Determination of Quality Changes throughout Processing Steps in Chinese-style Pork Jerky

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ABSTRACT : Chinese-style pork jerky is a typical intermediate moisture meat product obtained by curing, drying and roasting pork samples. The chemical, physical and microbiological characteristics of pork jerky were evaluated throughout processing. The moisture content varied from 72.5% to 23.4 or 19.6% and a_w varied form 0.97 to 0.74 or 0.72 in accordance with processing steps. The pork jerky roasted at 200°C had higher shear value than roasted at 150°C because the moisture content and a_w of the former sample was lower than the later sample. The nitrite losses during whole processing steps amount to nearly 50%. The TBA value of pork jerky varied from 0.34 to 9.25 or 9.83 mg of malonaldehyde depended on processing steps. The VBN value of pork jerky ranging from 0.25 to 22.4 or 23.5 mg/kg depended upon processing steps. The ATPase activity of myofibrillar proteins during processing steps were partly or entirely denatured by the heat-drying or heat-roasting treatment. A gradual decrease in microorganism count during processing of pork jerky was also observed. *(Asian-Aust. J. Anim. Sci. 2004. Vol 17, No. 5 : 700-704)*

Key Words : Chinese-style Pork Jerky, Quality Changes, Water Activity

INTRODUCTION

Chinese-style pork jerky product that has a water activity (a_w) of about 0.75 and is the most popular traditional Chinese meat item in Taiwan (Chen et al., 2000). Pork jerky have the following characteristics: relatively simple to process, easy to store, typical flavor (Chen et al., 2002a), ready-to-eat, and storable without refrigeration. The raw material used for pork jerky is mainly pork ham, and the ingredients of pork jerky including common salt, table sugar, monosodium glutamate, soy sauce, 5 spice powder (anise, cinnamon, clove, fennel, and watchou), etc. The type and amounts of spices used varies in the different regions of Taiwan. Numerous descriptions and investigations of pork jerky have been reported by Lin et al. (1979, 1982) who have described the production of shredded dried pork along with problems encountered in trying to adapt the small-scale operation to large-scale western-style on-line methods. Previous research indicates that moisture content, water activity and protein denaturation of pork jerky was affected by high levels of sucrose (Chen et al., 2002b). Wang and Leistner (1994) have also discussed the principles involved in production of a novel dried pork meat product based on hurdle technology.

Since production of pork jerky is rather as empirical process and suffers from lack of control of time and temperature, the present study was undertaken to investigate the operating parameters for better controlled heating-drying methods. Torres et al. (1994) have shown a high incidence of microbiological contamination in marketing intermediate moisture meat (IMM). Traditional techniques used in Taiwan, to produce pork jerky, often combine curing, drying (by convection oven) and grilling (by far-infrared grill or charcoal grill) (Chen et al., 2001).

Consumers desire the traditional pork jerky with softer texture and with well-controlled microbiological quality. Pork jerky has a relatively long shelf-life at room temperature due to the reduction of water activity (a_w). The growth of microorganisms can be inhibited by a low a_w. Drying and heating both are useful methods to reduce a_w in meat products, it is important that set up ideal model of drying and heating procedure to produce pork jerky with good quality. The aim of this work was to establish pork jerky quality parameters throughout processing by means of physico-chemical and microbiological determinations.

MATERIALS AND METHODS

Preparation of pork jerky

The formula of curing ingredients (based on raw meat weight) included 1% sodium chloride, 1% monosodium glutamate, 5% soybean sauce, 0.3% sodium tripolyphosphate, 0.2% sorbic acid, 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 18% of sucrose.

The pork jerky was processed by the following procedure: (1) frozen boneless pork ham thawed at 4°C for 24 h, (2) remove subcutaneous fat and connective tissue

from pork ham. (3) slice meat to 4 mm thickness by slicer (JWS-330, Woo Jin Co., South Korea). (4) mix curing ingredients with sliced pork. (5) cured at 4°C for 48 h. (6) dried at 55°C for 80 min. (7) roasted at 150 or 200°C by far-infrared grill (Shin Tsai, Taiwan) for 5 min and (8) final product was packaged in polyethylene film without vacuum, stored at room temperature (26°C) for subsequent measurement of physico-chemical and microbial properties. The moisture content, water activity, shear value, nitrite residue, Hunter L-value and a-value, thiobarbituric acid (TBA), volatile basic nitrogen (VBN) and ATPase activity of myofibrillar proteins and microbiological examination of pork jerky were determined during processing steps of raw meat, curing, drying and roasting. 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°C for 18 h (AOAC, 1980).

Water activity

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°C until equilibrium reached.

