

## Effects of Replacing Sucrose with Various Sugar Alcohols on Quality Properties of Semi-dried Jerky

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### Abstract

The objective of this study was to investigate the effects of replacing sucrose with sugar alcohols (sorbitol, glycerol and xylitol) on the quality properties of semi-dried jerky. Total 7 treatments of jerkies were prepared as follows: control with sucrose, and treatments with 2.5 and 5.0% of sucrose replaced by each sugar alcohol, respectively. Drying yield, pH, water activity, moisture content, shear force, myofibrillar fragmentation index (MFI), 2-thiobarbituric acid reactive substance (TBARS) value, sugar content, and sensory evaluation were evaluated. Xylitol slightly decreased the pH when compared to the other sugar alcohols ( $p > 0.05$ ). The water activity of the semi-dried jerky was significantly reduced by treatment with glycerol and xylitol ( $p < 0.05$ ). The moisture content of semi-dried jerky containing various sugar alcohols was significantly higher than that of the control ( $p < 0.05$ ), while replacing sucrose with glycerol yielded the highest moisture content. The shear force of semi-dried jerky containing sugar alcohols was not significantly different for the sorbitol and glycerol treatments, but that replacing sucrose with 5.0% xylitol demonstrated the lowest shear force ( $p < 0.05$ ). The TBARS values of semi-dried jerkies with sugar alcohols were lower than the control ( $p < 0.05$ ). The sugar content of the semi-dried jerkies containing sorbitol and glycerol were lower than the control and xylitol treatment ( $p < 0.05$ ). In comparison with the control, the 5.0% xylitol treatment was found to be significantly different in the sensory evaluation ( $p < 0.05$ ). In conclusion, semi-dried jerky made by replacement with sugar alcohols improved the quality characteristics, while xylitol has applicability in manufacturing meat products.

**Keywords:** humectant, moisture content, glycerol, sorbitol and xylitol

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### Introduction

Jerky is one of the typical intermediate-moisture foods (IMF) that has traditionally been made with sliced whole muscle or restructured meat of various animals, and has extended preservation through curing and drying with reduction in water activity (Choi *et al.*, 2008; Kim *et al.*, 2010; Mckee *et al.*, 1995; Quinton *et al.*, 1997). The water activity is lowered to 0.70-0.85 (Quinton *et al.*, 1997), which improves the shelf-stability of the jerky without refrigeration due to the control of microorganisms growth (Choi *et al.*, 2008; Fernández-Salguero *et al.*, 1994; Han *et al.*, 2011; Yang *et al.*, 2009; Yoon *et al.*, 2005). However, excessive moisture loss to lower the water activity also causes a tough texture, making the jerky too dry, brittle or chewy, and undesirable in color. In

the case of some comminuted jerky, while it has a soft texture, the high water activity and fat content bring about activation of lipid oxidation and growth of microorganisms (Miller *et al.*, 1996; Quinton *et al.*, 1997).

As humectants has been extensively used to improve the emulsifying capacity, water holding capacity, texture, and appearance of meat products. In addition, it has been recognized that humectants are useful to improve processing yield and sensory properties such as tenderness and juiciness of jerky products (Han *et al.*, 2011). Hence, various humectants including konjac, egg albumin, isolated soy protein, and sugar alcohols has been commonly used in meat processing industry (Han *et al.*, 2008). Sugar alcohols, such as sorbitol, glycerol and xylitol, contribute to the metal chelating capability and antioxidant activity, thus can slightly prevent oxidative damage of the meat products. Kim *et al.* (2010) indicated that sorbitol and glycerol improved the textural and sensory properties of pork jerky.

Sucrose, made from sugar cane or sugar beet, has generally been used to give sweet taste, and enhances the fla-

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vor of meat products while adding a gentle salty flavor (Jung, 2007). However, as consumer interest in health problems has grown, there have been lowered preferences for sugar in relation to chronic and adult diseases such as obesity and diabetes (Kang *et al.*, 2014; Kyung *et al.*, 2014).

In recent years, research has been conducted on the replacement of sugar with a sweetener. Roh *et al.* (1999) studied about sweeteners such as sucralose and tagatose with low calorie and sweetness, and sugar alcohols have been added instead of sucrose in the manufacturing of chocolate (Choi and Go, 2002). Studies have also been conducted in other food divisions such as cookies, rice cakes and sponge cake (Choi *et al.*, 2013; Kim *et al.*, 2004; Ronda *et al.*, 2005; Shin *et al.*, 1999). However, the study of replacing sucrose with sugar alcohols has remained in an incomplete state in meat products.

