



CHEMICAL AND PHYSICAL PARAMETERS OF DRIED SALTED PORK MEAT

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ABSTRACT

The aim of the present study was analysed and evaluated chemical and physical parameters of dried salted pork neck and ham. Dried salted meat is one of the main meat products typically produced with a variety of flavors and textures. Neck (14 samples) and ham (14 samples) was salted by nitrite salt mixture during 1 week. The nitrite salt mixture for salting process (dry salting) was used. This salt mixture contains: salt, dextrose, maltodextrin, flavourings, stabilizer E316, taste enhancer E621, nitrite mixture. The meat samples were dried at 4 °C and relative humidity 85% after 1 week salting. The weight of each sample was approximately 1 kg. After salting were vacuum-packed and analysed after 1 week. The traditional dry-cured meat such as dry-cured ham and neck obtained after 12 – 24 months of ripening under controlled conditions. The average protein content was significantly ($p < 0.001$) lower in dried pork neck in comparison with dried salted pork ham. The average intramuscular fat was significantly ($p < 0.001$) lower in dried pork ham in comparison with dried salted pork neck. The average moisture was significantly lower ($p \leq 0.05$) in dried salted ham in comparison with dried pork neck. The average pH value was 5.50 in dried salted pork ham and 5.75 in dried salted pork neck. The content of arginine, phenylalanine, isoleucine, leucine and threonine in dried salted ham was significantly lower ($p < 0.001$) in comparison with dried salted pork neck. The proportion of analysed amino acids from total proteins was 56.31% in pork salted dried ham and 56.50% in pork salted dried neck.

Keywords: 5 pork; neck; ham; chemical quality; intramuscular fat; moisture; amino acids; proteins; pH value

INTRODUCTION

Meat quality has always been important to the consumer, and it is an especially critical issue for the meat industry in the 21st century (Joo et al., 2013). In the course of production, the nutritional composition of commercial meat products undergoes changes due to variations in the meat and non-meat ingredients and the processing conditions. Animal production practices (genetic and dietary strategies) play an important role in the nutritional quality of meat raw materials (Jiménez-Colmenero, 2011). Consumers require meat products with high quality, health benefits and high safety. Nevertheless, processing of the muscle into ready-to-eat products with acceptable and high nutritional value, convenience and palatability to use is indispensable to add value to this muscle much higher it's conventional profitability. The pork dry-cured quality is defined as a combination of different characteristics of raw and processed meat (Joo et al., 2013).

The characteristics like water-holding capacity (WHC) of muscle and pH value are important because it affects both qualitative and quantitative aspects of meat and meat products (Van der Wal et al., 1997). These important factors have the biggest influence on biochemical changes in the muscle *post mortem*. The most popular meat products processed mostly from pork muscle is dry-cured meat according consumers expressions due its typical flavour and palatability (Ventanas et al., 2007).

Dry-cured ham is one of the main meat products typically produced with a variety of flavors and textures. The processing of dry-cured ham is based on traditional

manufacturing practices consisting primarily of salting and drying steps, followed by a more or less extensive ripening period, which is dependent on the desired final product quality (Toldrá, 2015). The dry – cured meat is produced salting, drying and ripening. The ripening process of dry-cured meat involves complex of biochemical and chemical changes (Ruitz et al., 2002). The ripening, is the processing step that develops the unique and characteristic aroma and flavor. The intensity of the dry- cured aroma and flavor is a result of extensive lipolysis and proteolysis that are proportional to the length of the aging time. The quality characteristics of dry-cured meat products are related to the raw material and processing technology (Jurado et al., 2007).

Dry-aging is typically the aging of premium meat under critically controlled ambient conditions of temperature, relative humidity and airflow. These parameters need to be carefully balanced and monitored to inhibit microbial growth and minimise weight loss while producing excellent eating quality resulting from tenderisation and enhanced flavour (Yuan et al., 2016). The acceptance of dry-cured hams by consumers is mainly determined by their sensory quality. The aroma is perhaps the most important quality parameter and it is markedly affected by the raw material and the processing of the dry- cured meat.

