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ARTICLE

Comparison of Meat Quality Traits in Salami Added by Nitrate-free Salts or Nitrate Pickling Salt during Ripening

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Abstract The intent of this study was to scrutinize the consequence of salt type [sun-dried salt, refined salt, baked salt, or nitrate pickling salt (NP)] on the physicochemical and microbiological features of salami formulated by soaking with *Aspergillus* spp. before ripening. The effects of nitrate-free salts added were not significant. Nitrate pickling salt samples were significantly higher in protein level, whereas those were lower in fat level during ripening ($p<0.05$). The pH of salamis treated with NP was higher than that of other salt treatments, while weight losses of those was lower ($p<0.05$). During the ripening and drying, NP produced lower extent of volatile basic nitrogen and lipid oxidation than those with other salts ($p<0.05$). The total aerobic population counts of NP samples revealed lower than that of other samples over the ripening time. The addition of NP in salamis produced redder sausages. The salamis containing NP found to be better physicochemical and microbiological quality attributes than the other salt types.

Keywords salami, nitrate-free salts, nitrate pickling salt, quality

Introduction

Although a demand for low salt products has grown owing to health concerns, 2%–4% NaCl is mainly employed for producing dry-fermented sausages (Ruusunen and Puolanne, 2005). It acts as a flavor and texture enhancer (Matulis et al., 1995), as well as ensures microbiological safety by lowering the water activity (Safa et al., 2015). Due to antimicrobial activity, nitrite and nitrate could be generally added as preservatives in salamis (Sebranek and Bacus, 2007). Moreover, these curing salts are mostly responsible for color formation as well as flavor in meat products (Olesen et al., 2004) and the oxidative stability of lipids is the results of these types of salts, that promots aroma triggering (Stahnke and Tjener, 2007).

Types of commonly used salt are refined salt (RS), sun-dried salt (SD), and processed salt in food and meat processing (Choi et al., 2016). Although SD is made of

seawater, it depends on evaporation from natural sun- and wind-mediated of salt brine that is held in open ponds. It consists of 92.4%–94.4% NaCl, and diverse minerals like calcium, potassium, magnesium as well as sulfur (Ha and Park, 1998). RS, containing 99.8% sodium chloride that is produced by electrodialysis applying ion-exchange membranes with successive evaporation in an evaporator tube from seawater (Choi et al., 2016). At present, RS is commonly added in meat processing. Baked salt is produced by roasting at more than 800°C two times to remove impurities and bittern. An ordinary salt type commercially used in meat industry is nitrate pickling salt (NP) containing approximately 0.4% sodium nitrate/nitrite added and helping to fix color and preserve meat products.

Salami basically meant all kinds of salted meats and voided into a casing, then lynch it to withstand for aging and drying process for months (Olivares et al., 2009). During the stage of salami production, various moulds on the surface of salami could be formed (Comi et al., 2004). It has been observed by (Nunez et al., 1996) in salamis, that typical flavor, delay rancidity as well as unwanted bacteria are imparted albeit moulds are used. Approximately 10^6 colony forming units (CFU)/mL of water was found when diluted mold starter cultures were used through spraying with or dipping in solutions (Jessen, 1995). Mould coated dry sausages are very popular in many countries i.e. Spain, Italy, and Germany (Comi et al., 2004), but very few studies have dealt with salami production with a mould coating in Asian countries. Added salt plays an important role during ripening of dry sausages in terms of storage, quality, and functional properties of the meat products.

The effect of different salt type and the ripening time together in salami has been scarcely studied. Therefore, the aim of this experiment was to annotate the effect of salt type on the physicochemical attribution of salami during the process of ripening and drying, as well as to compare of meat quality traits in salami between nitrate-free salt and NP.

Materials and Methods

Salami manufacture

Fresh beef (beef topside round) and pig (hind leg and frozen pork back fat) were collected from the local meat packer in a vacuum packaged condition. Visible fat and adhering skin of backfat were trimmed out from the beef and pork. Then both meat and backfat were cut in desirable size and shape and meat cuts was vacuumed. They kept in frozen condition at –24°C for 2 d.

