EFFECT OF SUBSTITUTING NACL WITH SALTED-FERMENTED SEAFOODS ON QUALITY CHARACTERISTICS OF BEEF JERKY

H.J. Lim[1], J.Y. Park[2], E.Y. Jung[1], G.D. Kim[1], H.S. Yang[2] & S.T. Joo[1, 2]

[1]Division of Applied Life Science (BK21 program) Graduate School, Gyeongsang National University, Jinju, 660-701, Republic of Korea

[2]Department of Animal Science· Institute of Agriculture and Life Science, Gyeongsang National University, Jinju, 660-701, Republic of Korea

***Abstract* – A study was conducted in which NaCl in beef jerky was replaced with salted-fermented seafoods (anchovy or shrimp) at 0, 25 and 50% levels. Results showed that water activity and pH values significantly increased with the replacement salted-fermented seafoods in beef jerky. The salted-fermented shrimp samples had higher water activity and moisture content compared with others (P<0.05). Replacement of NaCl with 50% anchovy and 25 or 20% shrimp samples decreased lightness, redness and yellowness (P<0.05). In particular, replacement of NaCl with salted-fermented seafoods samples lower shear force and hardness values (P<0.05). Sensory evaluation indicated that salted-fermented seafoods samples had significantly higher off-flavor than the control, whereas 50% anchovy and 25 or 20% shrimp samples had lower saltiness than the control (P<0.05).**

***Key Words* – Salted-fermented seafoods, beef jerky, quality characteristics**

I. INTRODUCTION

Jerky is made from sliced whole muscles which have been marinated and dried. It is relatively simple to process, with a typical flavor, and usually requires no refrigeration during commercial distribution, due to low water activity [1]. Jerky products can be made with various marinade techniques, meats from different species and drying conditions [2]. To achieve stability, jerky is dried to a_w 0.70-0.85 and is shelf-stable at a 0.75:1.00 moisture protein ratio [3]. NaCl is one of the most frequently used ingredients in meat processing. NaCl affects flavor, texture and shelf life of meat products. Besides the perceived saltiness, the NaCl brings out the characteristic taste of the meat product enhancing the flavor [4]. In recent years, an increased effort has been made to reduce the amount of salt in foodstuffs [5]. World Healthy Organization (WHO) has recommended a reduction of NaCl content of meat products [6]. There is a trend to reduce the salt content in foods because an excessive sodium intake contributes to raise blood pressure in salt susceptible consumers [7]. In Asia, salting is easily found in a preservation method of fishes or vegetables. Especially, salted and fermented seafoods are a traditional food in Korea. Since the fermentation processes such as salted-fermented seafoods involve the breakdown of proteins into precursor amino acids of biogenic amines through the action of digestive enzymes and microbes [8]. Therefore, this study investigated the effect of substituting NaCl with salted-fermented seafoods (anchovy or shrimp) on physicochemical and sensory properties of beef jerky.

II. MATERIALS AND METHODS

1. Sample preparation

The muscle of beef *semimembranosus* was dissected from carcass 48 h postmortem. All subcutaneous and intermuscular fat and visible connective tissue were removed from the fresh muscles. The sample was sliced to 0.5 cm thick pieces with a meat slicer (HFS 350G, Hankook Fugee Industries Co. Ltd., Korea). Sliced jerky samples were cut parallel in direction to muscle fibers. The sliced samples were then cured for 12 h in a cure solution (Table 1). Salted-fermented anchovy and shrimp sauce were purchased from traditional market in Korea. The salted-fermented anchovy and shrimp samples were homogenized with a Polytron homogenizer (T25-B, IKA Sdn. Bhd., Malaysia) at 8,000 rpm for 30 s. The slurry was filtered through two layers of cheese cloth to remove the bone and connective tissue. Prior to processing of beef jerky, the salinity of NaCl and salted-fermented seafoods was adjusted 2%. All samples were dried using a dryer (DS80-1, Dasol Scientific Co. Ltd., Korea) at a temperature of 70°C for 8

h. There was adequate air distribution between samples received the same drying treatment. Samples were than taken for water activity measurements, to a target a_w < 0.85. After drying and cooling to ambient temperature (≈25℃) the jerky samples were loosely packed (single package) and display to laying flat on the desk.

