EVALUATION OF HONEY AND RICE SYRUP AS REPLACEMENTS OF SORBITOL IN THE PRODUCTION OF RESTRUCTURED DUCK JERKY

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Abstract – The aim of this study was to evaluate the potential of natural humectants such as honey and rice syrup to replace sorbitol in the production of restructured duck jerky. The values of water activity and the moisture-to-protein ratio of all of the samples were maintained below 0.75. Jerky samples treated with honey retained more moisture than those exposed to other treatments. Among all samples, those treated with 10% sorbitol produced the highest processing yield and the lowest shear force values. The highest L* value and the lowest b* value were observed for the sorbitol-treated sample, followed by the rice syrup- and honey-treated samples. Duck jerky samples treated with 10% honey showed the highest scores for the sensory parameters evaluated. The overall acceptability scores of samples treated with rice syrup were comparable with those of samples treated with sorbitol. Microscopic observation of restructured duck jerky samples treated with honey showed stable forms and smaller pores when compared with other treatments.

Key Words – duck jerky, natural humectants, meat quality

I. INTRODUCTION

Meat jerky is a popular snack that is easily found in retail shops worldwide. An increase in overall duck meat consumption stimulated the idea of using it to develop a new similarly processed product. Duck meat has its own specific taste and positive reputation as a healthy food, and it can be processed into a unique meat jerky that is different from other conventional jerky products. However, the drawbacks of manufacturing meat jerky using duck meat instead of beef and pork meats include the soft texture, pale color, and specific odor. An appropriate choice of humectant is therefore a prerequisite for preserving the intermediately moistened texture of such jerky products. Honey is well known as the only natural humectant in a concentrated sugar form that is used in food preservation worldwide [1]. Rice syrup is also a natural humectant, consisting of dextrin, maltose, maltotriose, and a small amount of glucose. Sorbitol is an artificial humectant that is widely used in the jerky industry for several reasons: it has a low caloric value, is well tolerated by diabetics, extends the shelf life of food products, and does not cause browning in food when heated [2]. This study aims to evaluate the physicochemical characteristics of duck jerkies treated with honey and rice syrup and compare them to those treated with sorbitol at different concentrations.

II. MATERIALS AND METHODS

Duck meat (tenderloin with pH 6.00 ± 0.11) was purchased from a local company (90 Ori-Q, Sonja Ryong Food, Korea). Marinating ingredients were prepared by mixing water (2.60%), salt (1.32%), sugar (1.89%), spices (composed of powdered white pepper, black pepper, all spices, onion, red pepper, garlic, ginger, paprika, and celery) (2.04%), soybean sauce (3.78%), smoke oil (0.05%), nucleotide powder (0.07%), flavoring powder (0.60%), and ascorbic acid (0.08%). Honey (Acacia honey, Nonghyup National Agricultural Corp. Fed., Korea), rice syrup (Ssalyeot, Ottogi Co., Ltd., Korea), and sorbitol (Sorbitol powder, Taewon Food Industry Co., Ltd., Korea) were used as humectants. Each humectant was mixed at 3%, 6%, and 10% (wt/wt) concentrations with the marinating solution. The duck meat was ground using a grinder with an 8-mm hole plate (PM-85, Mainca, Spain) for 5 min, and subsequently mixed with the marinating solution for 10 min. The batter was stuffed into a jerky gun (37-0111-W, Weston Products, USA) and then squeezed onto parchment paper in 120 × 2 × 0.5 mm pieces. The samples were dried in a thermal processing oven (FX61E1, Angelo Po, Italy) according to the following conditions: 10 min at 79°C/50% RH, 30 min at 74°C/50% RH, 90 min at 65°C/30%