The salami batters were produced with different salt types explaining details below in three replicates. The batters composed of mainly 46% pork hind leg, 30% beef topside round, 20% back fat, 0.5% garlic, 0.1% monosodium glutamate (MSG), 0.4% glucose, and 0.2% starter culture. According to the instructions of manufacturer's, frozen meat starter culture which are commercially available (Lyocarni RBL-73, SACCO, Italy) containing of *Lactobacillus curvatus* and *Staphylococcus xylosus* with 2.5×10^6 CFU/g was being added. Treatments were prepared with 2.1% of different types of salt. The contents of pure salt from SD, RS, baked salt (BS), and NP was 80%, 99%, 88%, and 99%, respectively.

Pork, beef, and backfat were cut in the particle size (4.5 mm) in a chopper (Fujee Co., Seoul, Korea) at a low speed in a mixer (Fujee Co., Seoul, Korea). Subsequently, starter culture was used during mixing. The sausages (55 mm diameter fibrous casings, Seoul, Korea) were made using a stuffer (H20E, TALSA Co., Northampton, EU). Through a *Aspergillus* spp. solution the salamis were soaked. The *Aspergillus* spp. were collected from (National Academy of Agriculutural Science, RDA, Korea). The *Aspergillus* spp. were incubated at 25°C for 7 d and streaked onto Dichloran 18% Glycerol Agar (DG18) (MBcell, Kisanbio, Korea). For production *of Aspergillus* spp. solution, the fungal colonies were diluted adding distilled water. In laboratory dry-ripening room the manufactured salamis were dried as well as ripened under some terms and

condition of RH and temperature (97% RH and 19±1℃ for d 0–3; 81% to 91% RH and 17±1℃ for d 4–7; 79% to 83% RH and 17±1℃ for d 7–15; 71% to 76% RH and 15℃ after 15 d). Samples were taken from each treatment for physicochemical analysis on d 1, 3, 5, 7, 10, 15, 20, and 25 of ripening. Results from analysis were expressed in triplicate numbers of trials.

Proximate composition and physicochemical analysis

Moisture, fat, protein, and ash of the samples in triplicate were obtained by a procedure of AOAC (AOAC, 2000). The pH value were estimated by a pH meter (MP240, Mettler Toledo, Greifensee, Switzerland). Blending of 4 g salami adding 36 mL of distilled water homogenized for 70 s (T25-S2, IKA, Selangor, Malaysia). To measure the loss of weight, two strings of sausages were taken and weighed out just prior to put in the fermentation room. On the d of 1, 3, 5, 7, 10, 15, 20, and 25th of ripening, similar strings were weighed out again. Volatile basic nitrogen (VBN) contents were determined by slightly modified method described by Conway (1950) and the contents was expressed as mg/%. Briefly, the sample (5 g) was homogenized in 20 mL of deionized water (DW) in a stomacher bag, using a slap-type homogenizer (WS-400, Hansol Tech. Co., Korea) at a speed set at 9 times/sec for 180 s. The homogenate was filtered through Whatman filter paper Number 1. Then, the filtrate (1 mL) was transferred to the outer chamber, and 1 mL of 0.01 N H_3BO_3 and 100 μL of Conway solution (0.066% methyl red: 0.066% bromocresol green, 1:1; using 99.99% alcohol as solvent) as an indicator were added to the inner part of the Conway dish. The Conway unit was sealed immediately after pouring 1 mL of 50% K_2CO_3 into the outer chamber. The dish was incubated at 37℃ for 120 min. The VBN contents were determined following the addition of 0.02 NH_2SO_4 to the inner chamber of the Conway unit and were calculated as mg%. A blank test was conducted following the same process without adding sample.

The 2-thiobarbituric acid reactive substances (TBARS) values were measured by a slight modified procedure of Witte (Witte et al., 1970). Six grams of sample was diluted with 54 mL distilled water and blended for 1 min on high speed. The mixture was filtered through Whatman No. 1 filter paper. Filtrate (0.5 mL) was transferred to a test tube followed by addition of 4.5 mL TBA solution (0.25 N HCl, 15% TCA, and 0.375% TBA reagent). Afterwards, the tube was transferred to a water bath at 90℃ for 17 min. The sample was centrifuged at 3,000×g and 5℃ for 12 min. After that, 200 μL of the supernatant was pipetted into a 96-well plate. Readings were taken and recorded by a spectrophotometer (X-MA 3000, Seoul, Korea) at 531 nm. Water holding capacity (WHC) was measured by a modified procedure of Grau and Hamm (1953) where, 1 g of the minced sample was wrapped in gauze, subsequently placed into a conical tube, and centrifuged at 3,000×g for 10 min at 4℃. The WHC of samples was calculated as the ratio of the water remaining after centrifugation to the initial water content of the sample. The formula of WHC calculation was as follows: WHC (%)=100−(total meat area/meat film area×100). The CIE L*, a*, and b* values of the salamis were measured using a Minolta chromameter (Model CR-410, Tokyo, Japan) and the device was standardized by a white calibration plate (L*=94.4, a*=0.313, and b*=0.319). Color measurements were taken triplicate in number from each treatment.