Therefore, the objectives of this study were to investigate the effects of replacing sucrose with sugar alcohols on the physicochemical, textural, and sensory properties of semi-dried jerky.

## Materials and Methods

### Meat and curing solution preparation

Beef round (*M. semimebranosus*; pH: 5.43±0.01, moisture contents: 66.73±0.14%, protein: 25.65±0.10%, fat contents: 9.28±0.18%, ash contents: 1.50±0.06%) and chicken breast (*M. pectoralis major*; pH: 5.97±0.18, moisture contents: 74.60±0.28%, protein: 25.88±0.04%, fat contents: 2.60±0.08%, ash contents: 1.55±0.10%) in broilers (Arbor acre strain, 5 wk of age, approximately 1.5-2.0 kg live weight) were purchased from a local market. All subcutaneous and intermuscular fat and observable connective tissue were eliminated from the fresh meat. Beef round and chicken breast were initially ground using a grinder (PM-70, Mainca, Spain) equipped with 8 mm plate, and mixed in 5 to 5 ratio. The ground meat was packed in polyethylene bags, sealed by utilizing a vacuum packaging machine (Fj-500X1, Fjee Tech, Korea) and stored at

0°C until product was manufactured. A formulation (w/w) of jerky curing solution was 6% water, 1.2% nitrite pickled salt (NPS), 5% sucrose, 3% soy sauce, 0.1% black pepper powder, 0.1% monosodium L-glutamate (MSG), 0.1% ginger powder, 0.2% garlic powder, and 0.2% onion powder (Table 1). Additionally, sucrose was replaced with 2.5 and 5.0% sugar alcohols, respectively.

### Manufacturing of semi-dried jerky

The ground chicken breast (50%) and beef round meat (50%) were mixed with curing solution by hand for 3 min. The meat was then continuously tumbled in a tumbler (MGH-20, Vackona, Germany) at 4°C for 30 min at 25 rpm. Then cured meat was stuffed into cellulose casing (Ø - 18 mm), then dried in the following steps: fast drying (55°C, 90 min), slow drying (65°C, 180 min), slow drying (75°C, 90 min) and dry cook (75°C, 10 min), in a chamber (1600EL, Kerres GmbH, Germany). After cooling at 4°C, cellulose casing was removed from the semi-dried jerkies.

### Moisture content

Compositional properties of the semi-dried jerky were determined by using AOAC (2000). Moisture content was calculated by weight loss 24 hr of drying at 105°C in a drying oven (SW-90D, Sang Woo Scientific Co., Korea).

### Water activity

Dried jerky was ground using a food blender and passed through a sieve (25 mesh, 2 × 2 × 2 mm). The water activity of each samples was determined in duplicate with a hygrometer (BT-RS1, Rotronicag., Switzerland).

### pH measurements

pH values of raw and dried jerky were determined with a pH meter (Model 340, Mettler-Toledo GmbH, Switzerland). The pH values of samples were measured by blending a 5 g sample with 50 mL distilled water for 60 s in a

**Table 1. Formulation of semi-dried jerky replacing sucrose with various sugar alcohols**

Additive (%, w/w)	Control	Treatments <sup>1)</sup>					
		Sorbitol (2.5%)	Sorbitol (5.0%)	Glycerol (2.5%)	Glycerol (5.0%)	Xylitol (2.5%)	Xylitol (5.0%)
Sucrose	5.0	2.5	-	2.5	-	2.5	-
Sorbitol	-	2.5	5.0	-	-	-	-
Glycerol	-	-	-	2.5	5.0	-	-
Xylitol	-	-	-	-	-	2.5	5.0

<sup>1)</sup>Treatments: Control, semi-dried jerky with no sugar alcohols; sorbitol (2.5%), replacing sucrose with 2.5% sorbitol; glycerol (2.5%), replacing sucrose with 2.5% glycerol; xylitol (2.5%), replacing sucrose with 2.5% xylitol; sorbitol (5.0%), replacing sucrose with 5% sorbitol; glycerol (5.0%), replacing sucrose with 5.0% glycerol; xylitol (5.0%), replacing sucrose with 5.0% xylitol.

homogenizer at 8,000 rpm (Ultra-Turrax SK15, Janke& Kunkel, Germany).