2. Analytical methods

The water activities were determined with a water activity meter (AQS-2, Nagy mess system, Germany), calibrated at ambient temperature (20°C) with distilled water (a_w = 0.999) and saturated solutions of NaCl (a_w = 0.756) and KCl (a_w = 0.853). The pH value of the sample was determined using a pH meter (MP230, Mettler Toledo, Switzerland). Proximate composition (moisture content, %) was analysed by AOAC (1995) [9]. Surface color (CIE L*, a*, b*) of beef jerky was analysed by using of chroma-meter (CR-300, Minolta, Japan). Shear force (kg/cm^2) was determined using the Instron Universal Testing Machine (Instron Corporation, MA, USA) with a V-shaped shear blade. Textural properties such as hardness, adhesiveness, cohesiveness, springiness, gumminess and bittleness were analysed by using of Rheo-meter (Compac-100, Sun scientific Co., Japan). Sensory training and evaluation were recruited and trained by eight panelists (GNU: Gyeongsang National University students). Panelists evaluated the samples using a 9-point hedonic scale, where 1 was "dislike extremely" and 9 was "like extremely". The statistical analysis was performed by SAS program [10]. The data were subjected to analysis of variance (ANOVA) and Duncan's test to compare the sample means. The significance level was 0.05.

III. RESULTS AND DISCUSSION

Water activity (a_w), pH and moisture content of the beef jerky samples are shown in Table 2. Beef jerky samples showed significant differences in a_w, pH and moisture content ($p<0.05$). The samples with replacement of NaCl showed a higher a_w than the control. The samples with replacement of NaCl by salted-fermented shrimp showed a higher a_w than those of the other treatments. There were significant differences in a_w among the jerky samples with the same drying conditions. It is essential that jerky should be dried to a_w acceptable for proper shelf-life. The moisture content varied from 27.12% to 23.66%. The samples with replacement of NaCl by salted-fermented anchovy showed a lower moisture content than those of the other treatments. In general, jerky texture can be altered by the moisture contents. This indicates that any differences in the texture and shelf-life observed between salted-fermented anchovy and shrimp would be biased by different moisture contents. The pH value of salted shrimp jerky was significantly higher than those of other beef jerky samples ($p<0.05$). The spoilage of various dried meat products by mold growth can be inhibited or delayed by a lowering pH [11]. Color of the beef jerky samples is shown in Table 3. The addition of 50% salted shrimp showed a significantly lower lightness than control ($p<0.05$). However, control and 25% salted anchovy showed a higher lightness, redness and yellowness than those of the other treatments. The shear force values and hardness of control was significantly higher than those of other treatments ($p<0.05$) (Table 4). The sensory panels were convened to assess the effects on the color, off flavor, salty, texture, tenderness and overall acceptability of beef jerky samples (Table 5). Sensory results indicated that the off-flavor intensity was significantly ($p<0.05$) higher in treatments than the control beef jerky. Off-flavor scores were increased by the replacement of NaCl. However, saltiness and tenderness scores were improved by the replacement of the salted-fermented seafoods. The overall acceptability scores ranged from 4.67 to 5.60, with maximum acceptability obtained at the 25% salted-fermented anchovy level.

IV. CONCLUSION

Beef jerky samples made with salted-fermented seafoods obtained improved saltiness and textural attributes compared to control. The samples with replacement of NaCl produced a beef jerky with a softer texture. However, beef jerky with replaced NaCl samples could not be as safe as the control due to its higher water activity.

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Table 1. Basic formulation of beef jerky (%)

Ingredients	C	T1	T2	T3	T4
Meat	80.50	80.50	80.50	80.50	80.50
Water	8.05	8.05	8.05	8.05	8.05
Salt	1.61	1.21	0.80	1.21	1.21
SFA[a] 25%	-	0.40	-	-	-
SFA 50%	-	-	0.80	-	-
SFS[b] 25%	-	-	-	0.40	-
SFS 50%	-	-	-	-	0.80
Starch syrup	4.83	4.83	4.83	4.83	4.83
Sugar	4.83	4.83	4.83	4.83	4.83
Pepper	0.16	0.16	0.16	0.16	0.16
Sodium nitrate	0.02	0.02	0.02	0.02	0.02
Total	100	100	100	100	100

[a]Salted-fermented anchovy.

[b]Salted-fermented shrimp.