RH, and 210 min at 55°C/30% RH, before cooling at 10°C for 30 min. Water activity (a_w) was determined using a bench top water activity meter (Aqua Lab 4 TE, Decagon Devices Inc., USA). The moisture-to-protein ratio (MPR) was determined by dividing the moisture content by the protein content of sample. Moisture content was determined using a halogen moisture-drying machine, (US/SX-2000, Tekmar-Dorhmann, USA), in accordance with AOAC methods. Protein content was determined by using a Kjeldahl nitrogen analyzer (KjelFlex K-360, Buchi Labortechnik, Switzerland)**,** in accordance with the Kjeldahl procedure. The pH value was measured in triplicate using a digital pH meter (Sg2-ELK, Mettler Toledo Co., Ltd., Switzerland). Processing yields were calculated by dividing the sample weight after drying by the weight before drying. Shear force measurements were carried out using a texture analyzer (TA.XT.plus, Texture Technologies Corp., USA) equipped with a HDP/BS probe at a height of 6 mm, and 50% strain. TBARS analysis was conducted using the method described by Sinhuber and Yu [3]. The surface color of duck jerky samples was measured according to the CIE L^* (whiteness), a^* (redness), and b^* (yellowness) system using a colorimeter (CR-400, Konica Minolta Sensing Inc., Japan), and then standardized to a white calibration plate (Y = 93.7, x = 0.3132, and y = 0.3192). Microscopic observations of restructured duck jerky were conducted using a scanning electron microscope (SEM) (Inspect F50 Quanta, FEI, Japan) at an accelerating voltage of 5.00 kV, 20.000 magnification, and 10.4 mm working distance. Sensory evaluation using a 9-point hedonic scale was performed by 11-12 panelists who have experience in the quality assessment of meat jerky in terms of color, flavor, tenderness, sweetness, and overall acceptability.

III. RESULTS AND DISCUSSION

The values of a_w, moisture content, and MPR of restructured duck jerky treated with different concentrations of honey, rice syrup, and sorbitol are shown in Table 1. The measured a_w values in all samples ranged between 0.709-0.744, indicating that the restructured duck jerky samples were produced below 0.85, which is the critical limit value for the growth of bacteria. Maintaining an a_w below 0.85 is also important for inhibiting *Clostridium botulinum* growth, which is tremendously toxic to consumer health [4]. This study showed that samples treated with honey could maintain a higher moisture content than those treated with same concentrations of rice syrup and sorbitol. Moreover, samples treated with 10% honey showed the lower a_w value while maintaining higher moisture content than samples treated with same concentrations of rice syrup and sorbitol ($p<0.05$). According to Lee and Kang [5], moisture content and thermal conditions influence the tensile strength of ostrich jerky, which implies that jerky products with lower moisture content are more difficult to tear into bite-size pieces than those with higher moisture content.

Borneman *et al*. [6] define the MPR value of 0.75 as the upper limit for assuring microbiological safety in meat products. The MPR values of all samples measured in this study ranged from 0.705 to 0.745, indicating that the samples can be stored without any microbiological risk. The pH values of honey and rice syrup were in the range of 5.97-6.04 and 5.99-6.02, respectively, while those of sorbitol were between 6.01 and 6.05. Interestingly, samples treated with a 10% honey had the lowest pH values. The processing yields of the treated samples ranged from 44.12% to 49.39% and were positively correlated with the humectant concentration. In this study, the increment in yield was greater with higher concentrations of sorbitol, and the highest yield was obtained with 10% sorbitol.

Tenderness is a critical parameter influencing the consumer acceptance of meat products [7], and is commonly determined by shear force measurement [8]. In this study, of all humectant concentrations, samples treated with 10% humectant had the lowest shear force value, which tended to decrease with further addition of humectants. The TBARS values of all samples ranged from 0.43 to 0.98 mg MDA/kg. TBARS values between 0.5 and 1.0 have been suggested as the threshold for oxidized odor and samples with values above 1.0 tend to have an oxidized flavor [9]. The TBARS values of the restructured duck jerky produced in this study were below the oxidation threshold for meat products. Samples treated with sorbitol showed higher CIE L* values than those treated with rice syrup and honey, with the highest value obtained for samples treated with 10% sorbitol. The CIE a^* values were in the range of 4.22-5.08 for honey, 4.04-4.66 for rice syrup, and 3.97-4.18 for sorbitol. Interestingly, samples treated with 3% honey showed the highest CIE a^* values, which shows that honey can maintain the red color of duck jerky at low concentrations. Honey treatment also resulted in more yellow color than did treatment with same concentrations of the other humectants. Cho and Lee [10] reported that beef jerky samples treated with honey had higher CIE b^* values than samples treated with rice syrup. The addition of honey can therefore be regarded as a method of increasing the yellow color of restructured duck jerky that is more effective than rice syrup and sorbitol treatments. It is also worth mentioning that honey treatment is more effective in maintaining a dark red-yellow combined color in restructured duck jerky, which results in higher consumer acceptance, than rice syrup and sorbitol treatments.

