

The Effect of Roasting Temperature on the Formation of Volatile Compounds in Chinese-Style Pork Jerky

W. S. Chen¹, D. C. Liu*, M. T. Chen

Dept. of Animal Science, National Chung-Hsing University, Taichung, Taiwan 402, ROC

ABSTRACT : The purpose of this work was to study the effect of roasting temperature on the production of volatile compounds in Chinese-style pork jerky. The pork jerky was roasted by far-infrared grill at 150°C or 200°C for 5 min. The analysis of volatile compounds using a Likens-Nickerson apparatus coupled to a gas chromatograph and a mass spectrometer enabled us to identify 21 volatile compounds. The results showed that the volatile compounds coming from pork jerky can be divided into two groups in accordance with their possible origins. The first group of volatile compounds derived from oxidation of lipid included hexanal, ethylbenzene, nonanal, benzaldehyde, 2,4-decadienal, 1-octen-3-ol, octadecanal, and 9-octadecenal. The second group of volatile compounds generated from degradation of natural spices included 1,8-cinene, 4-terpineol, α -terpineol, e-anethole, methyl-eugenol, p-anisaldehyde, elemol, eugenol, methyl-isoeugenol and myristicin. Significant differences ($p < 0.05$) were found between 2 different roasted temperatures at levels for all volatile compounds. (*Asian-Aust. J. Anim. Sci.* 2002. Vol 15, No. 3 : 427-431)

Key Words : Chinese-Style Pork Jerky, Volatile Compound, Roast, Lipid, Spices

INTRODUCTION

Chinese-style pork jerky (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 typical flavor, and needs no refrigeration during commercial distribution. Several descriptions and investigations of pork jerky have been reported by Lin et al. (1979, 1982). These researchers described a new process (using restructured meat as a materials to produce pork jerky) to improve the quality of the product. No work has been done on the processing methods of pork jerky on the formation of volatile compounds.

Volatile compounds are an important sensory aspect of the overall acceptability of meat products. The level of production of volatile compounds has a tremendous influence on the sensory quality of muscle foods (Mottram, 1994). Although raw meat contains few volatiles and only a blood-like taste, it is a rich reservoir of compounds with taste properties as well as volatile precursors and aroma enhancers (Bender and Ballance, 1961). Non-volatile precursors of meat aroma included amino acids, peptides, reducing sugar, and nucleotides so on. Interactions between these components and/or their volatiles contribute to meat aroma development and aroma generation during heat processing. Lipids also play an important role in the overall volatile compounds of meat (Mottram and Edwards, 1983). Approximately one thousand compounds have so far been

identified in the volatile constituents of meat from beef, chicken, pork, and sheep (Shahidi et al., 1986; Shahidi, 1989). As analytical methodologies have improved, the identification of new volatile compounds contributing to aroma at low threshold values has become possible. The purpose of this study was to investigate the effect of pork jerky roasted by different temperatures on the properties of volatile compounds.

MATERIALS AND METHODS

Preparation of Chinese-style pork jerky

Pork freezing at -18°C after slaughter within 3 h. After 4 months frozen at -18°C, fifteen Frozen boneless pork legs came from different animals were trimmed of all subcutaneous fat and epimysial connective tissue. 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, 0.05% ascorbic acid, 0.01% sodium nitrite, 0.01% sodium nitrate, 0.1% cinnamon, 0.1% five-spices powder (containing anise, cinnamon, clove, fennel, and watchou), and 21% sucrose. The natural dried ground spices and seasonings were obtained from several local dealers.

The pork jerky was processed by the following procedure: (1) remove surface subcutaneous fat and epimysial connective tissue from pork ham muscles; (2) slice meat to 4 mm thickness by slicer along the parallel grain (JWS-330, Woo Jin Co., South Korea); (3) mix curing ingredients with sliced pork; (4) cure at 4°C for 48 h until the curing ingredients taken up by the meat during the curing period; (5) dry at 55°C for 80 min; (6) roast at 150°C or 200°C (surface temperature of meat) by far-infrared grill (Shin Tsai, Taiwan) for 5 min, air within the oven circulated

* Corresponding Author: D. C. Liu. Tel: +886-4-22872622, Fax: +886-4-22860265, Email: dcliu@dragon.nchu.edu.tw

¹ Dept. of Animal Products Processing, Taiwan Livestock Research Institute, Council of Agriculture, Hsinhua, Tainan, Taiwan 712, ROC.

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to keep an even temperature; and (7) each final product (2 kg) in polyethylene film without vacuum, storage at room temperature (26°C) within seven days for subsequent measurement of volatile compounds.

