Improving Texture and Storage Stability of Chinese-Style Pork Jerky by the Addition of Humectants

W. S. Chen[1], D. C. Liu, M. T. Chen* and H. W. Ockerman[2]
Department of Animal Science, National Chung-Hsing University, Taichung, Taiwan 40227, ROC

ABSTRACT : Chinese-style pork jerky with different levels (3, 6 and 9%) of glycerol or sorbitol were prepared. Moisture content, water activity (a_w) and shear value decreased with the addition of glycerol or sorbitol. During storage at 28℃, thiobarbituric acid (TBA) value of all samples declined with the addition of glycerol or sorbitol during storage time. After storage at room temperature (28℃) for 180 days, the volatile basic nitrogen (VBN) of all treated products were less than the control group. In addition, the mold and yeast growth were inhibited slightly with the addition of glycerol or sorbitol. The absorption isotherm of pork jerky with different levels of glycerol at 25℃ had an a_w above 0.75, and moisture contents at 6 and 9% which were higher than the control group. The moisture content was less than the control group with the addition of sorbitol. The chewiness desirability score of pork jerky with 6% glycerol was higher than the other treatments. However, no differences in hardness desirability score due to treatments were detected by sensory panelists. *(Asian-Aus. J. Anim. Sci. 2000. Vol. 13, No. 10 : 1455-1460)*

Key Words : Chinese-Style Pork Jerky, Humectant, Glycerol, Sorbitol, Texture

INTRODUCTION

Chinese-style pork jerky is one of the most popular traditional meat snacks in Taiwan. Characteristics of the pork jerky are that it is relatively simple to process, has a typical flavor, and needs no refrigeration during commercial distribution due to its low water activity (a_w). Su and Lin (1988) observed that the a_w of Chinese-style pork jerky ranged from 0.72 to 0.75. According to its a_w, pork jerky can be classified as an intermediate moisture food (IMF; 0.60 to 0.90, Leistner and Rodel, 1976). Several descriptions and investigations of Chinese-style pork jerky have been reported by Lin et al. (1979, 1982). These researchers described a new process for manufacturing pork jerky, but they did not report if it improved the quality of the product.

Consumers prefer products with a softer texture and with well-controlled microbiological quality during storage. Intermediate moisture meat (IMM) has a relatively long shelf-life at normal room temperature due to the reduction of a_w by the addition of various humectants. Since humectants can keep water in food, they can improve or soften the texture and reduce the a_w of food. The growth of microorganisms can be efficiently inhibited by a low a_w system. Several studies were undertaken to determine the effect of humectants, especially glycerol (Barrett et al., 1998) and sorbitol (Leung et al., 1984), on properties of IMM. Guilbert et al. (1981) found that the addition of 5 or 10% glycerol was most effective in reducing a_w. A further study by Leung et al., (1984) pointed out that the shelf-life of IMF can be prolonged by the incorporation of 12% sorbitol due to a lower a_w. In addition, humectants have other desirable characteristics, such as a low price, being nontoxic, relatively tasteless and colorless, and effective at low concentrations (Vallejo-Cordoba et al., 1986; Hamilton, 1988). This research was carried out to evaluate the effects of various levels of glycerol or sorbitol on the texture and storage stability of Chinese-style pork jerky.

MATERIALS AND METHODS

Preparation of Chinese-style pork jerky

Frozen boneless pork legs were obtained from a local meat plant and trimmed of all subcutaneous fat and connective tissue. The curing ingredients (based on raw meat weight) bought from a local food additives plant included 1% sodium chloride, 15% sucrose, 1% monosodium glutamate, 5% soybean sauce, 0.3% sodium tripolyphosphate, 0.1% cinnamon, 0.05% ascorbic acid, 0.01% sodium nitrite, 0.01% sodium nitrate, 0.1% five-spices powder (containing anise, cinnamon, clove, fennel, and watchou), and different amounts (3, 6 and 9%) of glycerol (Merck, Darmstadt, Germany) or sorbitol (Sigma Chemical Co., St. Louis, Mo.).