Texture measurement

Shear value was measured on the pork jerky (samples cut to 1.2 cm^2) using a Fudoh Rheometer (NRM-2010 J-CW, Japan). A Rheo Plotter (FR-801, Japan) was used to plot the picture. The measuring table speed was 6 cm/min and a peak force required to shear across the meat fibres was determined.

Color determination

The color of pork jerky samples were expressed by the Hunter L-values and a-values using the Handy Colorimeter (NR-300, Nippon Denshoku, Japan).

Nitrite residue

A 5 g of sample of the pork jerky were homogenized, heated and its color was developed with a Griess solution. The sodium nitrite content was measured at 540 nm (U-2001 Hitachi, Japan) and calculated as described by Ockerman (1972).

Thiobarbituric acid value

The Thiobarbituric acid (TBA) was determined to establish the extent of lipid oxidation (Witte et al., 1970) in pork jerky during different processing stages. 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 min and filter through Whatman (#1) filter paper. The filtrate was mixed with an equal volume of 0.02 M thiobarbituric acid and incubated at 100°C for 35 min. It was then cooled in tap water for 10 min. 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.$_{532}$×7.8.

Determination of volatile basic nitrogen

The volatile basic nitrogen (VBN) was determined by AOAC method (1980) for pork jerky during different processing stages. The results were expressed as VBN value (mg/kg meat).

Myofibrillar ATPase activity measurement

Myofibrils were prepared according to Perry and Grey (1956) with some modifications as follows: A minced jerky was homogenized with homogenizer in 5 volumes 39 mM borate buffer (pH 7.1) containing 25 mM KCl and centrifuged at 600×g for 15 min. After repeating the procedure, upper layer was recovered from the resulting precipitate and suspended in 4 volumes 39 mM borate buffer (pH 7.1) containing 0.1 M KCl. Unsuspended myofibrils and contaminating connective tissues were removed by centrifugation at 400×g for 3 min and fine myofibrils were collected by centrifugation at 600×g for 15 min. Myofibrils thus obtained were suspended in 39 mM borate buffer (pH 7.1) containing 0.1 M KCl and used for ATPase assay.

The reaction mixture (7.5 ml) consist of myofibrils (1 mg/ml), 1 M KCl, 0.1 M CaCl$_2$, and 1 mM ATP, was incubated at 25°C and assessed by pH-STAT (Model DL 25 titrator, Mettler Toledo, Switzerland). ATPase activity was expressed as μ mol of Pi liberated by 1 mg protein for 1 min (μmol/min/mg protein).

Microbiological examination

Total plate counts : Representative samples (25 g) were placed in sterile plastic bags with buffered peptone (225 ml, 1% w/v) and homogenized for 1 min in a stomacher (Lab-Blender 400, English). The 10^{-1} dilution was used for subsequent serial dilutions. Total plate counts were performed in duplicate by spread inoculation (0.1 ml) over plate count agar (Oxoid Cm 325) and incubation at 38°C for 48 h.

Mold and yeast counts : Both mold and yeast counts were measured by the FDA method (Bandler et al., 1995) for pork jerky. Medium of choice is potato dextrose agar (Difco Laboratories, Detroit, Mich.) and plates were incubated in the dark at 25°C for 5 days.

Table 1. Changes of moisture content, water activity, shear value, L-value, a-value and nitrite residue of Chinese-style pork jerky throughout processing steps

Processing steps	Moisture content (%)	Water activity	Shear value (kg)	L-value	a-value	Nitrite residue (ppm)
Raw meat	75.2±4.3[a]	0.97±0.05[a]	2.24±0.26[c]	29.6±1.2[a]	13.5±1.5[b]	ND
Curing	67.3±3.6[b]	0.96±0.04[a]	1.68±0.18[d]	28.7±2.1[a]	17.2±1.8[a]	99.2±8.9[a*]
Drying	35.6±2.5[c]	0.85±0.05[b]	2.89±0.13[c]	20.4±1.7[c]	6.47±0.4[d]	83.8±9.6[b]
Roasted at 150°C	23.4±2.3[d]	0.74±0.05[c]	6.85±0.48[b]	23.5±2.7[b]	14.5±1.3[b]	65.6±7.3[c]
Roasted at 200°C	19.6±1.2[e]	0.72±0.04[c]	9.34±0.53[a]	24.1±2.1[b]	11.6±1.4[c]	56.3±8.5[c]

[a, b, c, d, e] Values without a common superscript letter in the same row are significantly different (p<0.05).
* The nitrite residue is express in terms of dry weight basis. ND: no detected.

Statistic analysis

Data were analyzed by using a statistic software package (SAS. 1995). The GLM system was used to test the significance of treatment effect. When significant (p<0.05) differences were found, means were separated by the Duncan's multiple range test.