### Drying yield

Drying yield was determined by calculating the weight differences of jerky before and after drying as follows:

Drying yield (%) = [weight of dried sample (g) / weight of raw sample (g)] × 100

### Shear force measurements

Shear force values were determined with a Warner-Bratzler shear attachment on a texture analyzer (TA-XT2i, Stable Micro System Ltd., UK). Test speeds were set at 2 mm/s. Data were collected and analyzed from the shear force values to obtain for the maximum force required to shear through each sample.

### 2-Thiobarbituric acid reactive substance (TBARS) value

Thiobarbituric acid reactive substance (TBARS) values were determined using the distillation method of Tarladgis *et al.* (1960). Results were expressed as mg of malondialdehyde per kg of sample. Fifty mL of distilled water was added to 10 g of sample prior to homogenizing with a homogenizer (AM-7, Nihonseiki Kaisha Ltd., Japan) at 10,000 rpm for 2 min. The cup used for blending was washed with an additional 47.5 mL of distilled water, which was added to the same distillation flask containing 2.5 mL of 4 N HCl and a few drops of an antifoam agent, silicone o/w (KMK-73, Shin-Etsu Silicone Co., Ltd., Korea). The mixture was distilled and 50 mL distillate was collected. Five mL of 0.02 M TBA in 90% acetic acid (TBA reagent) was added to a vial containing 5 mL of the distillate and mixed well. The vials were capped and heated in a boiling water bath for 30 min to develop the chromogen and cooled to room temperature. The absorbance was measured at 538 nm, against a blank prepared with distilled water (5 mL) and TBA-reagent (5 mL), using a UV/VIS spectrophotometer (Libra S22, Biochrom Ltd., England). TBARS values were calculated by multiplying the absorbance by 73%, which was the recovery of the standard from meat, resulting in a K value of 7.8. The TBA values were calculated as mg malondialdehyde (MDA)/kg sample.

### Myofibrillar fragmentation index (MFI) measurements

The MFI was determined according to the procedures

of Olson and Parrish (1976) and Kim *et al.* (2013) with slight modifications. The myofibrils were extracted by MFI buffer (20 mM  $K_2HPO_4/KH_2PO_4$ , pH 7.0, 100 mM KCl, 1 mM EDTA, 1 mM  $NaN_3$ ). The protein concentration of the final suspension was determined by the Biuret method (Gornall *et al.*, 1949) and then diluted with MFI buffer to a protein concentration of  $0.5 \pm 0.05$  mg/mL. The absorbance of the diluted myofibril suspensions were measured at 540 nm using a UV/VIS spectrophotometer (Libra S22, Biochrom Ltd., England) and each absorbance was multiplied by 200 to obtain the MFI values.

### Sugar content measurements

The sugar content values of samples were measured by a refractometer (Model DBX-55, ATAGO Co. Ltd, Japan) that blending a 5 g sample with 50 mL distilled water for 60 s in a homogenizer at 8,000 rpm (Ultra-Turrax SK15, Janke& Kunkel, Germany).

### Sensory evaluation

Sensory analysis was conducted using a duo-trio test. Samples of the control and xylitol (replacing 2.5% and 5%) treatment semi-dried jerkies were prepared and cut into 5 mm size then placed in a petri dish and labeled with 3-digit random numbers. The samples were placed at room temperature and then three samples of the semi-dried jerky were presented to the 15 panelists at the same time. Two out of three samples were the same, with only one being different. The panelists consumed lemon water at 20°C between tasting the samples and were asked to pick one sample, such as the basic sample. Sensory analysis were conducted twice for the semi-dried jerky, once comparing the control to the 2.5% xylitol treatment, and once comparing the control to the 5.0% xylitol treatment.

### Statistical analysis

A total of three independent replicates were conducted and mean values were reported. The statistical analysis of all data was performed by SPSS Ver. 18.0 (SPSS Inc., USA). The one-way ANOVA (one-way analysis of variance) and Duncan's multiple range comparison were used to find the level of significant differences ( $p < 0.05$ ).