Volatile compounds isolation

A total of 500 g of pork jerky from both roasting temperature treatments (150 or 200°C) were separately placed into a 5 L round-bottomed flask. After adding 1 L of distilled water, the pork jerky slurries was obtained by using a commercial blender (Model 34BL97, Waring, USA) and pork jerky slurries were applied to a Likens-Nickerson steam distillation continuous extraction apparatus (Likens and Nickerson, 1964) and distilled for 4 hr to isolate the volatile compounds using steam as the heating medium and hexane-ether (1:1 v/v) as the extraction solvent. The procedure was performed in three initial samples, in which derived from the mixture of fifteen pig legs. After isolation of the volatile components, an adequate amount of cyclohexyl cinnamate stock solution (0.004 g in 100 mL of hexane-ether) was added to the extracts as an internal standard. The extracts were dried over anhydrous sodium sulfate, concentrated using a desiccator, and further concentrated under a stream of nitrogen (-170°C) in a small glass tube to a final volume of 0.04 mL.

Gas chromatography-Mass spectrometry (GC-MS) analysis

The concentrated extracts were analyzed by GC-MS using a Hewlett-Packard 5890 II gas chromatograph (Chrompack, The Netherlands) coupled to a Hewlett-Packard 5973A MSD equipped with a direct split interface. A fused silica capillary column (60 m×0.25 mm id.; CP-Wax 52, J and W Scientific, USA) was used to separate the volatile compounds. The injector temperature was 250°C. Carrier gas (Helium) flow rate was 1.0 ml/min. The temperature programs were as follows: initial temperature 40°C; temperature increasing rate 2°C/min; final temperature 220°C (hold for 90 min). Mass spectra were obtained by electron ionization at 70 eV.

Quantification of the volatile compounds

The quantification of the volatile compounds in pork jerky was based on the internal standard method. The calculation of the quantity of the volatile compounds was based on the area % of the total ion chromatogram from GC-MS analysis against the weight of the concentrated extracts of each pork jerky. The quantity of the volatile compounds was calculated using the following equation:

$$\text{Amount } (\mu\text{g/kg}) = [(A/A_s) \times W_s] / (W/1,000,000,000)$$

Where A=area of the samples; A_s=area of internal

standard; W_s=weight of internal standard (g); W=weight of the samples (g).

Identification of the volatile compounds

Identification of the volatile compounds in the extracts was according to GC-MS. The volatile compounds of pork jerky were identified by comparing the mass spectral data with those of actual compounds available from the TNO (TNO, 1988) and NIST (NIST, 1990) computer libraries.

Statistical analysis

Statistical analysis between groups was by two-tailed Student's t-test (SAS, 1997).

RESULTS AND DISCUSSION

A typical chromatogram from pork jerky roasted by far-infrared grill at 150 or 200°C, obtained by plotting the total ion current obtained during the GC-MS run, is shown in figure 1. The results showed that the total amount of volatile compounds (0.2 mL) of pork jerky roasted at 200°C was higher than the pork jerky roasted at 150°C ($p < 0.05$). The results was similar to report by Mottram (1985), in which the effects of cooking conditions (well-done grilled, roasted and boiled pork) on the formation of volatile compounds in pork. Well-done grilled pork contained more volatile compounds than the pork heated by roasted and boiled methods. Mussinan and Walradt (1974) also pointed out that in the pork liver pressure-cooked at 163°C, over 70% of the total volatile compounds were furans and pyrazines, while in boiled pork, the volatile compounds were dominated by aliphatic aldehydes and alcohols.

As shown in table 1, a total of 21 volatile compounds were identified from pork jerky roasted at 150°C or 200°C. These volatile components can be divided into two groups in accordance with their possible sources (Ho et al., 1994). The first group of volatile compounds were derived from oxidation of lipid. The second group of volatile compounds were generated from degradation of natural spices. The major volatile compounds found in pork jerky extracts that are likely to have been generated from oxidation of lipids include hexanal, ethylbenzene, nonanal, benzaldehyde, 2,4-decadienal, 1-octen-3-ol, octadecanal, and 9-octadecenal. Nonanal is an oxidation product of oleic acid, hexanal and 2,4-decadienal are major volatile oxidation products of linoleic acid. Oleic acid and linoleic acid are the two most abundant unsaturated fatty acids of pork (Schliemann et al., 1987). Shahidi et al. (1987) reported a linear relationship among hexanal content, sensory scores and Thiobarbituric acid (TBA) of cooked ground pork. The higher the hexanal content, the lower the acceptability of the meat. A few studies have shown that the 2,4-decadienals are associated with a 'french fry' aroma, while hexanal is characterized as