In the case of dry-cured hams, the aroma is due to the presence of many volatile compounds, most of them produced by chemical and enzymatic mechanisms during the post-mortem process (Sánchez-Peña et al., 2005). Flavor and aroma are key attributes that impact the overall acceptance of dry-cured hams and are markedly affected

by raw material processing techniques and aging time. The flavor and aroma of dry-cured ham can be determined by sensory descriptive analysis and the composition of aroma impact compounds, most of which are produced *post-mortem* by chemical and enzymatic mechanisms (Pham et al., 2008). Flavour is a very important attribute contributing to the sensory quality of meat and meat products. Although the sensory quality of meat includes orthonasal and retronasal aroma, taste as well as appearance, juiciness and other textural attributes (Neethling et al., 2016). Flavour affects on the customer acceptance (Ruiz et al., 2002). In general, important reductions in both moisture content and water activity take place during the production process of dry-cured meat products. This reduction depends on the drying conditions and the decreasing water activity may affect enzyme activity which influences the sensory characteristics of the final product (Jiménez-Colmenero et al., 2010).

Sodium chloride is the very important ingredient, its manufacturing process begins with a salting step during which salt and other curing ingredients (nitrate or nitrite) and additives (ascorbic acid) slowly diffuse into the meat followed by brushing or washing of hams to remove the excess of salt, a post-salting step and a ripening or drying stage (Martínez-Onandi et al., 2016). Salt, nitrate and nitrite are the major ingredients in the cure mix. Salt inhibits the growth of spoilage microorganisms by reducing the water activity and solubilizing some of the myofibrillar proteins. Nitrate is reduced to nitrite and then nitric oxide by nitrate reductase a natural enzyme in the ham. The typical red/pinkish color of ham is due to the reaction of nitric oxide and myoglobin which forms nitrosyl myoglobin (Zhao et al., 2016).

Lipid oxidation is a very important biochemical reaction in dry-cured meat products. Many studies have investigated the relationship between the muscle lipid oxidation and flavor formation in dry-cured meat products and proved that lipid oxidation plays an important role in the formation of the final flavor of dry-cured meat products (Guofeng et al., 2015).

The effect of environmental, nutritional and production factors on intramuscular fat have formerly been quantified as well as their subsequent influence on meat quality. Genetic factors also influence intramuscular fat deposition (Pannier et al., 2014). Intramuscular fat of dry-cured meat contributes to odour and flavour impression during mechanisms such as lipid oxidation. Fat content is believed to be one of the most crucial quality traits of cured hams (the higher the fat content, the greater the acceptability of cured hams) but what most affects the appearance, texture (juiciness) and intensity and persistence of flavour of dry-cured hams is the intramuscular fat content (Jiménez-Colmenero et al., 2010). Intramuscular fat plays one of important role in the impression of the texture of dry-cured meat, especially in juiciness (Ventanas et al., 2005). Maillard reactions concerned creation of volatile compounds formation (Ruiz et al., 2002).

Proteolysis is one of the most important biochemical processes during the ripening of ham and neck. This biochemical process influences texture and flavour due to the formation of free amino acids and other low-molecular weight compounds. Free amino acids influence directly in

taste. The major ways for generation of volatile compounds from amino acids in ham and neck are Maillard and Strecker reactions (Jurado et al., 2007). The sensory quality depends not only of the curing process but also on factors such as the age, breed and feeding of pigs. The chemical changes occurring in different muscles during the ripening of hams and necks influence the ham and neck aroma and flavour (Diego et al., 2008). The flavour of high quality is the result of enzymatic reactions (proteolysis and lipolysis) and chemical processes (lipid autooxidation, Strecker degradation and Maillard reactions) (González et al., 2008).

According to the nutrition importance for human the amino acids are divided into essential: valine (Val), leucine (Leu), isoleucine (Ile), threonine (Thr), methionine (Met), lysine (Lys), phenylalanine (Phe) and tryptophan (Trp); semi-essential: arginine (Arg) and histidine (His); and nonessential ones: glycine (Gly), alanine (Ala), serine (Ser), cysteine (Cys), aspartic acid (Asp), asparagine (Asn), glutamic acid (Glu), glutamine (Gln), tyrosine (Tyr) and proline (Pro) (Belitz et al., 2001).