Instrumental texture analysis

Texture profile analysis (TPA; Bourne, 1978) of the salamis were accomplished using a Texture Analyzer (TA-XT2 Stable Micro Systems, Godalming, UK) with a 2,500 N load cell. The height and diameter of the samples were 1.2 cm and 1.7 cm respectively. The hardness, springiness, cohesiveness, gumminess, and chewiness will be carried out from force-deformation curves.

Microbiological analysis

Total aerobic plate counts were analyzed for microorganisms and the plates were incubated for 48 h at 36±1℃. The results were expressed as Log CFU/g.

Statistical analysis

Experimental diagram used was salt type×ripening time factorial analysis. All variables were measured by using the General Linear Model (GLM) procedure of the SAS statistical package (SAS Inst., 2002). To determine the differences among the treatments means the Duncan's multiple range test ($p<0.05$) was used.

Results and Discussion

Proximate composition

Effect of salt type on the proximate composition of salamis during ripening is shown in Table 1. During ripening, the

Table 1. Effect of sodium type on the proximate composition of salamis during ripening

		Days of ripening						
		1	5	10	15	20	25	SEM
Moisture (%)	SD[1)]	58.06^{Ba}	51.16^{b}	42.06^{c}	35.03^{Bd}	31.97^{Be}	30.39^{f}	0.75
	RS	61.09^{Aa}	52.06^{b}	42.52^{c}	35.94^{ABd}	32.67^{Be}	29.58^{f}	0.41
	BS	58.16^{Ba}	52.23^{b}	42.48^{c}	36.86^{Ad}	33.39^{Ae}	30.06^{f}	0.91
	NP	57.05^{Ba}	52.15^{b}	43.18^{c}	35.03^{Bd}	31.50^{Be}	29.93^{f}	0.41
	SEM	0.38	0.44	1.51	0.43	0.62	0.22	
Fat (%)	SD	21.75^{e}	25.04^{d}	29.53^{Bc}	34.64^{Ab}	35.54^{b}	39.88^{a}	0.51
	RS	22.03^{f}	24.77^{e}	30.95^{Ad}	33.57^{Ac}	35.59^{b}	39.92^{a}	0.25
	BS	22.45^{e}	24.47^{d}	31.18^{Ac}	31.78^{Bc}	35.22^{b}	40.58^{a}	0.27
	NP	22.67^{e}	26.12^{d}	29.40^{Bc}	30.42^{Cc}	35.25^{b}	39.92^{a}	0.88
	SEM	0.44	0.70	0.30	0.44	0.76	0.23	
Protein (%)	SD	18.91^{f}	20.08^{e}	22.77^{d}	24.51^{BCc}	28.14^{b}	28.90^{a}	0.05
	RS	19.17^{d}	19.88^{d}	22.84^{c}	23.98^{Cb}	28.09^{a}	28.78^{a}	0.18
	BS	19.01^{f}	20.01^{e}	22.67^{d}	25.08^{Bc}	27.67^{b}	29.01^{a}	0.11
	NP	18.62^{f}	19.86^{e}	22.50^{d}	26.02^{Ac}	27.89^{b}	28.96^{a}	0.19
	SEM	0.17	0.20	0.05	0.12	0.18	0.07	
Ash (%)	SD	2.89^{d}	4.03^{Bc}	4.50^{ab}	4.21^{Abc}	4.56^{ab}	4.47^{a}	0.06
	RS	3.06^{c}	4.05^{ABb}	4.68^{a}	4.26^{Aab}	4.76^{a}	4.40^{ab}	0.04
	BS	3.06^{e}	4.11^{Ac}	4.57^{a}	3.93^{Bd}	4.37^{b}	4.43^{ab}	0.01
	NP	3.05^{d}	4.02^{ABbc}	4.67^{a}	3.96^{Bc}	4.55^{ab}	4.48^{a}	0.03
	SEM	0.01	0.01	0.02	0.01	0.10	0.07	