## Results and Discussion

### pH value and drying yield

The effects of replacing sucrose with sugar alcohols on the pH value and drying yield of the semi-dried jerkies are shown in Table 2. The pH values of all jerkies ranged

**Table 2. Comparison on pH, drying yields, moisture contents and water activity of semi-dried jerky replacing sucrose with various sugar alcohols**

Traits	Replaced level <sup>2)</sup>	Sorbitol	Glycerol	Xylitol
pH	0%	5.86±0.04 <sup>1)a</sup>	5.86±0.04 <sup>a</sup>	5.86±0.04 <sup>a</sup>
	2.5%	5.84±0.01 <sup>a</sup>	5.84±0.01 <sup>a</sup>	5.84±0.02 <sup>a</sup>
	5.0%	5.84±0.01 <sup>a</sup>	5.85±0.01 <sup>a</sup>	5.83±0.02 <sup>a</sup>
Drying yield (%)	0%	42.09±1.58	42.09±1.58	42.09±1.58
	2.5%	41.94±0.40	42.21±0.60	41.61±0.93
	5.0%	41.95±1.70	42.01±1.62	41.73±1.59
Water activity	0%	0.87±0.02 <sup>a</sup>	0.87±0.02 <sup>a</sup>	0.87±0.02 <sup>a</sup>
	2.5%	0.86±0.01 <sup>Aa</sup>	0.84±0.01 <sup>Bb</sup>	0.85±0.01 <sup>Aa</sup>
	5.0%	0.86±0.01 <sup>Ab</sup>	0.83±0.02 <sup>Bc</sup>	0.84±0.03 <sup>Bb</sup>
Moisture contents (%)	0%	31.11±0.22	31.11±0.22 <sup>b</sup>	31.11±0.22 <sup>b</sup>
	2.5%	31.65±0.65 <sup>B</sup>	33.00±0.34 <sup>Aa</sup>	31.65±0.23 <sup>Ba</sup>
	5.0%	31.27±0.12 <sup>B</sup>	33.26±0.22 <sup>Aa</sup>	31.72±0.30 <sup>Ba</sup>

<sup>1)</sup>All values are mean±standard deviation of three replicates.

<sup>A,B</sup>Means within a row with different letters are significantly different ( $p<0.05$ ).

<sup>a-c</sup>Means within a column with different letters are significantly different ( $p<0.05$ ).

<sup>2)</sup>Replaced level: 0%, no replacing sucrose; 2.5%, replacing sucrose with 2.5% sugar alcohols; 5.0%, replacing sucrose with 5.0% sugar alcohols.

from 5.84 to 5.86, and the increase in the level of sugar alcohol replacements tended to cause a slight decrease in the pH value of the semi-dried jerkies, regardless of the type of sugar alcohols. However, there were no significant differences in pH values among all treatments ( $p>0.05$ ). In this study, the pH values of the sorbitol, glycerol, and xylitol used were 4.36, 5.67, and 5.26, respectively (data not shown), but the replacement levels within 5% had no influence on the pH values of the semi-dried jerkies. In another food study, Park (2007) reported that the pH values of strawberry jam in which sucrose was replaced with sugar alcohols had no significant differences ( $p>0.05$ ).

The range of drying yield of the semi-dried jerkies ranged 41.73-42.21%, but there were no differences among the treatments ( $p>0.05$ ). Seol (2003) and Han *et al.* (2011) reported that humectant (konjac, egg albumin and isolated soy protein) treatments resulted in higher drying yields than control beef and chicken jerky. In addition, Song *et al.* (1997) reported higher drying yields of beef jerky containing glycerol, rice syrup and honey than that of the control. In this study, however, the replacement of sucrose with sugar alcohols had no effect on the drying yield of semi-dried jerkies. The hygroscopic property of sugar alcohols is based on the hydrogen bond between the sugar alcohol and water, but it is considered that the drying process over a long time could break the hydrogen bonds between the sugar alcohol and water. This reaction might be associated with the no impacts of sugar alcohols on drying yield of semi-dried jerkies.