Passi and de Luca (1998) stated that in the human nutrition it is possible to consider only 10 amino acids as principal, i.e. essential nutrients, which the humans must obtain from various diets. The remaining amino acids may be synthesized from the products of metabolism and of essential amino acids.

The aim of the study was analysed basic chemical and aminoacids composition of dry-cured pork ham and neck salted and matured during 1week. After salting were vacuum-packed and analysed after 1 week.

MATERIAL AND METHODOLOGY

The aim of the present study was to determine and evaluate chemical parameters of dried, salted pork neck and ham. Neck (14 samples) and ham (14 samples) was matured and salted by nitrite salt mixture during 1week. The nitrite salt mixture was used for salting process (dry salting). This salt mixture contains: salt, dextrose, maltodextrin, flavourings, stabilizer E316, taste enhancer E621, nitrite mixture. The meat samples were matured at 4 °C and relative humidity 85% after 1 week of salting. The samples were vacuum-packed and storage 1 week after salting. The weight of each sample was approximately 1 kg.

Determination of chemical composition analysis and amino-acids analysis

The chemical composition and amino-acids composition of the ham and the neck (50 g) was measured by the device Nicolet 6700 (Thermo Scientific, USA). The intramuscular fat content in $\text{g}\cdot 100\text{g}^{-1}$, total proteins in $\text{g}\cdot 100\text{g}^{-1}$, total water in $\text{g}\cdot 100\text{g}^{-1}$, amino-acids in $\text{g}\cdot 100\text{g}^{-1}$ were analysed by the FTIR method. FTIR spectroscopy provides information about the secondary structure content of proteins. This spectroscopy works by shining infrared radiation on a sample and seeing which wavelengths of radiation in the infrared region of the spectrum are absorbed by the sample. Each compound has a characteristic set of absorption bands in its infrared spectrum. The infrared spectrum of the muscular

homogenate analysis was transferred out by molecular spectroscopy method.

Determination of NaCl (salt content)

Samples (approximately 2 g) with 2 mL of indicator were titrated by solution of silver nitrate by using the indicator potassium chromate. This suspension was titrated by solution of silver nitrate until a light orange colour. The amount of chloride ions was evaluated. The titration amount of silver nitrate was divided by weight of sample.

Determination of pH value

The pH value was measured using the pH meter Gryf 209L (Sigma-Aldrich, Czech Republic). The pH value of dried neck and ham at different ripening periods were measured.

Determination of water activity a_w

Water activity of salted and dried neck and ham was determined at 25 °C by using the device FA-st lab (GBX advanced technology, Switzerland).

Statistical analyse

The data were subjected to statistical analysis using the SAS (Statistical Analysis System) package SAS 9.3 using of application Enterprise Guide 4.2. Differences between groups were analysed by t-test.

RESULTS AND DISCUSSION

The traditional dry-cured meat such as dry-cured ham and neck obtained after 12 – 24 months of ripening under controlled conditions (Dall'asta et al., 2010). Nowadays is tendency to make aging time shorter. Chemical parameters of dried salted pork neck and ham were analysed in this article.

Table 1 shows basic chemical parameters of dried salted pork neck and ham. The moisture content ranged from 61.11% to 67.13% in dried salted pork ham and from 52.98% to 64.18% in dried salted pork neck. The average

moisture content was 63.52% in dried salted pork ham and 58.88% in dried salted pork neck. There was found significantly lower ($p \leq 0.05$) moisture content in dried salted pork neck in comparison with dried salted pork ham. Benedini et al., (2012) found out similar results of moisture in ham (61.2%) in dried salted *biceps femoris* muscle.

The protein content ranged from 22.91% to 26.34% in dried salted pork ham and from 18.41% to 22.22% in dried salted pork neck. The average protein content was 23.37% in dried salted pork ham and 19.98% in dried salted pork neck. There was found significantly lower ($p < 0.001$) protein content in dried salted pork neck in comparison with dried salted pork ham.