Each values are reported as means of three replicate experiments with three samples analyzed per replicate (n=9).
[1)] SD, sun-dried salt, 2.1%; RS, refined salt, 2.1%; BS, baked salt, 2.1%; NP, nitrate pickling salt, 2.1%.
[A–C] Figures with different letters within a same column differ significantly ($p<0.05$).
[a–f] Figures with different letters within a same row differ significantly ($p<0.05$).

moisture contents were conversely proportional to the fat and protein contents. At day of 1, the moisture content ranged from 57.05% to 61.09% and from 29.58% to 30.06% at day of 25 respectively. The moisture content was highest in RS samples at d 1 ($p<0.05$). The fat content ranged from 21.75% to 22.67% at d 1 and from 39.88% to 40.58% at d 25. The fat content was the lowest in NP salami at d 10 and 15 ($p<0.05$). The samples with NP showed the highest protein levels (26.02%), while salami with RS contained the lowest (23.98%) at d 15. The storage conditions differed significantly on the chemical composition of the samples ($p<0.05$). It was observed that due to ripening, the moisture contents of salamis were decreased significantly and the content of protein on 25 d was increased compare to d of 1 ($p<0.05$). This study is supported by (Olivares et al,. 2010), who conducted the depletion of moisture in fermented sausages during the time of ripening and which cause was the increasing of fat and protein contents. Our study concluded that proximate composition of salamis was positively affected by NP due to the low fat and high protein contents.

Physicochemical characteristics

Impact of sodium type on physicochemical traits of salamis during aging is presented in Table 2. The initial pH of salamis ranged from 5.39 to 5.60 and finally at 25th d it was from 4.48 to 4.66. The pH values of salamis were declined at d 25 in comparison with d 1 ($p<0.05$). The pH values were influenced by the salt type and were the highest ($p<0.05$) in NP salamis ($p<0.05$). The weight losses of salamis were increased at d 25 in comparison with d 1 ($p<0.05$) during ripening and drying. The NP samples contained the lowest weight losses, while RS samples contained the highest ($p<0.05$). Similar study was found by Papadima and Bloukas (1999), who indicated that the lower weight loss of stored sausages could be caused by higher pH values in the aging room. During ripening, samples with NP had lower VBN compared to other samples ($p<0.05$) (Table 2). The VBN of salamis constantly increased during aging ($p<0.05$), and it maintained by d 25 at values less than 30 mg/%. TBA value is considered as an indicator of acceptability for fresh meat of rancidity (Ockerman, 1976). As presented in Table 2, samples with NP had significantly lower TBA values than those with other salts during ripening ($p<0.05$). In general, TBA values could be affected by salt concentration (Choi et al., 2016). In this case, it appears that samples with NP promoted lipid oxidation slower than other salts. Low TBA values was similar to previous study (Honikel, 2008), which indicated that nitrate acts as antioxidants. Lee and Lee (2014) mentioned that TBA value was significantly lower in *tteokgalbi* added solar salt compared to those added RS. Overall, owing to release of iron ions from heme piments, sodium chloride affects the oxidation of lipid (Buckely et al., 1989). WHC of samples continuously decreased during aging (Table 2). In d 1 and 7, WHC of SD samples showed lower compared to other samples ($p<0.05$). Low WHC could be explained by excessive protein denaturation (Barbut, 2010). The impact of sodium type on the color of salamis during aging is shown in Table 2. While NP samples produced darker salamis than other samples, RS samples produced lighter ($p<0.05$). CIE L* values increased slightly up to d 7 in salamis and decreased slowly up to d 15 ($p<0.05$). The NP samples showed a higher CIE a* value when compared to the other samples, whereas SD samples showed a lower ($p<0.05$). Basically, nitrite and nitrite were responsible for red colour in cured meat products (Honikel, 2008) and similar result was shown in our study. Salamis with SD had higher than those with RS. Choi et al. (2016) found that CIE a* values in pork loin with solar salt lowered than those with RS. CIE a* values in all samples decreased continuously during the ripening period, except NP salamis ($p<0.05$). The reason of decreasing in CIE a* values of salamis was for the brown metmyoglobin which was due to oxidation of nitrosylmyoglobin to nitrate (Gotterup et al., 2008). During aging, CIE b* values of salamis were declined at d 25 in comparison with d 1 ($p<0.05$).