SEM observation showed that the pores of the restructured duck jerky samples treated with honey had stable structural forms and remained smaller than those of the samples treated with rice syrup and sorbitol (Fig. 1). This might be attributed to honey, which might be effective in retaining moisture within the jerky during the drying process, thereby facilitating the formation of smaller and more pores than that achieved with the other treatments. The sensory evaluation scores of duck jerky treated with honey increased with increasing concentration of humectants ($p<0.05$), although differences in color and overall acceptability properties remained insignificant between 6% and 10% concentrations (Table 4). Samples treated with 10% honey showed the highest scores, followed by those treated with rice syrup and sorbitol. However, the tenderness scores of the samples treated with rice syrup were lower than those of the samples treated with 6% and 10% sorbitol. The unique flavor, sweetness, and dark red-yellow color resulting from honey treatment played a positive role in the sensory evaluation of restructured duck jerky, distinguishing it from other humectant treatments.

Table 1. Comparison of a_w, moisture content, and MPR of restructured duck jerkies prepared with honey, rice syrup, and sorbitol

Treatments	%	a_w	Moisture Content (%)	MPR
Honey	3	0.744 ± 0.00^{a}	36.15 ± 0.04^{a}	0.745 ± 0.01^{a}
	6	0.733 ± 0.00^{bc}	35.01 ± 0.28^{bc}	0.730 ± 0.03^{a}
	10	0.709 ± 0.00^{g}	34.66 ± 1.00^{abc}	0.720 ± 0.03^{a}
Rice syrup	3	0.733 ± 0.00^{bc}	33.93 ± 1.26^{bcd}	0.745 ± 0.02^{a}
	6	0.729 ± 0.00^{c}	33.93 ± 1.24^{bcd}	0.720 ± 0.04^{a}
	10	0.725 ± 0.00^{e}	32.76 ± 0.74^{d}	0.720 ± 0.00^{a}
Sorbitol	3	0.735 ± 0.00^{b}	33.93 ± 0.64^{bcd}	0.740 ± 0.03^{a}
	6	0.732 ± 0.00^{c}	32.84 ± 0.01^{cd}	0.735 ± 0.01^{a}
	10	0.713 ± 0.00^{f}	30.87 ± 0.31^{e}	0.705 ± 0.04^{a}

A-G Means±SD in the same row with different superscripts are significantly different at $p<0.05$

Table 2. Comparison of pH, processing yield, shear force, and TBARS of restructured duck jerkies prepared with honey, rice syrup, and sorbitol

Treatments	%	pH	Processing Yield (%)	Shear Force (N/cm^2)	TBARS (mg MDA/kg)
Honey	3	6.04 ± 0.02^{ab}	45.27 ± 1.42^{cd}	25.46 ± 3.54^{ab}	0.82 ± 1.00^{a}
	6	5.99 ± 0.03^{cde}	46.34 ± 1.71^{bc}	22.06 ± 3.67^{bc}	0.96 ± 0.00^{a}
	10	5.97 ± 0.00^{e}	46.96 ± 1.27^{b}	20.05 ± 2.57^{cd}	0.98 ± 0.01^{a}
Rice syrup	3	6.02 ± 0.00^{bc}	44.12 ± 1.04^{d}	29.31 ± 3.49^{a}	0.73 ± 0.08^{a}
	6	6.00 ± 0.01^{cd}	44.18 ± 1.11^{d}	26.75 ± 3.58^{ab}	0.56 ± 0.42^{a}
	10	5.99 ± 0.02^{de}	47.62 ± 1.03^{b}	18.48 ± 3.68^{cd}	0.43 ± 0.50^{a}
Sorbitol	3	6.05 ± 0.02^{a}	45.46 ± 0.74^{cd}	26.66 ± 1.16^{ab}	0.43 ± 0.31^{a}
	6	6.01 ± 0.00^{cd}	47.58 ± 1.54^{b}	17.70 ± 1.44^{cd}	0.43 ± 0.16^{a}
	10	6.01 ± 0.02^{cd}	49.39 ± 1.14^{a}	16.62 ± 2.36^{d}	0.43 ± 0.16^{a}

A-F Means±SD in the same row with different superscripts are significantly different at $p<0.05$

Table 3. Comparison of surface color of restructured duck jerkies prepared with honey, rice syrup, and sorbitol

