MgCl_2$) replacing NaCl strongly influenced the quality traits of salami throughout the ripening processing. Addition of KCl or $MgCl_2$ showed different patterns at certain meat quality attributes. In case of salami texture, $MgCl_2$ showed greater hardness due to the formation of relatively hard skin coat surrounding salami circumferences. Although it is not easy to select an appropriate sodium-alternative curing salts for manufacturing low-sodium salamis, a sodium-alternative salt can be used considering targeted meat quality traits of the meat products. From result of the present study, KCl can be used for the purpose of sodium reduction in salamis with improved physicochemical characteristics. Especially, the substitution of NaCl to KCl had advantages in maintaining relatively high pH, low protein degradation, and low lipid oxidation during the 40 days of ripening. Besides, KCl showed more favorable red color in salami. Sodium nitrite showed its own characteristic impact on especially color and microbiological safety of fermented salamis. Therefore, combined use of sodium-alternative curing salts with minimal amounts of sodium nitrite can be used for the development of lower sodium salami products without adverse effects on the physicochemical traits.

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TABLE 1. Effect of different curing salts on pH and water activity of salamis during ripening

		Days of ripening			
		0	20	40	SEM
pH	T1[1]	5.35^{Aa}	4.78^{Ab}	4.87^{Ab}	0.01
	T2	5.36^{Aa}	4.75^{Bb}	4.78^{Bb}	0.01
	T3	5.36^{Aa}	4.42^{Db}	4.43^{Db}	0.01
	T4	5.26^{Ba}	4.60^{Cb}	4.68^{Cb}	0.01
	SEM	0.01	0.01	0.01	0.01
A_w	T1[1]	0.99^{a}	0.85^{b}	0.84^{b}	0.01
	T2	0.98^{a}	0.83^{b}	0.84^{b}	0.01
	T3	0.98^{a}	0.83^{b}	0.84^{b}	0.01
	T4	0.98^{a}	0.87^{b}	0.86^{b}	0.01
	SEM	0.02	0.03	0.02	

[1] T1: NaCl 1.9%; T2: NaCl 1.9%+ $NaNO_2$ 0.01%; T3: KCl 1.9%+ $NaNO_2$ 0.01%; T4: $MgCl_2$ 1.9%+ $NaNO_2$ 0.01%

[2]Standard error of the means (n=16).

[a-c] Figures with different letters within a same row differ significantly (p<0.05).

[A-D] Figures with different letters within a same column differ significantly (p<0.05).

TABLE 2. Effect of different curing salts on the physicochemical traits of salamis during ripening

		Days of ripening			
		0	20	40	SEM
VBN (mg%)	T1[1]	6.13^{Ac}	19.57^{Cb}	31.88^{Ca}	0.17
	T2	4.93^{Bc}	20.62^{Bb}	34.97^{Ba}	0.15
	T3	3.72^{Cc}	19.61^{Cb}	31.95^{Ca}	0.21
	T4	4.55^{Bc}	21.61^{Ab}	40.26^{Aa}	0.12
	SEM	0.01	0.21	0.10	
TBARS (mg MDA/kg)	T1[1]	0.67^{Ac}	1.17^{Cb}	1.37^{Ca}	0.01
	T2	0.55^{Cc}	1.90^{Ab}	2.01^{Aa}	0.01
	T3	0.60^{Bc}	1.03^{Db}	1.15^{Da}	0.01
	T4	0.55^{Cb}	1.56^{Ba}	1.47^{Ba}	0.01
	SEM	0.01	0.01	0.01	0.01
WHC (%)	T1[1]	95.08^{Aa}	49.32^{Ab}	42.20^{Ac}	4.02
	T2	87.01^{Ba}	36.46^{Bb}	29.26^{Bb}	15.99
	T3	92.34^{Aa}	34.60^{Bb}	30.07^{Bb}	6.35
	T4	96.69^{Aa}	30.78^{Cb}	28.74^{Bb}	3.27
	SEM	5.22	1.82	3.69	
Total plate counts (Log CFU/g)	T1[1]	7.21^{c}	7.81^{b}	7.93^{a}	0.19
	T2	7.24^{c}	7.35^{b}	7.56^{a}	0.05
	T3	7.12^{b}	7.13^{b}	7.26^{a}	0.08
	T4	7.15^{b}	7.14^{b}	7.29^{a}	0.06
	SEM	0.22	0.80	0.78	
Lactic acid bacteria (Log CFU/g)	T1[1]	7.02^{b}	8.19^{a}	8.43^{a}	0.65
	T2	7.04^{b}	8.47^{a}	8.21^{a}	0.57
	T3	7.09^{b}	8.43^{a}	8.18^{a}	0.67
	T4	7.01^{b}	8.09^{a}	8.10^{a}	0.63
	SEM	0.26	0.58	0.51	
Coliforms (Log CFU/g)	T1[1]	1.25^{A}	1.76	<0.1	-
	T2	0.94^{B}	<0.1	<0.1	-
	T3	0.85^{B}	<0.1	<0.1	-
	T4	0.98^{B}	<0.1	<0.1	-
	SEM	0.15	-	-	

