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Effect of modified atmosphere on sensory, chemical and physico-chemical properties of Serbian traditional smoked meat products

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A b s t r a c t: The products included in this study were beef prosciutto and pork prosciutto, common traditional Serbian dry-cured and smoked meat products. The products were packaged with a gas mixture containing 30% vol carbon dioxide and 70 % vol nitrogen (excluded oxygen in packs was below the limit of detection) and stored between 4°C and 7°C. Packaging units were formed from bottom foil based on APET (amorphous polyester) with a sealing layer of polyethylene and top foil composite film containing oriented polyester and a peelable polyethylene-sealant with a barrier layer. A total of 120 packages were examined (60 packages/product) during the storage period of 180 days. The measured concentration of oxygen in packages during the whole storage period was less than 0.1%. A decline in the carbon dioxide concentration at the end of the storage period was registered in packages of pork prosciutto (to 10% vol). Based on the results obtained, both of the products maintained acceptable sensory and chemical qualities during the storage period, meaning they were suitable for consumption.

Keywords: *traditional food, MAP packaging, sensoric quality.*

Introduction

The definition of traditional food products may not necessarily reflect opinions of consumers. According to research conducted by *Vanhonacker et al*. (2008), European consumers include well-known food and food they have eaten already or which their ancestors consumed among traditional products.

Despite technological progress and the obligation to comply with modern food safety regulations, production and/or processing must still be consistent with the methods that were originally used, and the food products obtained must preserve the intrinsic features (physical, chemical, and microbiological) (*Grujic et al*., 2012). Meat production systems using traditional recipes use modern industrial equipment and adapt some processing steps in order to ensure quality and specific characteristics of traditional product.

In Serbia, traditional smoked meat products constitute a diverse group of food products. Originating from distinct Serbian geographic regions, they bear characteristic sensorial properties typical in high-quality meat products.

These products were made of the most valuable parts of beef and pork carcasses (round muscles, loin muscles and tenderloin) (*Tomic et al.,* 2008). The majority of traditionally processed meat products in Serbia are made on the basis of personal knowledge and rarely upon counselling with an expert technologist. Packaging and marketing are almost completely neglected. Modern trends in the processed meat market show that consumers tend to satisfy their needs for food with flavours which combine the tradition and culture of the area they come from, without concern for the price.

Developments in packaging materials and technologies have made the application of modified atmosphere packaging (MAP) feasible on a larger scale to meat and meat products (*Brody*, 1989). For most food products, preservation is a vital function of packaging which ensures that the product is sold fresh (*Helström and Saghir*, 2006). By using MAP with one or more gases, atmospheric conditions can be designed to maximise product life and develop desired product characteristics (*Viana et al.,* 2005). The main purposes of MAP of meat products are to ensure the microbiological shelf life and the sensory

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quality of the product, including the colour, door and palatability.

The aim of the present work was to study the effect of modified atmosphere (30% CO_2 /70% N_2) on the chemical, physico-chemical and sensory quality of two traditional products, beef prosciutto and pork prosciutto, stored for 180 days between 4°C and 7°C, after slicing and packaging in retail packs.

Materials and Methods

Preparation of meat products

The products included in this study were: beef prosciutto – traditionally cured, smoked and dried beef sirloin and pork prosciutto – traditionally cured, smoked and dried pork sirloin. Basically, both of the products were made in the common, traditional way, widely established in Serbia. The products were manufactured by and taken directly from respective industrial meat processing facilities who have been adapting their meat processing and packaging operations, combining traditional (curing and smoking) and modern (slicing and packaging) steps.

Packaging machine and materials

For analysis in this study, packaging units containing very thin slices of beef or pork prosciutto were formed using an industrial packaging machine MULTIVAC R 230 (Wolfertschwenden, Germany). Net weight of packaged products was 80g. Individual packs contained 100 ml of gas (30% CO_2:70% N_2) per 100g of product packaged. Packaging units were formed from bottom foil (declared thickness 300 microns) based on APET (amorphous polyester) with a sealing layer of polyethylene and top foil composite film (declared thickness 80 microns) containing oriented polyester and a peelable polyethylene sealant with a barrier layer. Manufacturer-declared oxygen-permeability measurements (23°C/35% r.F; DIN 53380) of bottom foil and top covering foil were: ≤14 bar cm^3 m^{-2} day^{-1} and ≤4.2 bar cm^3 m^{-2} day^{-1}, respectively. Declared water-vapour permeability (23°C/85% r.F; DIN 53122) of bottom and top foils were: ≤2.3 g m^{-2} day^{-1} and ≤1.5 g m^{-2} day^{-1}, respectively.

Storage and sampling of packaged products

A total of 120 packages were examined (60 packages/product). Packages were stored between 4°C and 7°C. Sensory and chemical evaluation of packaged products was performed on the second day of packaging and after 2, 35, 60, 90, 105, 135, 150, 165 and 180 days of storage.

Gas analyses in package headspace

The concentration of gases (O_2 and CO_2) in the headspace atmosphere during storage was measured using a WITT Oxybaby V® analyser (WITT, Gasetechnik GmbH & Co. KG, Witten, Germany).

Sensory analyses

Sensory evaluation was performed by a panel of five experienced members using a point system of descriptive analytical tests according to *SRPS* (2013). Surface colour of slices, taste, odour and consistency were evaluated using a point system with a scale of 1 to 5, where optimal single characteristics were scored as 5 (1 – unacceptable; 2 – ultimate acceptable limit; 3 – acceptable; 4 – very acceptable; 5 – exceptionally acceptable).