Treatments	%	L*	a*	b*
Honey	3	24.51 ± 0.70^{e}	5.08 ± 0.53^{a}	3.83 ± 0.31^{a}
	6	25.03 ± 0.59^{e}	4.23 ± 0.57^{bc}	2.83 ± 0.44^{b}
	10	27.15 ± 0.53^{d}	4.22 ± 0.41^{bc}	2.01 ± 0.34^{c}
Rice syrup	3	28.23 ± 0.25^{c}	4.66 ± 0.44^{ab}	2.57 ± 0.23^{b}
	6	28.34 ± 0.47^{c}	4.36 ± 0.31^{bc}	1.97 ± 0.42^{c}
	10	28.70 ± 0.41^{bc}	4.04 ± 0.51^{c}	1.75 ± 0.16^{cd}
Sorbitol	3	29.10 ± 0.52^{ab}	4.18 ± 0.27^{bc}	1.65 ± 0.16^{cd}
	6	29.20 ± 0.30^{ab}	4.06 ± 0.37^{bc}	1.58 ± 0.22^{cd}
	10	29.47 ± 0.30^{a}	3.97 ± 0.64^{c}	1.51 ± 0.60^{d}

A-F Means±SD in the same row with different superscripts are significantly different at $p<0.05$

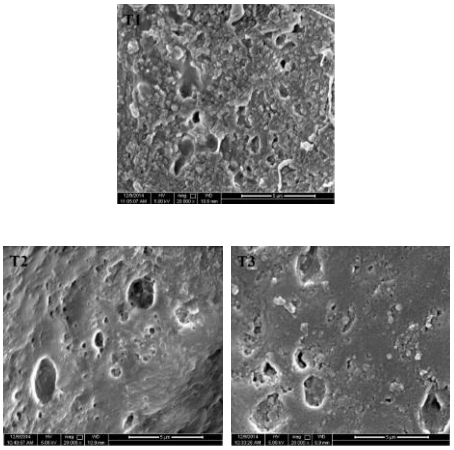

Figure 1. Typical SEM pictures of restructured duck jerkies prepared with 6% honey (T1/honey), 6% rice syrup (T2/rice syrup), and 6% sorbitol (T3/sorbitol) (wt/wt).

Table 4. Sensory evaluations of restructured duck jerkies prepared with honey, rice syrup, and sorbitol

Treatments	%	Colour	Flavor	Tenderness	Sweetness	Overall Acceptability
Honey	3	8.00 ± 0.48^{b}	7.50 ± 0.46^{c}	7.60 ± 0.20^{c}	7.00 ± 0.52^{d}	7.60 ± 0.25^{bc}
	6	8.50 ± 0.46^{a}	8.00 ± 0.43^{b}	8.20 ± 0.46^{b}	8.00 ± 0.63^{b}	8.03 ± 1.24^{ab}
	10	8.50 ± 0.41^{a}	8.50 ± 0.55^{a}	8.60 ± 0.29^{a}	8.50 ± 0.35^{a}	8.27 ± 0.23^{a}
Rice syrup	3	8.00 ± 0.55^{b}	6.50 ± 0.27^{e}	7.40 ± 0.20^{c}	6.50 ± 0.27^{e}	7.08 ± 0.51^{d}
	6	7.50 ± 0.30^{c}	7.00 ± 0.36^{d}	7.50 ± 0.29^{c}	7.00 ± 0.27^{d}	7.42 ± 0.19^{cd}
	10	7.40 ± 0.24^{c}	7.50 ± 0.33^{c}	8.00 ± 0.31^{b}	7.50 ± 0.50^{c}	7.55 ± 0.50^{cd}
Sorbitol	3	7.50 ± 0.28^{c}	6.40 ± 0.30^{e}	7.50 ± 0.29^{c}	6.40 ± 0.21^{e}	7.10 ± 0.47^{d}
	6	7.30 ± 0.35^{cd}	7.00 ± 0.17^{d}	8.00 ± 0.31^{b}	6.50 ± 0.45^{e}	7.42 ± 0.19^{cd}
	10	7.00 ± 0.37^{d}	7.50 ± 0.33^{c}	8.50 ± 0.36^{a}	7.00 ± 0.27^{d}	7.53 ± 0.47^{cd}

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

IV. CONCLUSION

This study was conducted in order to examine the effects of honey and rice syrup treatment on the production of restructured duck jerky, and evaluate their feasibility as replacements for sorbitol. The use of natural humectants in this study positively affected the chemical properties of duck jerky, especially at higher concentrations. The samples treated with honey had better properties than samples treated with the same concentration of rice syrup and sorbitol. Honey therefore has the potential to be used as a natural humectant and replace the use of sorbitol. Further research is needed to study the ability of these humectants to extend the shelf life of restructured duck jerky.

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