[1] T1: NaCl 1.9%; T2: NaCl 1.9%+ $NaNO_2$ 0.01%; T3: KCl 1.9%+ $NaNO_2$ 0.01%; T4: $MgCl_2$ 1.9%+ $NaNO_2$ 0.01%

[2]Standard error of the means (n=16).

[a-c] Figures with different letters within a same row differ significantly (p<0.05).

[A-D] Figures with different letters within a same column differ significantly (p<0.05).

363 **TABLE 3.** Effect of different curing salts on color values of salamis during ripening

		Days of ripening			
		0	20	40	SEM
L*	T1[1]	56.71^{a}	46.68^{b}	43.71^{b}	0.05
	T2	53.69^{a}	45.98^{b}	44.14^{b}	0.14
	T3	55.28^{a}	44.06^{b}	41.33^{b}	0.14
	T4	53.04^{a}	41.83^{b}	40.84^{b}	0.08
	SEM	0.02	0.13	0.16	
a*	T1[1]	2.37^{Da}	2.04^{Db}	0.47^{Dc}	0.01
	T2	6.35^{Ba}	4.09^{Bb}	2.75^{Bc}	0.01
	T3	7.78^{Aa}	5.78^{Ab}	2.99^{Ac}	0.01
	T4	4.59^{Ca}	3.22^{Cb}	1.40^{Cc}	0.01
	SEM	0.01	0.01	0.01	0.01
b*	T1[1]	9.96^{Aa}	5.57^{Ab}	4.51^{Ac}	0.01
	T2	8.27^{Ca}	3.85^{Cb}	1.41^{Cc}	0.01
	T3	8.89^{Ba}	4.94^{Bb}	1.81^{Bc}	0.01
	T4	7.59^{Da}	3.18^{Db}	1.27^{Dc}	0.01
	SEM	0.02	0.01	0.01	

364 [1] T1: NaCl 1.9%; T2: NaCl 1.9%+ $NaNO_2$ 0.01%; T3: KCl 1.9%+ $NaNO_2$ 0.01%; T4: $MgCl_2$ 1.9%+
365 $NaNO_2$ 0.01%
366 [2]Standard error of the means (n=16).
367 [a-c] Figures with different letters within a same row differ significantly (p<0.05).
368 [A-D] Figures with different letters within a same column differ significantly (p<0.05).
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370 **TABLE 4.** Effect of different curing salts on texture profiles of salamis during ripening