Texture profile

No differences were found in texture profile (Table 3) in between salt types during ripening and drying. Hardness,

Table 2. Effect of sodium type on physicochemical traits of salamis during ripening

		Days of ripening								
		1	3	5	7	10	15	20	25	SEM
pH	SD[1)]	5.43^{Ba}	4.37^{Dg}	4.38^{Cg}	4.39^{Cf}	4.40^{Ce}	4.47^{Cd}	4.49^{Cc}	4.54^{Bb}	0.01
	RS	5.40^{Ca}	4.39^{Cf}	4.40^{Bef}	4.43^{Bd}	4.40^{Ce}	4.49^{Bc}	4.54^{Bb}	4.48^{Dc}	0.01
	BS	5.39^{Ca}	4.44^{Be}	4.35^{Dh}	4.40^{Cg}	4.40^{Bf}	4.46^{Dd}	4.55^{Bb}	4.50^{Cc}	0.01
	NP	5.60^{Aa}	4.48^{Af}	4.45^{Ag}	4.51^{Ae}	4.60^{Ad}	4.64^{Ac}	4.63^{Ac}	4.66^{Ab}	0.01
	SEM	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
Weight loss (%)	SD	0	6.14^{Bg}	17.66^{Af}	23.22^{Be}	28.21^{Bd}	34.17^{Bc}	37.04^{Bb}	39.92^{Ba}	0.01
	RS	0	6.63^{Ag}	17.15^{Af}	25.34^{Ae}	30.02^{Ad}	35.87^{Ac}	38.79^{Ab}	41.52^{Aa}	0.01
	BS	0	6.69^{Ag}	17.04^{Af}	21.88^{Ce}	26.59^{Cd}	32.47^{Cc}	35.53^{Cb}	38.12^{Ca}	0.01
	NP	0	6.12^{Bg}	16.71^{Bf}	19.07^{De}	24.14^{Dd}	30.02^{Dc}	32.86^{Db}	35.90^{Da}	0.01
	SEM	0	0.01	0.01	0.01	0.01	0.01	0.01	0.01	
VBN	SD	7.85^{Ag}	10.41^{Bf}	14.68^{Ae}	17.59^{Bd}	18.29^{ABd}	22.63^{Ac}	24.11^{Ab}	28.30^{Aa}	0.19
	RS	7.17^{Bf}	9.86^{Be}	13.96^{Bd}	18.21^{Ac}	18.37^{ABc}	22.79^{Ab}	22.45^{Bb}	27.67^{Aa}	0.16
	BS	7.22^{Bg}	11.09^{Af}	14.08^{Be}	18.16^{Ad}	19.26^{Ac}	23.20^{Ab}	23.71^{Ab}	28.73^{Aa}	0.12
	NP	6.00^{Cf}	9.88^{Be}	13.25^{Cd}	17.35^{Bc}	17.66^{Bc}	20.74^{Bb}	21.69^{Ca}	22.02^{Ba}	0.22
	SEM	0.04	0.11	0.10	0.17	0.26	0.10	0.14	0.44	
TBA	SD	0.62^{Ae}	1.10^{Aa}	0.96^{Bb}	0.87^{Bc}	0.74^{Cd}	0.86^{Ac}	0.74^{Bd}	0.74^{Bd}	0.01
	RS	0.58^{Ae}	1.08^{Ba}	0.93^{Cb}	0.86^{Bc}	0.78^{Bd}	0.87^{Ac}	0.83^{Acd}	0.80^{ABd}	0.01
	BS	0.60^{Ag}	1.10^{Ba}	1.03^{Ab}	0.91^{Acd}	0.94^{Ac}	0.87^{Ade}	0.78^{ABf}	0.85^{Ae}	0.01
	NP	0.44^{Bc}	0.61^{Ba}	0.52^{Db}	0.54^{Cb}	0.52^{Db}	0.60^{Ba}	0.51^{Cb}	0.54^{Cb}	0.01
	SEM	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01	0.01