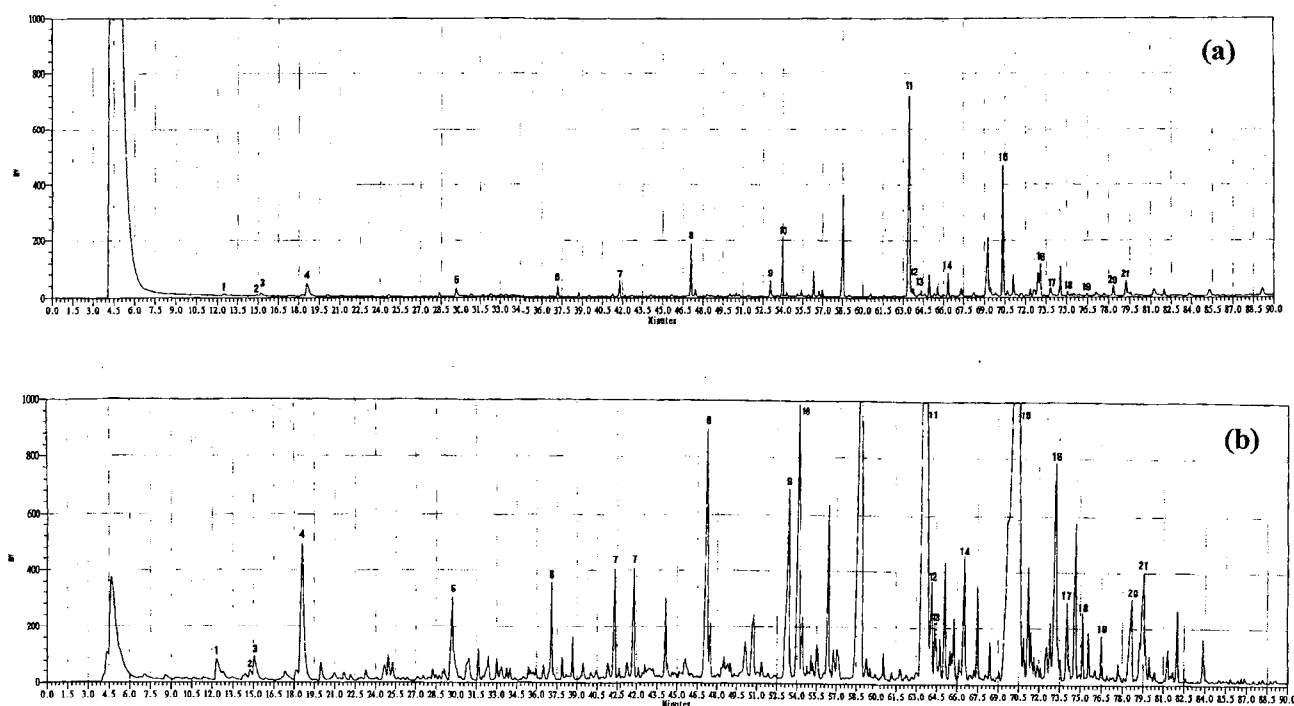


Figure 1. GC-MS chromatogram of the volatile compounds collected from Chinese-style pork jerky. Peak identification is stated in table 1. (a) roasted at 150°C; (b) roasted at 200°C

being 'green or grassy' (Kimoto and Gaddis, 1969; Henderson et al., 1980). Benzaldehyde can be formed from the decomposition of linoleic acid, although a few studies, using chemically defatted meat, have suggested that a non-lipid route may also be involved (Mottram and Edwards, 1983). The highest concentration of 1-octen-3-ol was found in the present studies, and the 1-octen-3-ol may be derived from the 12-hydroperoxide of arachidonic acid of cooked pork (Chou and Wu, 1983). Substances such as hexanal, nonanal and 1-octen-3-ol, which have very intense odors during sniffing, are thought to contribute significantly to the aroma of pork hams (Berdague et al., 1993). The heterocyclic compounds such as 2-pentylfuran has been identified in the pork jerky. Formation of the compound is normally associated with heat, that is a well-known Maillard reaction product. The heterocyclic compound have been reported in roasted, grilled or pressure-cooked meat (Mottram, 1985). Cooked meat volatile compounds are formed virtually entirely during the heating process from non-volatile and volatile precursors. The most important mechanisms responsible for these volatile compounds are lipid reactions, Maillard browning and thiamin degradation in cooked meat. Of these reactions, about 90% of the volume of volatile compounds in cooked meat arise due to lipid reactions (Reineccius, 1994). This leaves only about 10% of the volatiles coming from Maillard browning (Bailey, 1983) and thiamin degradation.