		Days of ripening			
		0	20	40	SEM
Shear force (kg)	T1[1]	0.07^{Bc}	0.27^{Bb}	1.93^{Ba}	0.01
	T2	0.09^{Ac}	1.29^{Ab}	3.46^{Aa}	0.08
	T3	0.09^{Ac}	1.09^{Ab}	3.44^{Aa}	0.07
	T4	0.10^{Ac}	1.33^{Ab}	2.92^{Aa}	0.18
	SEM	0.01	0.05	0.14	
Hardness (kg)	T1[1]	0.22^{Ac}	0.74^{Cb}	4.24^{Ca}	0.01
	T2	0.22^{Ac}	2.63^{Ab}	4.82^{Ca}	0.16
	T3	0.20^{Bc}	1.79^{Bb}	9.45^{Ba}	0.09
	T4	0.16^{Cc}	1.48^{Bb}	12.12^{Aa}	0.37
	SEM	0	0.08	0.86	
Springiness	T1[1]	0.31^{Cb}	0.34^{Cb}	0.42^{Ca}	0.01
	T2	0.36^{Bb}	0.52^{Ba}	0.47^{Ba}	0.01
	T3	0.37^{Bb}	0.51^{Ba}	0.50^{Ba}	0.01
	T4	0.42^{Ab}	0.60^{Aa}	0.57^{Aa}	0.01
	SEM	0.01	0.01	0.01	
Cohesiveness	T1[1]	0.27^{Cb}	0.32^{Ca}	0.33^{Ca}	0
	T2	0.44^{Ab}	0.46^{Aa}	0.46^{ABa}	0
	T3	0.35^{Bb}	0.39^{Ba}	0.40^{BCa}	0
	T4	0.45^{Ac}	0.48^{Ab}	0.50^{Aa}	0
	SEM	0	0	0	
Gumminess	T1[1]	0.17^{Bc}	0.24^{Cb}	1.34^{Ba}	0
	T2	1.03^{Ac}	1.38^{Bb}	1.46^{Ba}	0.02
	T3	0.61^{ABb}	3.85^{Aa}	3.80^{Aa}	0.07
	T4	1.02^{Ac}	3.14^{Ab}	3.69^{Aa}	0.12
	SEM	0.06	0.19	0.05	
Chewiness	T1[1]	0.05^{Cc}	0.09^{Cb}	0.13^{Ca}	0
	T2	0.53^{Bb}	0.53^{Bb}	0.63^{Ba}	0.01
	T3	0.72^{Ab}	0.81^{Ab}	1.32^{Aa}	0.02
	T4	0.44^{Bc}	0.70^{Ab}	1.42^{Aa}	0.03
	SEM	0.01	0	0.03	

371 [1] T1: NaCl 1.9%; T2: NaCl 1.9%+ $NaNO_2$ 0.01%; T3: KCl 1.9%+ $NaNO_2$ 0.01%; T4: $MgCl_2$ 1.9%+
372 $NaNO_2$ 0.01%
373 [2]Standard error of the means (n=16).
374 [a-c] Figures with different letters within a same row differ significantly (p<0.05).
375 [A-D] Figures with different letters within a same column differ significantly (p<0.05).
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TABLE 5. Effect of different curing salts on the nucleotide contents (mg/100 g) of salamis during ripening

	GMP	AMP	IMP	Inosine	Hypoxanthine
T1[1]	1.44[b]	0.18	1.89[b]	0.72	73.78
T2	2.44[a]	0.20	2.22[a]	1.23	87.70
T3	2.36[a]	0.15	2.22[a]	1.91	80.22
T4	2.54[a]	0.16	2.39[a]	2.88	79.49
SEM[2]	0.10	0.02	0.24	0.50	4.91

[1] T1: NaCl 1.9%; T2: NaCl 1.9%+ $NaNO_2$ 0.01%; T3: KCl 1.9%+ $NaNO_2$ 0.01%; T4: $MgCl_2$ 1.9%+ $NaNO_2$ 0.01%

[2]Standard error of the means (n=16).

[A-B] Figures with different letters within a same column differ significantly (p<0.05).