Table 2. Water activity, pH and Moisture content of beef jerky

	Treatments[1]				
	C	T1	T2	T3	T4
Water activity (a_w)	0.78 ± 0.01^{D}	0.81 ± 0.01^{C}	0.81 ± 0.01^{C}	0.83 ± 0.00^{B}	0.85 ± 0.00^{A}
pH	5.72 ± 0.01^{C}	5.73 ± 0.01^{C}	5.75 ± 0.01^{B}	5.79 ± 0.02^{A}	5.79 ± 0.01^{A}
Moisture (%)	25.32 ± 0.31^{B}	23.66 ± 0.18^{C}	23.96 ± 0.09^{C}	27.12 ± 0.16^{A}	27.04 ± 0.35^{A}

[1] C; 100% salt, T1; 75% salt and 25% salted anchovy, T2; 50% salt and 50% salted anchovy, T3; 75% salt and 25% salted shrimp, T4; 50% salt and 50% salted shrimp.

[A-D] Means±SD with different superscripts in the same row significantly differ at $p<0.05$.

Table 3. Surface color of beef jerky

	Treatments[1]				
	C	T1	T2	T3	T4
CIE L*	24.76±0.65^{A}	24.57±1.07^{A}	23.31±1.16^{B}	22.90±0.72^{BC}	22.01±1.10^{C}
CIE a*	8.14±0.68^{A}	8.03±0.51^{A}	4.91±0.21^{C}	6.05±1.10^{B}	6.26±0.63^{B}
CIE b*	2.05±0.33^{A}	1.85±0.19^{A}	1.28±0.15^{B}	1.50±0.37^{B}	1.39±0.20^{B}

[1] C; 100% salt, T1; 75% salt and 25% salted anchovy, T2; 50% salt and 50% salted anchovy, T3; 75% salt and 25% salted shrimp, T4; 50% salt and 50% salted shrimp.
[A-C] Means±SD with different superscripts in the same row significantly differ at $p<0.05$.

Table 4. Shear force and textural properties of beef jerky

	Treatments[1]				
	C	T1	T2	T3	T4
Shear force (kg/cm^2)	9.69±0.19^{A}	6.94±0.26^{C}	8.49±0.19^{B}	6.50±0.32^{D}	5.29±0.36^{E}
Hardness (g/cm^2)	13290.42±566.90^{A}	8419.98±309.90^{B}	9145.17±631.50^{B}	8376.55±135.10^{B}	8451.49±1698^{B}
Adhesivness (g)	102.00±11.31^{A}	37.00±5.66^{B}	61.50±2.12^{B}	104.00±21.21^{A}	107.00±5.66^{A}
Cohesivness (%)	16.77±2.30	12.82±2.01	14.91±7.72	28.92±9.13	22.57±3.57
Springness (%)	75.76±7.96^{A}	51.45±5.95^{B}	72.96±6.81^{A}	48.24±4.63^{B}	84.57±8.14^{A}
Gumminess (g)	125.67±8.88^{B}	105.09±16.74^{B}	129.80±11.72^{B}	182.16±8.94^{A}	126.31±11.85^{B}

[1] C; 100% salt, T1; 75% salt and 25% salted anchovy, T2; 50% salt and 50% salted anchovy, T3; 75% salt and 25% salted shrimp, T4; 50% salt and 50% salted shrimp.
[A-E] Means±SD with different superscripts in the same row significantly differ at $p<0.05$.

Table 5. Sensory evaluation of beef jerky

	Treatments[1]				
	C	T1	T2	T3	T4
Color	4.33±0.52^{B}	4.40±0.89^{B}	5.80±0.45^{A}	4.83±0.41^{B}	6.5±0.55^{A}
Off-flavor	1.33±0.58^{B}	3.50±1.00^{A}	3.67±0.58^{A}	2.50±0.58^{AB}	3.00±1.00^{A}
Saltiness	6.25±0.5^{A}	6.33±0.52^{A}	5.20±0.45^{B}	5.17±0.41^{B}	5.40±0.55^{B}
Texture	4.80±0.45	4.60±0.55	4.25±0.50	5.67±0.58	5.00±1.15
Tenderness	5.25±0.96^{A}	5.83±0.41^{A}	3.75±0.96^{B}	5.75±0.50^{A}	5.25±0.96^{A}
Overall acceptability	4.67±0.52	5.60±1.00	5.00±0.82	5.40±0.55	5.50±0.55

[1] C; 100% salt, T1; 75% salt and 25% salted anchovy, T2; 50% salt and 50% salted anchovy, T3; 75% salt and 25% salted shrimp, T4; 50% salt and 50% salted shrimp.
[A-C] Means±SD with different superscripts in the same row significantly differ at $p<0.05$.