### Water activity and moisture content

Water activity is one of the important factors related to the classification standard for dehydrated food. In general, the water activity of semi-dried food usually ranges from 0.60-0.90, which is considered to be relatively safe against microorganisms (Ku *et al.*, 2013). The effects of replacing sucrose with sugar alcohols on the water activity and moisture content of the semi-dried jerkies are shown in Table 2. The water activity of the semi-dried jerky with sugar alcohol replacements ranged from 0.84-0.87, and the addition of 2.5% glycerol, 5.0% glycerol, and 5.0% xylitol in the semi-dried jerky led to lower water activity than the control ( $p<0.05$ ). However, the addition of 2.5% and 5% sorbitol to the semi-dried jerky showed no significant effect on the water activity ( $p>0.05$ ). Similarly, Choi *et al.* (2008) reported the water activity of semi-dried jerky prepared with various pork/beef levels and casings to be within the range of 0.82-0.88. Han *et al.* (2011) also obtained water activities of 0.84-0.86 for semi-dried chicken jerky with various humectants. In the previous studies, glycerol was an effective additive for the control of water activity (Linko *et al.*, 1985). Sorbitol is a six-carbon (molecular weight: 128), glycerol is an aliphatic three-carbon (molecular weight: 92) and xylitol is a five-carbon (molecular weight: 158) sugar alcohol among the monosaccharides. In contrast, sucrose combines  $\alpha$ -glucose and  $\beta$ -fructose (molecular weight: 342) and is among the disaccharides. When the amount of the solute is the same, as the molecular weight is decreased by substitution the osmotic pressure is

increased, and the increase osmotic pressure subsequently causes the water activity to decline (Ko *et al.*, 2006). Because xylitol is low molecular weight, xylitol solution has greater osmotic pressure than the same amount of sucrose solution and low water activity. Thus, it has greater conservation effects. (Oh *et al.*, 2002).

When manufacturing intermediate-moisture food, it is important to control the moisture content, as water activity is highly related to the moisture content (Leistner, 1987). Among the functional properties of sugar alcohols, the hygroscopic property, which is the ability to absorb and retain water, and increase in the molecular weight of the sugar alcohols could prevent change in the moisture content of foods. In products such as confectionery, less than 5.0% of the sugar alcohols are used with the purpose of maintaining freshness and preventing the formation of sugar crystals (Noh and Kim, 2000). In the present study, the moisture content of the semi-dried jerky with sugar alcohol replacements ranged from 30.79-33.26%, and treatment groups, with the exception of 5.0% sorbitol, had higher moisture content than the control ( $p < 0.05$ ).

#### **Shear force and myofibrillar fragmentation index (MFI) measurements**

Tenderness is the most important textural factor of meat and meat products, and significantly influences consumer preference (Guerrero *et al.*, 1999; Kim and Lee, 2003). The shear force and MFI of semi-dried jerkies made by replacing sucrose with sugar alcohols are shown in Table 3. The increase in the level of sugar alcohols tended to cause a slight decrease in the shear force of the semi-dried jerkies. However, there were no significant differences in shear force except for the 5.0% xylitol replacement ( $p < 0.05$ ). Kim *et al.* (2010) demonstrated that the shear force of pork jerky decreased significantly with increased levels of glycerol (2% and 5%) and sorbitol (2% and 5%). However, Barrett *et al.* (1998) observed the firmness of 2% glycerol samples to be higher than that of 0% and 4% glycerol. Lacroix and Castigne (1985) reported a complex, nonlinear correlation between glycerol level and texture. Their results reported the slight firmness of frankfurters at low glycerol levels, attributing the cause to glycerol-enhanced emulsion stability, which decreased at higher glycerol levels. According to Barrett *et al.* (1998), glycerol may have chemical and physicochemical effects. Glycerol has competing effects such as glycerol-facilitated cross-linking and glycerol-promoted scission of protein, which can happen at the same time in meat products. For this reason, our results suggest that the

semi-dried jerkies were not linearly influenced by the increasing replacement levels of sugar alcohols, and the replacement with 5.0% xylitol effectively improved tenderness of semi-dried jerkies.