The pork jerky was processed by the following procedure: (1) the selected pork legs were trimmed of all subcutaneous fat and connective tissue; (2) sliced into 4 mm thick by slicer (JWS-330, Woo Jin Co., South Korea); (3) the curing ingredients mixed with sliced pork chops; (4) cured at 4℃ for 48 hours; (5) dried at 55℃ for 70 minutes; (6) roasted at 180℃ for

* Address reprint request to M. T. Chen. Tel: +886-4-2850788, Fax: +886-4-2860451.
[1] Taiwan Livestock Research Institute, Council of Agriculture, Hsinhua, Tainan, Taiwan, ROC.
[2] Department of Animal Science, The Ohio State University, OH 01234, USA.

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5 minutes. The final product was stored at room temperature (28℃) for six months for a storage experiment. The moisture content, water activity, shear value and absorption isotherm were determined immediately when the final products were prepared, before storage. On the 0, 45th, 90th, 135th, and 180th day, the growth of mold and yeast, thiobarbituric acid (TBA) and volatile basic nitrogen (VBN) of pork jerky were determined. All analyses were performed in duplicate or triplicate.

Moisture content

The moisture content was determined by oven drying the sample to constant weight at 100℃ for 18 h (AOAC, 1980).

Water activity measurements

Water activity (a_w) of the sample was determined by using a hygrometer (TH/RTD 523, Novasina, Swiss). The a_w was determined in triplicate on 2 g ground samples held at 25±0.1℃ until equilibrium was reached.

Texture measurement

Shear value was measured on the pork jerky (samples cut into 1.2 cm^2) using a Warner-Bratzler Shear device (Salter, GR electric Mfg. Co. USA). The device was programmed for a load range of 20 kg (at a crosshead speed of 100 mm/min) and the force required to shear across the meat fibres was determined.

Thiobarbituric acid value

The thiobarbituric acid (TBA) was determined to establish the extent of lipid oxidation (Witte et al., 1970) in pork jerky during storage at room temperature. A 10 g sample was added to a blender with 25 ml of 20% trichloroacetic acid and 20 ml deionized water. The mixture was homogenized for 2 mins and filtered through Whatman (#1) filter paper. The filtrate was mixed with an equal volume of 0.02 M thiobarbituric acid and incubated at 100℃ for 35 mins. It was then cooled in tap water for 10 mins. The absorbance of the solution was measured with a spectrophotometer (U-2001 Hitachi, Japan) at 532 nm. The results were expressed as TBA values (mg malonaldehyde/kg meat). The formula for calculation: TBA value = $O.D._{532} \times 7.8$.

Determination of volatile basic nitrogen

The volatile basic nitrogen (VBN) was determined by the AOAC method (1980) for pork jerky at the 0, 45th, 90th, 135th, and 180th day. The results were expressed as VBN value (mg/kg meat).

Mold and yeast counts

Both mold and yeast counts were measured by the FDA method (Bandler et al., 1995) for pork jerky at the 0, 45th, 90th, 135th, and 180th day. Medium of choice is potato dextrose agar (Difco Laboratories, Detroit, Mich.) and plates were incubated in the dark at 25℃ for 5 days.

Sensory evaluation

A total of 32 panelists (undergraduate and graduate students of the Department of Animal Science, National Chung-Hsing University) evaluated the samples for hardness and chewiness desirability. Samples were prepared by cutting into 2 cm^2 pieces for this test. Sensory evaluation method used was the hedonic test. A score of 1 indicated very low desirability in hardness and chewiness and a score of 7 indicated very high desirability in hardness and chewiness.