WHC	SD	57.41^{Ba}	45.61^{b}	44.12^{b}	40.41^{Bbc}	40.17^{bc}	37.58^{d}	32.27^{e}	29.91^{e}	1.44
	RS	70.17^{Aa}	48.83^{b}	44.63^{c}	42.96^{Ac}	42.39^{c}	38.75^{d}	37.69^{Ad}	31.19^{e}	2.32
	BS	69.42^{Aa}	48.74^{b}	44.19^{c}	41.20^{Ad}	40.10^{d}	37.67^{e}	36.46^{Ae}	33.76^{e}	1.97
	NP	65.05^{Aa}	44.92^{b}	44.40^{b}	43.22^{Ab}	42.31^{b}	38.67^{c}	37.66^{Ac}	33.09^{d}	2.79
	SEM	4.72	3.74	2.51	1.67	4.81	2.64	1.48	2.27	
L*	SD	51.61^{Bc}	54.04^{Bb}	54.95^{Ca}	54.08^{Cb}	51.61^{Cc}	48.76^{Bd}	47.69^{Be}	47.22^{Ae}	0.07
	RS	53.59^{Ab}	55.88^{Aa}	56.01^{Aa}	55.12^{Aa}	52.55^{Ab}	50.22^{Ac}	50.31^{Ac}	47.27^{Ad}	0.06
	BS	51.82^{Bc}	56.3^{Aa}	55.54^{Bb}	54.92^{Bb}	52.19^{Bc}	48.35^{Cd}	48.00^{Bd}	46.18^{Be}	0.18
	NP	51.25^{Cb}	54.13^{Ba}	53.45^{Da}	53.82^{Da}	51.41^{Cb}	48.09^{Cc}	48.17^{Bc}	44.51^{Cd}	0.27
	SEM	0.05	0.33	0.02	0.01	0.58	0.08	0.52	0.11	
a*	SD	6.81^{Ca}	4.75^{Db}	3.54^{Dc}	3.55^{Dc}	2.76^{Cd}	2.73^{Cd}	1.98^{Ce}	1.41^{Df}	0.01
	RS	7.31^{Ba}	6.21^{Bab}	5.45^{Bbc}	5.47^{Bbc}	5.12^{Bc}	3.80^{Bd}	3.29^{Bd}	3.14^{Bd}	0.34
	BS	9.78^{Aa}	5.46^{Cb}	4.63^{Cc}	4.71^{Cc}	2.13^{Dd}	2.41^{Dd}	2.05^{Cd}	2.96^{Cd}	0.01
	NP	8.75^{Ac}	10.89^{Aa}	11.01^{Aa}	10.74^{Aa}	9.27^{Ab}	8.20^{Ad}	7.33^{Af}	7.60^{Ae}	0.03
	SEM	0.68	0.04	0.01	0.01	0.01	0.01	0.02	0.01	
b*	SD	8.41^{Ba}	5.66^{Cb}	5.62^{Cb}	5.21^{Dc}	4.66^{Cd}	4.55^{Ae}	2.92^{Cf}	2.74^{Dg}	0.01
	RS	8.70^{Aa}	6.54^{Ab}	5.61^{Cd}	6.41^{Bc}	5.22^{Ae}	4.43^{Bf}	3.68^{Ag}	3.36^{Ch}	0.01
	BS	8.24^{Ca}	6.48^{Ab}	6.27^{Bc}	6.08^{Cd}	3.97^{Dg}	4.23^{Cf}	2.75^{Ch}	4.39^{Ae}	0.02
	NP	7.54^{Da}	6.04^{Bc}	6.43^{Ab}	6.47^{Ab}	5.02^{Bd}	4.07^{De}	3.4^{Bf}	3.88^{Bg}	0.02
	SEM	0.01	0.04	0.01	0.01	0.01	0.01	0.02	0.01	

Each values are reported as means of three replicate experiments with three samples analyzed per replicate (n=9).
[1)] Sun-dried salt, 2.1%; Nitrate pickling salt, 2.1%; Refined salt, 2.1%; Baked salt, 2.1%.
[A–D] Figures with different letters within a same column differ significantly ($p<0.05$).
[a–h] Figures with different letters within a same row differ significantly ($p<0.05$).