Proteolysis of meat and meat products is one of the main factors influencing the tenderness of meat (Kim *et al.*, 2013), and myofibrillar fragmentation index (MFI) has been used as an indicator for protein degradation during aging and meat processing (Gerelt *et al.*, 2000). In this study, MFI was measured to determine the difference in protein degradation of semi-dried jerkies containing several sugar alcohols. Karumendu *et al.* (2013) reported that MFI had a high correlation with both sensory tenderness scores and shear force. In this study, MFI was used to evaluate effects on the proteolysis of added sugar alcohols in semi-dried jerky. The MFI values of semi-dried jerky made by replacing sucrose with sugar alcohols were 84.80-88.53, but there were no significant differences among the treatments ( $p > 0.05$ ). Similar results were reported in study of Kim *et al.* (2010), in which the sodium dodecyl sulfate poly-acrylamide gel (SDS-PAGE) patterns of pork jerky containing sugar alcohols, sorbitol and glycerol showed no influence on the degradation of myofibrillar protein. Those results showed that myofibrillar protein did not undergo fragmentation reaction, thus sorbitol and glycerol did not affect the proteolysis. The results of the present study were in agreement with the previous results, and it was considered that sugar alcohols did not affect the MFI.

#### **Sugar content**

The sugar content of the semi-dried jerkies in which sucrose was replaced with sugar alcohols is shown in Table 3. The sugar contents of semi-dried jerkies containing sorbitol (2.5% and 5.0%) and glycerol (2.5% and 5.0%) were significantly lower than the control ( $p < 0.05$ ), but the replacement of sucrose with xylitol showed no significant difference. Generally, sucrose is known to have the sugar content of 1.0 (brix), while sorbitol, glycerol and xylitol have sugar contents of 0.6-0.8, 0.6 and 1.0-1.1, respectively. Thus, sorbitol and glycerol treatments produced semi-dried jerky with lower sugar content.

#### **2-thiobarbituric acid reactive substance (TBARS) value**

The TBARS value is the most commonly used indicator to measure the extent of lipid oxidation in meat products (Chen *et al.*, 2004). The TBARS values of semi-dried jerkies made by replacing sucrose with sugar alcohols are

**Table 3. Comparison on shear force, MFI and sugar content of semi-dried jerky replacing sucrose with various sugar alcohols**

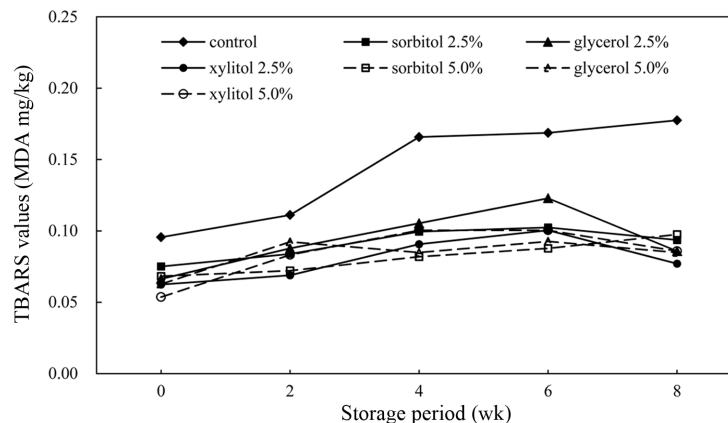
Traits	Replaced level <sup>2)</sup>	Sorbitol	Glycerol	Xylitol
Shear force (kg)	0%	14.17±1.80 <sup>1)</sup>	14.17±1.80	14.17±1.80 <sup>a</sup>
	2.5%	13.70±1.39	13.86±2.07	13.99±1.61 <sup>a</sup>
	5.0%	13.76±2.43	13.30±1.83	12.71±1.57 <sup>b</sup>
MFI	0%	88.47±1.29	88.47±1.29	88.47±1.29
	2.5%	86.35±2.32	85.40±4.06	84.80±3.54
	5.0%	86.27±8.10	87.47±1.45	88.53±1.36
Brix (%)	0%	5.38±0.05 <sup>a</sup>	5.38±0.05 <sup>a</sup>	5.38±0.05 <sup>ab</sup>
	2.5%	5.13±0.05 <sup>Bb</sup>	5.05±0.06 <sup>Bc</sup>	5.45±0.06 <sup>Aa</sup>
	5.0%	5.13±0.10 <sup>Bb</sup>	5.18±0.05 <sup>Bb</sup>	5.33±0.10 <sup>Ab</sup>

<sup>1)</sup>All values are mean±standard deviation of three replicates.

<sup>A,B</sup>Means within a row with different letters are significantly different ( $p<0.05$ ).

<sup>a-c</sup>Means within a column with different letters are significantly different ( $p<0.05$ ).

<sup>2)</sup>Replaced level: 0%, no replacing sucrose; 2.5%, replacing sucrose with 2.5% sugar alcohols; 5.0%, replacing sucrose with 5.0% sugar alcohols.