RESULTS AND DISCUSSION

Physical and chemical characteristics

The moisture content and water activity (aw) of pork jerky are shown in Table 1. The moisture content varied from 72.5% to 23.4% or 19.6% and a_w varied form 0.97 to 0.74 or 0.72 in accordance with processing steps. Drying have traditionally been used to preserve meat products in local place. based on the decrease of a_w. According to the level of this parameter, meat products can be classified as intermediate moisture meats (IMM) with a_w ranging from 0.60 to 0.90 (Leistner and Rodel. 1976). The concept of a_w has been very useful in food preservation and based on that concept many processes could be successfully adapted and new products could be designed (van den Berg, 1991). When we consider the stability of the jerky product, however, we need to assess not only its total moisture content but also the portion of that water is readily available for chemical and biological reactions. The present results confirmed pork jerky is a typical intermediate moisture meat (IMM). On the other hand, these results were similar to Su and Lin (1988) who reported that the moisture content of commercial dried sliced pork varied from 19.5 to 20.6% and a_w varied from 0.72 to 0.75.

Shear force values (texture) can be used to identify if whole-muscle meat products contain a high amount of variability in total shear force. Differences in shear force values can be used to determine differences exist in total force between meat simples. Warner-Bratzler shear force values have been criticized for not accounting for all the texture characteristics of muscle foods. For the evaluation of texture in meat products. the American Meat Science Association (AMSA. 1978) recommends Warner-Bratzler shear force machine. Miller (1994) pointed out that Warner-Bratzler shear force values were highly correlated with

overall texture of muscle meat. The result of shear value showed that the pork jerky from raw meat and curing periods had the lower shear value (2.24 and 1.68 kg); but the pork jerky from roasted at 150 or 200°C had the higher shear value (6.85 or 9.34 kg). It is obvious that the differences in shear force values between the two roasting temperatures are due to moisture content. Consumers prefer pork jerky with a softer texture in local area. according to the results. the pork jerky roasted at 150°C for 5 min had lower shear force than that products roasted at 200°C for 5 min. The former temperature and duration could be as a standard roasting index to produce pork jerky in large scale production.

The Hunter L-value and a-value varied from 29.6 to 23.5 and 6.47 to 14.5 in accordance with processing steps. The nitrite residue varied from 99.2 ppm to 65.5 or 56.2 ppm based on different processing steps in terms of dry weight basis. In meat industries. nitrite serves as a vital bacteriostatic control over the outgrowth of spores produced from *Clostridium botulinum* and involves in cured pigment and flavor protection. Cured meat pigment have been the subject of studies for many years. Nitrosylmyoglobin is the normal pigment of uncooked cured meats and nitrosylhaemochromogen is form on cooking (Varnam and Sutherland. 1995). Nitrite is a strong oxidant and reacts with endogenous or added reductants to produce nitric oxide (NO). Pathway for formation is the oxidation. by nitrite, of myoglobin to metmyoglobin and the simultaneous reduction of nitrite to NO. Nitrite is than thought to combine with metmyoglobin to form nitrosylmetmyoglobin. which undergoes rapid autoreduction to ntrosylmyoglobin. Nitrosylmyoglobin is untable in air and discoloration can be rapid. The different stages of pathway of nitrite is dramatically influence the color change of pork jerky during different processing steps. In the present work. the nitrite may be oxidized: nitrite losses during processing steps amount to nearly 50%. with additional breakdown of nitrite occurring during storage. According to the Food Sanitary Laws in Taiwan. legal limit for nitrite residue in processed meat is 70 ppm for various meat products. From the results showed that the nitrite residue of all final products clearly fitted the regulation in Taiwan.

Table 2. Changes of TBA, VBN and ATPase of Chinese-style pork jerky throughout processing steps

Processing steps	Thiobarbituric acid (mg of alonaldehyde/kg meat)	Volatile base nitrogen (mg/kg meat)	ATPase activity (μmoles i/min.mg)
Raw meat	0.34 ± 0.05^d	0.25 ± 0.04^d	0.125 ± 0.01^a
Curing	6.75 ± 0.90^c	16.7 ± 1.8^c	0.085 ± 0.01^b
Drying	8.21 ± 0.78^b	19.5 ± 1.4^b	0.029 ± 0.00^c
Roasted at 150°C	9.25 ± 0.75^{ab}	22.4 ± 1.9^a	ND
Roasted at 200°C	9.83 ± 0.88^a	23.5 ± 1.8^a	ND

[a,b,c,d] Values without a common superscript letter in the same row are significantly different (p<0.05). ND: no detected.