Table 3. Effect of sodium type on texture profile of salamis during ripening

		Days of ripening								
		1	3	5	7	10	15	20	25	SEM
Hardness (kg)	SD[1)]	0.20^{g}	1.21^{ef}	1.03^{f}	1.31^{e}	1.96^{d}	2.49^{c}	2.93^{b}	3.34^{a}	0.02
	RS	0.18^{e}	1.09^{d}	1.04^{d}	1.19^{d}	1.78^{c}	2.6^{b}	2.68^{b}	4.12^{a}	0.1
	BS	0.19^{f}	0.92^{e}	1.27^{d}	1.3^{d}	2.05^{c}	2.2^{c}	3.72^{b}	3.14^{a}	0.06
	NP	0.16^{f}	0.95^{e}	1.13^{de}	1.01^{e}	1.46^{d}	2.18^{c}	3.22^{b}	3.85^{a}	0.09
	SEM	0.18	0.19	0.51	0.52	0.87	0.89	1.15	0.95	
Springiness	SD	0.29^{d}	0.53^{a}	0.55^{a}	0.52^{a}	0.52^{a}	0.46^{b}	0.41^{c}	0.44^{c}	0.01
	RS	0.32^{e}	0.56^{a}	0.57^{a}	0.53^{ab}	0.48^{bc}	0.49^{bc}	0.46^{cd}	0.42^{d}	0.01
	BS	0.33^{d}	0.54^{b}	0.61^{a}	0.54^{b}	0.47^{c}	0.48^{c}	0.46^{c}	0.43^{c}	0.01
	NP	0.31^{f}	0.55^{b}	0.63^{a}	0.51^{cd}	0.5^{d}	0.54^{bc}	0.49^{d}	0.44^{e}	0.01
	SEM	0.17	0.15	0.24	0.12	0.24	0.64	0.21	0.14	
Cohesiveness	SD	0.24^{e}	0.41^{b}	0.45^{a}	0.39^{b}	0.33^{cd}	0.33^{cd}	0.36^{c}	0.32^{d}	0.01
	RS	0.26^{f}	0.4^{b}	0.46^{a}	0.35^{cde}	0.36^{cd}	0.36^{c}	0.33^{de}	0.32^{e}	0.01
	BS	0.25^{e}	0.36^{c}	0.42^{a}	0.34^{cd}	0.37^{b}	0.39^{b}	0.32^{d}	0.32^{d}	0.01
	NP	0.27^{f}	0.38^{c}	0.47^{a}	0.32^{e}	0.37^{cd}	0.43^{b}	0.35^{d}	0.34^{d}	0.01
	SEM	0.10	0.16	0.10	0.09	0.08	0.16	0.11	0.07	
Gumminess	SD	0.05^{f}	0.5^{d}	0.49^{d}	0.39^{e}	0.58^{c}	0.82^{b}	1.02^{a}	1.03^{ca}	0.01
	RS	0.04^{e}	0.46^{cd}	0.48^{c}	0.37^{d}	0.56^{c}	0.96^{b}	0.9^{b}	1.23^{a}	0.01
	BS	0.05^{e}	0.24^{d}	0.54^{c}	0.34^{d}	0.62^{c}	1.01^{b}	1.25^{a}	1.01^{b}	0.01
	NP	0.04^{f}	0.35^{de}	0.48^{cd}	0.31^{e}	0.57^{c}	0.89^{b}	1.15^{a}	1.15^{a}	0.01
	SEM	0.08	0.31	0.18	0.17	0.17	0.35	0.52	0.31	
Chewiness	SD	0.01^{e}	0.27^{c}	0.33^{b}	0.2^{d}	0.23^{cd}	0.35^{b}	0.48^{a}	0.44^{a}	0.01
	RS	0.02^{d}	0.24^{c}	0.26^{c}	0.26^{c}	0.24^{c}	0.52^{a}	0.41^{b}	0.45^{b}	0.01
	BS	0.02^{d}	0.09^{d}	0.35^{b}	0.23^{c}	0.31^{bc}	0.50^{a}	0.53^{a}	0.45^{a}	0.01
	NP	0.01^{f}	0.20^{de}	0.29^{c}	0.16^{e}	0.27^{cd}	0.46^{b}	0.57^{a}	0.46^{b}	0.01
	SEM	0.01	0.28	0.26	0.19	0.20	0.31	0.23	0.10	