**Fig. 1. TBARS values of semi-dried jerky replacing sucrose with various sugar alcohols during storage.** Treatments: (◆) control, semi-dried jerky with no sugar alcohols; (■) sorbitol 2.5%, semi-dried jerky replacing sucrose with 2.5% sorbitol; (▲) glycerol 2.5%, semi-dried jerky replacing sucrose with 2.5% glycerol; (●) xylitol 2.5%, semi-dried jerky replacing sucrose with 2.5% xylitol; (□) sorbitol 5.0%, semi-dried jerky replacing sucrose with 5.0% sorbitol; (△) glycerol 5.0%, semi-dried jerky replacing sucrose with 5.0% glycerol; (○) xylitol 5.0%, semi-dried replacing sucrose with 5.0% xylitol.

shown in Fig. 1. In this study, the semi-dried jerkies containing sugar alcohols had lower TBARS values than the control (no replacement with sugar alcohols). Over increasing storage period, the TBARS values tended to increase, while the TBARS values of sugar alcohol replacements remained lower than the control. The TBARS value generally increases in meat with increasing storage time due to lipid oxidation (Yang *et al.*, 2009). Sugar alcohols combine with free radicals to form a composite, so the oxidation reaction occurs relatively slowly, and the sugar alcohols have metal ion-chelating ability, promoting oxidation (Noh and Kim, 2000). According to Kang *et al.* (2007), who evaluated the antioxidant activity of sugar alcohols (xylitol, sorbitol and mannitol) using the TOSC (total oxy-radical scavenging capacity) assay, low molec-

ular weight antioxidants such as vitamin C or E have hydroxyl groups, which generally combine with free-radicals to inhibit the oxidation reaction. Therefore, the oxy-radical scavenging capacity of sugar alcohols was expected to increase proportionally with the increase in hydroxyl groups. When the hydroxyl groups of sugar alcohols increased from 5 to 6, however, the hydroxyl radical scavenging capacity did not show a significant change. Kang *et al.* (2007) therefore suggested that between the types or replacement levels of sugar alcohol and the antioxidant capacity, there seems to be a non-linear relationship. Thus, the replacement of sucrose with sugar alcohols could inhibit lipid oxidation of the semi-dried jerkies due to free-radical scavenging activity; however, the type and replacement level of sugar alcohols had no influence on

**Table 4. Number of correct answers in the duo-trio test on semi-dried jerky replacing sucrose with various sugar alcohols**

Comparison	Number of panelists	Number of correct answers necessary to establish level of significance ( $p < 0.05$ )	Number of correct answers received	Result
Xylitol 2.5%	15	12	10	Not significant
Xylitol 5.0%	15	12	12	Significant

the antioxidant effect.

### Sensory evaluation

Based on the above results, it was expected that xylitol would be useful to improve water activity and tenderness and to prevent lipid oxidation. Thus, the sensory evaluation of semi-dried jerky made by replacing sucrose with xylitol was conducted (Table 4). When sucrose was replaced with 5.0% xylitol in the semi-dried jerky and compared with the control in a duo-trio test, 12 of 15 panelists were able to choose the same sample as the standard sample correctly ( $p < 0.05$ ). However, when sucrose was replaced with 2.5% xylitol in the semi-dried jerky and compared with the control, only 10 of 15 panelists were able to pick the same sample as the standard sample ( $p > 0.05$ ). This indicated that only the replacement of sucrose with 5.0% xylitol was significantly different from the control. The reason is considered to be that physical experiments revealed lower shear force values, thus the mechanical experiments affected the sensory evaluation.

### Conclusion

The results from this study demonstrated that semi-dried jerkies made by replacing sucrose with sugar alcohols had more moisture content and lower water activity and TBARS values than that made without sugar alcohol replacements. On the other hand, the shear force of the semi-dried jerkies was the lowest when sucrose was replaced with 5.0% xylitol. According to sensory evaluations, the replacement of sucrose with 5.0% xylitol has a significant difference in the overall evaluation, as contrasting with no replacement with xylitol. Therefore, it is suggested that the replacement of sucrose with sorbitol, glycerol and xylitol provide partially positive effects on the quality characteristics of semi-dried jerkies, and the replacement with 5.0% xylitol could be the optimal replacement level.

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