Determination of absorption isotherms

The pork jerky was put into weighing bottles and kept in containers which contained different saturated salt solutions. Those containers were kept in an oven at 25℃ for 4 days. The salts were LiCl (0.11 a_w), CH_3COOK (0.23 a_w), $MgCl_2$ (0.33 a_w), K_2CO_3 (0.44 a_w), $Mg(NO_3)_2$ (0.53 a_w), NaBr (0.58 a_w), $SrCl_2$ (0.71 a_w), NaCl (0.75 a_w), KCl (0.84 a_w) and $BaCl_2$ (0.90 a_w) according to the description of Spiess and Wolf (1987). As the time for a_w determination was reached, same pork jerky sample was weighed rapidly and then used for moisture content determinations. The data were plotted as a_w and moisture content (dry matter basis) to draw absorption isotherm.

Statistical analysis

All data were subjected to analysis of variance, using the General Linear Model (GLM) procedure (SAS, 1995). Comparison of treatment means was based on Duncan's multiple range test. A significance level of $p<0.05$ was applied in all cases.

RESULTS AND DISCUSSION

Moisture content, water activity and shear value changes

The results of table 1 showed that moisture content of pork jerky decreased slightly with increased levels of glycerol or sorbitol. The water activity (a_w) of the pork jerky also decreased with increased levels of glycerol or sorbitol. With the addition of 9% glycerol or sorbitol the moisture content and a_w were significantly lower ($p<0.05$) than the control. These results agreed with the literature that moisture content and a_w in IMM was reduced by the addition of glycerol (Boyle et al., 1993) and sorbitol (Muguruma et al., 1987). The shear value of pork jerky decreased significantly ($p<0.05$) with increased levels of glycerol or sorbitol. The results were identical to those reported

Table 1. Effect of glycerol or sorbitol on moisture content, water activity, and shear value in Chinese-style pork jerky

Items	Control	Glycerol (%)			Sorbitol (%)		
		3	6	9	3	6	9
Moisture content, %	24.23 ± 0.55^{a}*	23.66 ± 0.42^{ab}	23.93 ± 0.59^{ab}	22.50 ± 0.38^{bc}	23.51 ± 0.59^{ab}	22.95 ± 0.55^{abc}	21.82 ± 0.42^{c}
Water activity	0.78 ± 0.01^{a}	0.76 ± 0.01^{abc}	0.75 ± 0.01^{bc}	0.75 ± 0.01^{bc}	0.77 ± 0.01^{ab}	0.76 ± 0.01^{abc}	0.74 ± 0.01^{d}
Shear value, kg	6.07 ± 0.13^{a}	5.25 ± 0.11^{bc}	5.06 ± 0.45^{cd}	3.79 ± 0.32^{f}	5.56 ± 0.65^{b}	4.64 ± 0.56^{de}	4.49 ± 0.70^{e}

Control=contains no glycerol or sorbitol.

* Mean±Standard error (SE).

^{a,b,c,d,e,f} Values without a common superscript letter in the same row are significantly different ($p<0.05$).

by Barrett et al. (1998). They indicated that the glycerol functioned as an effective textural plasticizer in certain meat products. Also, a similar conclusion showed that decreasing the firmness in whole-muscle meat was due to increased water and glycerol (Okonkwo et al., 1992). The results showed that sorbitol was incorporated into pork jerky resulted in less firmness and were similar to those from glycerol in this study.