Each values are reported as means of three replicate experiments with three samples analyzed per replicate (n=9).
[1)] SD, sun-dried salt, 2.1%; RS, refined salt, 2.1%; BS, baked salt, 2.1%; NP, nitrate pickling salt, 2.1%.
[A–D] Figures with different letters within a same column differ significantly ($p<0.05$).
[a–g] Figures with different letters within a same row differ significantly ($p<0.05$).

gumminess and chewiness of samples showed a trend of increasing initially during the first 3 or 5 d, with subsequent slowly fluctuating or increasing ($p<0.05$). Springiness and cohesiveness of salamis indicated initial advancement up to d 5, with subsequent slowly fluctuating or steady ($p<0.05$). Various factors like as moisture, protein, and types of additives of meat products than can affect the hardness and chewiness (Song et al., 2000).

Microbial analysis

The impact of sodium type on bacterial counts of salamis during aging is manifested in Table 4. The total aerobic plate

Table 4. **Effect of sodium type on total plate counts of salamis during ripening**

		Days of ripening						
		1	5	10	15	20	25	SEM
Total plate counts (Log CFU/g)	SD[1)]	6.24^{Ba}	5.59^{Ab}	5.37^{Ac}	5.66^{Bb}	5.15^{ABd}	5.02^{Ce}	0.08
	RS	6.34^{Aa}	5.60^{Ac}	5.36^{Ad}	5.82^{Ab}	5.32^{Ad}	5.19^{Be}	0.09
	BS	6.35^{Aa}	5.67^{Ab}	5.31^{Ac}	5.77^{Ab}	5.24^{ABc}	5.37^{Ac}	0.11
	NP	6.14^{Ca}	5.20^{Bb}	5.23^{Bb}	5.25^{Cb}	5.06^{Cc}	4.88^{Dd}	0.07
	SEM	0.06	0.09	0.07	0.04	0.04	0.03	

Each values are reported as means of three replicate experiments with three samples analyzed per replicate (n=9).
[1)] SD, sun-dried salt, 2.1%; RS, refined salt, 2.1%; BS, baked salt, 2.1%; NP, nitrate pickling salt, 2.1%.
[A–D] Figures with different letters within a same column differ significantly ($p<0.05$).
[a–e] Figures with different letters within a same row differ significantly ($p<0.05$).

counts of samples were influenced by salt type. The populations of total aerobic counts of NP samples had lower than other samples from 1 to 25 d during aging ($p<0.05$). Similar research was shown by Honikel et al. (2008), who found showed that nitrite prevents or retards microbial growth in meat products. Initially decreasing tendency was followed during the 10 d among all samples, with subsequent slowly fluctuating or decreasing after 15 d of aging ($p<0.05$). The salts in meat products halt putrefaction by retarding the growth of harmful food-borne microorganisms reported by (Na and Ha, 2009). However, only salamis added with 1.9% NP represented the retardation in terms of growth and microbial counts in this study. Honikel et al. (2008) concluded that the positive effects of nitrate or nitrite are profuse adjacent to the small feasibility of the formation of nitrosamines.

Conclusions

The obtained data show that the various salt types in salamis influence the proximate composition as well as physicochemical attributions at ripening and drying condition. Especially, proximate composition of salamis was positively affected by NP due to the low fat and high protein contents. Moreover, salamis containing this salt had reduced weight losses, VBN, TBA, and microbial growth during ripening. The addition of NP showed a higher CIE a* value. In recent years, the uses of nitrite in processed meat in form of nitroso-compounds makes the consumption which is a matter of controversy. However, no use of nitrate as curing agents in processed meats might negatively impact overall quality. The results of this study contribute to meat processor on commercial and potential use of NP in cured meat and meat products, as maintaining a more restrictive regulation. Further study is needed on antimicrobial and antioxidants effects, and quality traits of salami soaked with *Aspergillus* spp.

Conflicts of Interest

The authors declare no potential conflict of interest.

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Author Contributions

Conceptualization: Yim DG. Formal analysis: Yim DG. Methodology: Yim DG. Validation: Ali M, Nam KC. Investigation: Nam KC. Writing - original draft: Yim DG, Ali M. Writing - review & editing: Yim DG, Ali M, Nam KC.

Ethics approval

This article does not require IRB/IACUC approval because there are no human and animal participants.

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