Table 3. Growth of total plate counts, yeast and mold counts of Chinese-style pork jerky throughout processing steps (log CFU/g of meat)

Processing steps	Total plate counts	Yeast counts	Mold counts
Raw meat	5.2	2.6	3.7
Curing	3.5	2.4	3.2
Drying	1.9	1.8	2.5
Roasted at 150°C	<1*	<1	<1
Roasted at 200°C	<1	<1	<1

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

Many complicated reactions take place in most meat products during storage and some damage meat quality, including fat oxidation (Obanu, 1988). The Thiobarbituric acid (TBA) value is the most common indicator used to measure the degree of lipid oxidation in meat products. In this procedure, malonaldehyde and other oxidation products of unsaturated lipids react with TBA to produce a colored complex. The results from present study showed that the TBA value of pork jerky varied from 0.34 to 9.25 or 9.83 mg of malonaldehyde depended on processing steps, but there are no differences between the two roasting temperatures (Table 2). The result was similar to Obanu et al. (1975) who demonstrated that the initial TBA value is 10 to 100 times higher than normally observed for newly cooked meat. When the malonaldehyde content of several species was measured after heating by conventional dry and moist heat cookery methods demonstrated that the greatest increase in malonaldehyde content. However, the TBA assay indicates there is a relationship between a_w and the TBA index: as the value of a_w decreases there is a proportional increase of lipid oxidation during processing. This phenomena can be related to the presence of NaCl which acts as pro-oxidant (Terres et al., 1989).

Changes in volatile base nitrogen (VBN) during processing steps are also shown in Table 2. The results showed that the VBN value of pork jerky ranging from 0.25 to 22.4 or 23.5 mg/kg depended upon processing steps. The trend of VBN changes during storage period was similar to the results of Su and Lin (1988), who stated that the VBN value of pork jerky was increased with extended storage period. Few researchers reported that some bacteria have the ability to decompose proteins, causing the spoilage of meat products and generating volatile nitrogen compounds (Marangkey et al., 1989; Darmadji et al., 1990).

It is well established that the actin-myosin interaction and myofibrillar structure are modified during post-mortem ageing as evidenced by changes in ATPase activity of myofibrils. Regarding the myofibrillar ATPase activity as a means of monitoring myofibrillar structure changes, we undertook to compare the effect of different temperature treatments on myofibrillar ATPase activity of pork jerky during processing steps. Changes in the ATPase activity of myofibrillar proteins extracted from samples of pork jerky with processing steps also shown in Table 2. The ATPase activity of myofibrillar proteins from pork jerky with processing steps were 0.125, 0.085, 0.029, 0.000 and 0.000. There was no significantly difference between roasted at 150 or 200°C. The ATPase activity of myofibrillar proteins during processing steps were partly denatured by the heat-drying or heat-roasting treatment. Toldra et al. (1993) stated that all enzymes were active in the range of 15 to 30°C and that the temperature of optimal activity was around 35°C. In the presence study, the pork jerky were dried at 55°C and roasted at 150 or 200°C, under such temperatures which can easy destroy the ATPase activity of myofibrillar proteins.

Microbiological assessment

Populations of total plate counts, yeast and mold in the pork jerky during processing steps are shown in Table 3. The results from the present study showed that total plate counts, mold and yeast counts were 5.2, 2.6 and 3.7 log, respectively, in the initial phase. After roasted at 150 and 200°C, the total plate counts, yeast and mold were lower than 1.0 log. This result was similar to Torres et al. (1994) who pointed out that the microorganism status of intermediate moisture meat are gradual decrease during processing. These results clearly indicated that the production of pork jerky with low counts of microorganisms when adequate heating conditions are maintained during processing. Many food spoilage bacteria are unable to multiply at a_w value below 0.95 and growth of most microorganisms is retarded or inhibited below 0.90 (Leistner and Rodel, 1975). Haas and Herman (1978) found several types of spoilage bacteria capable of growth at minimum a_w values of 0.84 to 0.87 in intermediate moisture food (IMF). As mentioned in Table 1, the final products of a_w of pork jerky between 0.72 to 0.74. Generally, most of the bacteria wouldn't grow at such low a_w values. However,

with semi-solid IMF with a_w values within the range of 0.65 to 0.90, both mold and yeast growths are usually the most important microbiological spoilage problem during storage (Seiler, 1976).

CONCLUSION

The results came from total plate count indicated that the feasibility of obtaining a final product with a low level of microbial count when raw materials of good quality. According to several parameters were examined, we suggested that the commercial practice of pork jerky by the following procedure: raw pork ham chips cured at 4°C for 48 h; dried at 55°C for 80 min, roasted at 150°C for 5 min and final product was packaged without vacuum, stored at room temperature.

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