Changes in TBA value

Many complicated reactions take place in most meat products during storage and some damage meat quality, including fat oxidation and pigment discoloration (Obanu, 1988). The TBA value is the most common indicator used to measure the degree of lipid oxidation in food. The results from the present study showed that the TBA value of pork jerky with glycerol were higher than sorbitol and the control group in the initial phase (table 2). This result was similar to those of Okonkwo et al. (1992), who reported that intermediate moisture smoked meats with glycerol had a higher TBA value than the control group in the initial storage phase. Bello and Bello (1976) have shown that appreciable concentrations of both aldehydes and peroxides can be formed by glycerol in the presence of oxygen and can be oxidized in an intermediate environment (Obanu et al., 1977). However, the TBA value of the glycerol treated pork jerky declined during storage in this study ($p<0.05$). In contrast to the glycerol treatments, the TBA value of the control increased significantly and after 180 days storage the TBA value of the glycerol treatment was significantly lower ($p<0.05$) than the control. The pork jerky with the addition of 9% sorbitol had a lower ($p<0.05$) TBA value than the other treatments at 180 days of storage. Obanu et al. (1975) stated that the initial TBA value is 10 to 100 times higher than normally observed for newly cooked meat. Also, they reported that the TBA value of some beef products was high immediately after processing but declined during the first few weeks of storage at 38℃ and then continued to decrease during prolonged storage. The results of this study followed the same pattern as in the studies reviewed above.

Changes in VBN

Changes in VBN during the storage period are shown in table 3. The VBN of all pork jerky stored at 28℃ increased ($p<0.05$) with storage time. The

Table 2. Changes of TBA value in Chinese-style pork jerky with different levels of glycerol or sorbitol during storage at 28℃ (mg malonaldehyde/kg meat)

Treatment	Level (%)	Storage time (days)				
		0	45	90	135	180
Control*		7.6 ± 0.18^{ex}**	7.3 ± 0.16^{bcx}	8.6 ± 0.20^{cy}	8.9 ± 0.18^{bcy}	9.8 ± 0.31^{az}
Glycerol	3	13.0 ± 0.38^{bcz}	11.4 ± 0.18^{ay}	9.5 ± 0.21^{bx}	9.1 ± 0.20^{bcx}	9.2 ± 0.52^{cx}
	6	13.3 ± 0.18^{bz}	7.6 ± 0.17^{bw}	8.7 ± 0.19^{cx}	8.6 ± 0.16^{cx}	9.1 ± 0.15^{bcy}
	9	14.7 ± 0.32^{az}	7.1 ± 0.16^{cx}	6.0 ± 0.13^{ew}	5.4 ± 0.13^{ev}	7.9 ± 0.14^{dy}
Sorbitol	3	10.2 ± 0.31^{dy}	7.0 ± 0.16^{cx}	11.1 ± 0.24^{az}	10.4 ± 0.31^{ayz}	9.7 ± 0.26^{aby}
	6	10.3 ± 0.26^{dz}	6.1 ± 0.15^{dx}	9.5 ± 0.26^{by}	9.4 ± 0.41^{by}	9.1 ± 0.14^{cy}
	9	11.9 ± 0.25^{cz}	11.0 ± 0.21^{ay}	6.8 ± 0.22^{dx}	6.3 ± 0.14^{dx}	6.4 ± 0.17^{ex}

* Control=Contains no glycerol or sorbitol.

** Mean±SE.

^{a,b,c,d,e} Values without a common superscript letter in the same column are significantly different ($p<0.05$).

^{v,w,x,y,z} Values without a common superscript letter in the same row are significantly different ($p<0.05$).

Table 3. Changes of VBN value in Chinese-style pork jerky with different levels of glycerol or sorbitol during storage at 28℃ (mg/kg meat)

		Storage time (days)				
Treatment	Level (%)	0	45	90	135	180
Control*		12.4 ± 0.74^{y}**	23.2 ± 1.02^{ax}	26.8 ± 0.97^{aw}	28.7 ± 0.77^{avw}	31.1 ± 0.70^{av}
Glycerol	3	11.1 ± 0.46^{y}	21.3 ± 0.49^{bx}	25.2 ± 0.99^{abw}	27.1 ± 0.72^{abvw}	28.9 ± 0.84^{bv}
	6	12.0 ± 0.82^{y}	21.2 ± 0.56^{bx}	24.7 ± 0.87^{abw}	25.8 ± 0.58^{bw}	28.3 ± 0.53^{bcv}
	9	11.6 ± 0.51^{z}	19.4 ± 0.64^{by}	22.6 ± 0.88^{bx}	25.1 ± 0.58^{bw}	27.0 ± 0.88^{cv}
Sorbitol	3	12.0 ± 0.72^{y}	20.1 ± 0.47^{bx}	26.3 ± 0.77^{aw}	27.1 ± 0.63^{abw}	29.2 ± 0.68^{bv}
	6	12.2 ± 0.77^{y}	19.8 ± 0.50^{bx}	24.6 ± 0.87^{abw}	27.1 ± 0.75^{abv}	28.5 ± 0.79^{bcv}
	9	11.9 ± 0.76^{y}	19.9 ± 0.48^{bx}	23.5 ± 0.62^{bw}	24.9 ± 0.94^{bw}	27.8 ± 0.61^{bcv}