Kunová et al., (2015) found out similar our results protein content 24.87% in dried salted pork ham and 20.51% in dried salted pork neck. Lorido et al., (2015) found out higher protein content (39.26%) in *musculus semimembranosus*. Benedini et al., (2012) found out protein content 27.00% in *biceps femoris* muscle.

The intramuscular fat ranged from 3.38% to 8.99% in dried salted pork ham and from 7.26% to 20.80% in dried salted pork neck. The average intramuscular fat was 4.05% in dried salted pork ham and 14.11% in dried salted pork neck. There was found significantly higher ($p < 0.001$) intramuscular fat in dried salted pork neck in comparison with dried salted pork ham. Lorido et al., (2015) found out higher content of intramuscular fat (10.62%) in *semimembranosus*. Jiménez-Colmenero et al., (2010) found out in Iberian ham content of intramuscular fat in range 2.6 – 9.5%.

The salt content ranged from 3.01% to 6.68% in dried salted pork ham and from 4.35% to 6.05% in dried salted pork neck. The average salt content was 4.85% in dried salted pork ham and 4.41% in dried salted pork neck. There wasn't found statistical difference between salt content in dried salted pork neck in comparison with dried salted pork ham.

Matínez – Onandi et al., (2016) found out salt content in average 5.49% and ranged from 2.87% to 7.91% in

Table 1 The basic chemical composition of dried salted pork ham and neck.

	Moisture (%)	Proteins (%)	Intramuscular fat (%)	Salt (%)
Ham				
x	63.52	23.37	4.05	4.85
s	2.09	0.68	2.30	1.19
s_x	0.75	0.21	0.65	0.36
min.	61.11	22.91	3.38	3.01
max.	67.13	26.34	8.99	6.68
v%	3.09	2.79	40.10	21.90
Neck				
x	58.88	19.98	14.11	4.41
s	4.42	0.88	4.55	0.55
s_x	1.64	0.22	1.64	0.19
min.	52.98	18.41	7.26	4.35
max.	64.18	22.22	20.80	6.05
v%	7.55	4.33	32.90	14.00
t-test	+	+++	+++	-

Note: - $p > 0.05$; + $p \leq 0.05$, ++ $p < 0.01$, +++ $p < 0.001$.

Table 2 Physical parameters of dried salted pork ham and neck.

Parameters	pH value	Water activity (a_w)
Ham		
x	5.50	0.899
s	0.06	0.019
s_x	0.03	0.003
min.	5.75	0.822
max.	6.05	0.945
v%	0.75	1.235
Neck		
x	5.75	0.935
s	0.25	0.035
s_x	0.03	0.005
min.	5.42	0.888
max.	6.10	0.955
v%	1.62	2.236
t-test	-	-

Note: $-p > 0.05$; $+p \leq 0.05$, $++p < 0.01$, $+++p < 0.001$.

Table 3 Content of amino acids of dried salted pork neck and ham (g.100g⁻¹).

Parameters	neck				ham				t-test
	x	s	s_x	v%	x	s	s_x	v%	
arginine	1.72	0.13	0.05	7.69	1.44	0.10	0.04	7.09	+++
cysteine	0.44	0.03	0.01	6.71	0.47	0.06	0.02	11.9	-
phenylalanine	1.09	0.08	0.03	7.48	0.92	0.07	0.03	7.07	+++
histidine	1.17	0.12	0.05	10.2	0.99	0.13	0.05	13.4	+
isoleucine	1.04	0.09	0.03	8.44	0.84	0.08	0.03	9.23	+++
leucine	2.09	0.17	0.06	7.96	1.72	0.15	0.06	8.44	+++
lysine	2.35	0.18	0.07	7.51	2.01	0.12	0.05	6.06	++
methionine	0.94	0.06	0.02	6.17	0.91	0.04	0.02	4.60	-
threonine	1.19	0.09	0.03	7.42	1.02	0.05	0.02	4.97	+++
valine	1.12	0.11	0.04	9.83	0.97	0.09	0.04	10.2	+

Note: $-p > 0.05$; $+p \leq 0.05$, $++p < 0.01$, $+++p < 0.001$.