The soybean sauce used in the preparation of pork jerky showed a significant effect on the quantity of some volatile compounds generated in pork jerky. The *syn*-3,5-Dimethyl-1,2,4-trithiolane was found in pork jerky. Chou and Wu (1983) stated that several alkyl-substituted trithiolanes such as *syn*-3,5-Dimethyl-1,2,4-trithiolane and *anti*-3,5-Dimethyl-1,2,4-trithiolane were identified in the volatile components of stewed pork. Neither soybean sauce nor cooked pork contained these trithiolanes. Apparently, they were generated when pork was stewed with soybean sauce. The amount of *syn*- and *anti*- 3,5-Dimethyl-1,2,4-trithiolanes increased with increasing amounts of soybean sauce. Soybean sauce may provide the acetaldehyde which is the necessary intermediate for the formation of 3,5-Dimethyl-1,2,4-trithiolane (Ho et al., 1994).

The cinnamon and five-spices powder (containing anise, cinnamon, clove, fennel, and watchou) are commonly used by manufactures in the production of Chinese-style processed meat (such as Chinese-style sausage, dried pork jerky or dried beef jerky) as a flavoring substances. Although spices are still most commonly used in their natural form, extracts of natural spices are becoming increasingly more popular. The major volatile compounds found in pork jerky extracts according to their likely derived from degradation of natural spices included 1,8-cinene, 4-terpineol, α -terpineol, e-anethole, methyl-eugenol, p-anisaldehyde, elemol, eugenol, methyl-isoeugenol and

Table 1. List of the volatile compounds identified in the pork jerky roasted by far-infrared grill at 150°C or 200°C*

Peak no.**	Compound	Extracted quantities		Possible origin of compound
		(µg/kg)		
		Roasted at 150°C (n=6)	Roasted at 200°C (n=6)	
1	Hexanal	Tr.	34.3±16.2	Oxidation of lipid
2	Ethylbenzene	Tr.	11.6±4.6	Oxidation of lipid
3	Xylene	Tr.	37.8±20.1	?
4	1,8-cinene	23.8±6.3 ^b	226.8±121.7 ^a	Spices
5	Nonanal	15.9±3.3 ^b	185.3±50.7 ^a	Oxidation of lipid
6	Benzaldehyde	14.9±5.2 ^b	158.2±49.1 ^a	Oxidation of lipid
7	4-terpineol	14.0±3.6 ^b	178.4±60.4 ^a	Spices
8	-terpineol	35.1±11.3 ^b	452.6±144.6 ^a	Spices
9	2,4-decadienal	15.2±3.7 ^b	431.0±145.2 ^a	Oxidation of lipid
10	E-anethole	45.2±16.4 ^b	532.8±167.7 ^a	Spices
11	Methyl-eugenol	169.1±34.8 ^b	1321.4±343.4 ^a	Spices
12	P-anisaldehyde	14.5±4.4 ^b	168.4±38.6 ^a	Spices
13	<i>Syn</i> -3,5-Dimethyl-1,2,4-trithiolane	15.7±3.9 ^b	231.5±54.1 ^a	Degradation from soybean sauce
14	Elemol	19.2±5.1 ^b	188.3±32.0 ^a	Spices
15	1-octen-3-ol	192.2±36.1 ^b	2108.6±458 ^a	Oxidation of lipid
16	Eugenol	28.9±6.8 ^b	452.8±144.8 ^a	Spices
17	Methyl-isoegenol	15.7±4.3 ^b	179.5±41.4 ^a	Spices
18	Myristicin	12.1±4.1 ^b	147.0±38.9 ^a	Spices
19	2-pentylfuran	Tr.	104.5±27.7	Maillard reaction
20	Octadecanal	16.3±4.3 ^b	219.5±60.5 ^a	Oxidation of lipid
21	9-octadecenal	34.2±10.4 ^b	278.2±69.9 ^a	Oxidation of lipid

* The drying losses are 40.5% and the roasting losses are 12.5% and 16.5% in accordance with 2 different temperatures. The lipid content of the raw, dried and roasted product containing 2.3%, 4.2% and 5.2%, respectively.

** The peak numbers in column 1 is cross-referenced figure 1. Tr.=trace amount (<10 µg/kg).

^{a,b} Means±standard deviation within each row which do not have the same superscript letter are significantly different (p<0.05, two tailed t-test).

myristicin. Spices have been used not only for their flavoring properties but also for their food-preserving ability. Recent studies have identified a number of volatile compounds, including eugenol, methyl-isoegenol and methyl-eugenol, which degradation from cloves, that have antioxidant properties (Rajalakshma and Narasimhan, 1996). The cloves extracts have the potential for application as natural antioxidants in food industries.

CONCLUSION

Pork jerky roasted by far-infrared grill at 200°C contained higher amounts of volatile compounds compared to pork jerky roasted at 150°C. Volatile compounds of pork jerky can be divided into two groups in accordance with their possible origins. The first group of volatile compounds were derived from the oxidation of lipid. The second group of volatile compounds were generated from the degradation of natural spices.

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