* Control=Contains no glycerol or sorbitol.

** Mean±SE.

a,b,c Values without a common superscript letter in the same column are significantly different ($p<0.05$).

v,w,x,y,z Values without a common superscript letter in the same row are significantly different ($p<0.05$).

pork jerky with different glycerol or sorbitol contents had lower VBN values than the control group ($p<0.05$). This result, and those described in the following section, suggests that microbial growth was faster in pork jerky without glycerol or sorbitol: These bacteria have the ability to decompose proteins, causing the spoilage of meat products and generating VBN (Marangkey et al., 1989).

Mold and yeast counts

With semi-solid intermediate moisture foods (IMF) with a_w values within the range of 0.65 to 0.90, mold and yeast growths are usually the most important microbiological spoilage problem (Seiler, 1976). Populations of mold and yeast in the pork jerky during the storage period are shown in table 4 and 5. The results from the present study showed that the mold and yeast counts were higher in the initial phase. The addition of 6 or 9% glycerol or sorbitol resulted in lower mold and yeast counts during storage. Increasing the glycerol or sorbitol resulted in a gradual inhibition of mold and yeast growth in this study. These results clearly indicated that it is possible to produce pork jerky with low mold and yeast counts when 6 or 9% of glycerol or sorbitol are incorporated.

Absorption isotherms of pork jerky

IMF exhibit hysteresis phenomena in their water sorption isotherms (Labuza, 1968). Two different isotherms are obtained depending on the direction of the water transfer (desorption and absorption). Furthermore, at the same a_w, greater microbial death rates were recorded for absorption compared to desorption samples (Plitman et al., 1973). The absorption isotherms of pork jerky with various glycerol or sorbitol levels at 25℃ for 4 days are shown in figure 1. These results indicated that at a_w of 0.75, the moisture content of the 6 and 9% glycerol samples were higher than the others treated pork jerky, and the moisture contents of all sorbitol treated pork jerky were lower than the other treatments. Meanwhile, at an a_w of 0.9, the moisture contents of the 6 or 9% glycerol treatments were higher than the other treatments but the moisture contents of 3 or 6% sorbitol contents were lower than the other groups.

Table 4. Growth of mold in Chinese-style pork jerky with different levels of glycerol or sorbitol during storage at 28℃ (log CFU/g of meat)

		Storage time (days)				
Treatment	Level (%)	0	45	90	135	180
Control*		2.47	<2**	2.90	3.30	2.36
Glycerol	3	3.47	<1**	<2	2.39	2.16
	6	2.30	<1	2.25	<2	<2
	9	3.47	2.90	<2	<2	<2
Sorbitol	3	<2	<1	<2	2.18	2.32
	6	2.90	<2	2.30	<2	<2
	9	2.30	<1	<2	<2	<2

* Contains no glycerol or sorbitol.