Serrano hams. **Lorido et al., (2015)** found out similar salt content (4.38%) in *musculus semimembranosus*.

Table 2 shows the change in pH value and water activity (a_w) of dried salted pork neck and ham. The pH value ranged from 5.75 to 6.05 in dried salted pork ham and from 5.42 to 6.10 in dried salted pork neck. The average pH value was 5.50 in dried salted pork ham and 5.75 in dried salted pork neck. The pH value of both products showed that meat has not been ripened. **Bednářová et al., (2014)** found out in *musculus semimembranosus* pH values in range from 5.56 to 5.63.

The water activity ranged from 0.822 to 0.945 (a_w) in dried salted pork ham and from 0.888 to 0.955 (a_w) in dried salted pork neck. The average water activity was 0.899 in dried salted pork ham and 0.935 (a_w) in dried salted pork neck. **Bjarnadottir et al., (2015)** found out similar value of water activity in dried ham.

Table 3 shows content of amino acids composition of dried salted pork neck and ham. The average content of arginine in dried salted pork ham was 1.44 ± 0.10 g.100g⁻¹ and 1.72 ± 0.13 g.100g⁻¹. There was found significantly higher ($p < 0.001$) content of arginine in dried salted pork neck in comparison with dried salted pork ham. The

average content of lysine was 2.01 ± 0.12 g.100g⁻¹ in dried salted pork ham and 2.35 ± 0.18 g.100g⁻¹ in dried salted pork neck. There was found significantly higher ($p < 0.01$) content of lysine in dried salted pork neck in comparison with dried salted pork ham. The average content of leucine was 1.71 ± 0.15 g.100g⁻¹ in dried salted pork ham and 2.09 ± 0.17 g.100g⁻¹ in dried salted pork neck. There was found significantly higher ($p < 0.001$) content of leucine in dried salted pork neck in comparison with dried salted pork ham. The average content of methionine was 0.91 ± 0.04 g.100g⁻¹ in dried salted pork ham and 0.94 ± 0.06 g.100g⁻¹ in dried salted pork neck. There wasn't found statistical difference between content of methionine in dried salted pork neck in comparison with dried salted pork ham.

Bučko et al., (2015) found out similar content of aminoacids in the pork *musculus longissimus dorsi* but with lower intramuscular fat content (1.19 g.100g⁻¹). Contents of arginine found out 1.50 g.100g⁻¹, cysteine 0.36 g.100g⁻¹, lysine 2.01 g.100g⁻¹ and histidine 1.09 g.100g⁻¹. **Wilkinson et al., (2014)** and **Okrouhlá et al., (2006)** found out the proportion of amino acid from total amount of amino acids. **Wilkinson et al., (2014)** found out content

of arginine 7.16 g.100g⁻¹, lysine 8.64 g.100g⁻¹, leucine 8.68 g.100g⁻¹ and methionine 2.97 g.100g⁻¹. Okrouhlá et al., (2006) found out content of arginine 7.3 g.100g⁻¹, lysine 9.71 g.100g⁻¹ and leucine 8.38 g.100g⁻¹. The proportion of analysed amino acids from total proteins was 56.31% in pork salted dried ham and 56.50% in pork salted dried neck. Wilkinson et al., (2014) found out proportion of amino acids from total proteins 66.42%, but they analysed more amino acids in comparison with our experiment.

CONCLUSION

The aim of this article was to determine physical and chemical parameters of dried salted pork neck and ham. The protein content in dried salted pork ham was significantly higher in comparison with dried salted pork neck. The value of intramuscular fat in dried salted pork neck was significantly higher in comparison with dried salted pork ham. The moisture was significantly lower in neck in comparison with dried salted pork ham. The salt content was comparable in neck with ham. The pH value was similar in dried salted pork neck as in dried salted pork ham. The value of water activity (a_w) was similar in ham as in neck. The content of arginine, phenylalanine, isoleucine, leucine and threonine in dried salted ham was significantly lower ($p < 0.001$) in comparison with dried salted pork neck. The proportion of analysed amino acids from total proteins was 56.31% in pork salted dried ham and 56.50% in pork salted dried neck.

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