** No colony growth found in samples diluted to 10^{-2} or 10^{-1}.

Table 5. Growth of yeast in Chinese-style pork jerky with different levels of glycerol or sorbitol during storage at 28℃ (log CFU/g of meat)

Treatment	Level (%)	Storage time (days) 0	45	90	135	180
Control*		2.47	<2**	2.90	3.30	2.36
Glycerol	3	3.47	<1**	<2	2.42	<2
	6	2.30	<1	2.45	<2	2.36
	9	3.47	2.90	<2	<2	<2
Sorbitol	3	2.47	<1	<2	2.86	2.56
	6	2.30	<2	2.30	<2	<2
	9	2.47	<1	<2	<2	<2

* Control=Contains no glycerol or sorbitol.
** No colony growth found in samples diluted to 10^{-2} or 10^{-1}.

Table 6. Effect of glycerol or sorbitol on sensory evaluation in Chinese-style pork jerky*

Parameter	Control	Glycerol (%) 3	6	9	Sorbitol (%) 3	6	9
Hardness desirability	4.86±0.28^{ab}**	4.93±0.33^{ab}	5.58±0.31^{ab}	5.67±0.25^{a}	5.28±0.26^{ab}	4.75±0.27^{b}	4.86±0.26^{ab}
Chewiness desirability	4.87±0.25^{ab}	5.33±0.25^{ab}	5.62±0.20^{a}	5.43±0.24^{ab}	5.11±0.25^{ab}	4.68±0.22^{b}	4.73±0.28^{ab}

Control=contains no glycerol or sorbitol.
* Seven point hedonic score, 1=extremely undesirable and 7=extremely desirable.
** Mean±SE of hardness and chewiness desirability evaluation for each treatment is the average of two replications.
^{a,b} Values without a common superscript letter in the same row are significantly different ($p<0.05$).

Sensory evaluation

The mechanical characteristics in this study can be divided into the following parameters: a) Hardness, defined as the force necessary to attain a given deformation; b) Chewiness, defined as the energy required to masticate a solid food product to a state ready for swallowing (Szczesniak, 1963). Sensory evaluation was performed using a hedonic test. The results in table 6 show that the hardness desirability of pork jerky with 9% glycerol was higher than other groups ($p<0.05$); the chewiness desirability of pork jerky with 6% glycerol was higher than other groups ($p<0.05$). This study showed that glycerol can be used as an effective plasticizer in pork jerky because it not only reduced the a_w of the product, but it also improved its organoleptic properties. There has been a similar finding: glycerol has been an effective plasticizer in some protein foods (Kalichevsky et al., 1992). The hardness desirability of pork jerky with 3% sorbitol was higher than the control group. In addition to 3% sorbitol, the hardness and chewiness desirabilities of pork jerky with 6 or 9% sorbitol were lower than the other treatments (no improvement in the organoleptic properties).

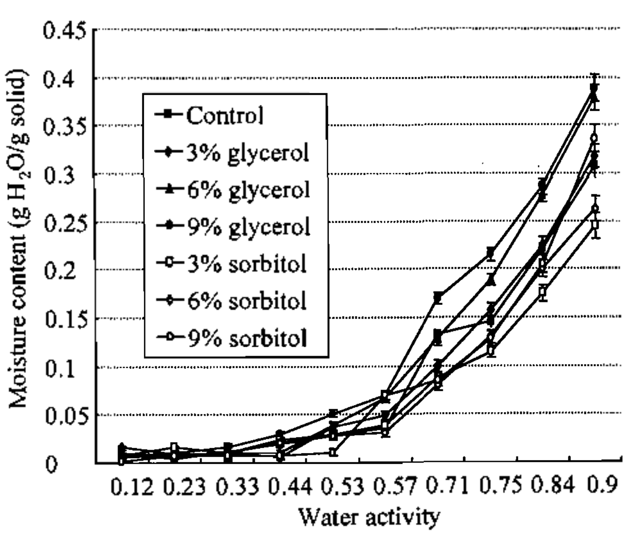

Figure 1. Effect of glycerol and sorbitol on absorption isotherm of Chinese-style pork jerky at kept 25℃ for 4 days. All points are the means of duplicate determinations.

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