Chemical analyses

Lipid oxidation was measured in duplicate from each of the six packs for each treatment in each trial during the storage period. Peroxide value (PV) was determined by standard method (*SRPS,* 2011), and thiobarbituric acid reactive substances (TBARS) according to *Tarladgis et al.* (1964) and *Holland* (1971). The pH of meat was measured by laboratory pH-meter (EUTECH Instruments, Landsmeer, Holland), according to standard method (*SRPS,* 2004), and the water activity (a_w) was measured with a hygrometer (GBX Scientific Instruments, Dublin, Ireland) according to standard method (*ISO,* 2004).

Statistics

Statistical analysis was performed using the MINITAB INC. software package, version 16.0. Before choosing the appropriate statistical analysis, individual distribution identification was conducted to identify the native distribution (Normal, Lognormal, Weibull, Exponential), as the first step. Box-Cox and Johnson transformation of raw data were used to follow a normal distribution. The One Way ANOVA and the post-hoc HSD Tukey's test were used to examine statistical differences of chemical and physico-chemical parameters during storage periods. The differences were considered statistically significant when $p \leq 0.05$. Mean values and standard deviations were used to illustrate both a measure of central tendency and variability of the data.

Results and Discussion

Decreases in CO_2 concentration in the packaged beef prosciutto were from the initial 27.0% to 19.0% at the end of the storage period. Pork prosciutto packages showed CO_2 decreases from initial 30.0% to 9.3% during the study period. The average percentage of CO_2 in gas from the beef prosciutto and pork prosciutto packages during the study period was 21.63% and 17.33%, respectively. The larger decline in the concentration of CO_2 in MAP packaged pork prosciutto (Figure 2) can be attributed to a slightly higher moisture content in comparison to beef prosciutto (Figure 1), which allowed CO_2 to dissolve into the meat's liquid phase (*Quintavalla and Vicini*, 2002). The absorption of CO_2 is highly dependent on the moisture and fat content of the product, initial CO_2 concentration in the gas-phase and the gas/product ratio (*Rubio et al.*, 2007)

Chemical and physico-chemical parameters (TBARS, PV, pH and a_w) of beef prosciutto and pork prosciutto packaged in MAP are presented in Table 1.

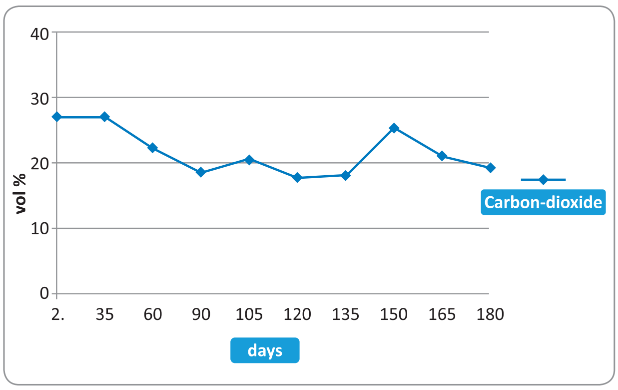

Figure 1. Changes in CO_2 concentration in the MAP packaging of beef prosciutto during 180 days of storage

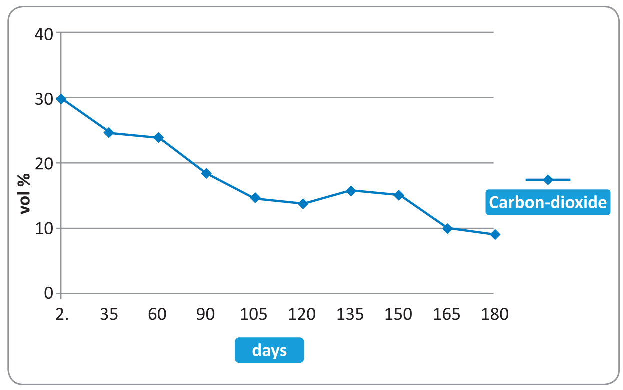

Figure 2. Changes in CO_2 concentration in the MAP packaging of pork prosciutto during 180 days of storage

Table 1. Chemical and physico-chemical parameters of two traditional meat products packaged in MAP during 180 days of storage

	Beef prosciutto				Pork prosciutto			
Days	TBARS[1] (mg MAL kg^{-1})	PV[2] (mmol kg^{-1})	pH	a_w[3]	TBARS (mg MAL kg^{-1})	PV (mmolkg^{-1})	pH	a_w
1	≤ LOQ[4]	0.22±0.02^{a}	5.79±0.02^{a}	0.913±0.006^{a}	≤ LOQ	≤ LOQ	5.32±0.02^{a}	0.874±0.002^{a}
35	≤ LOQ	0.42±0.01^{b}	6.03±0.01^{a}	0.904±0.008^{a}	0.02±0.01^{a}	0.08±0.01^{a}	5.61±0.02^{a}	0.907±0.002^{a}
60	0.02±0.01^{a}	0.68±0.04^{c}	5.81±0.02^{a}	0.900±0.006^{a}	0.05±0.01^{b}	0.30±0.02^{b}	5.46±0.02^{a}	0.874±0.001^{a}
90	0.09±0.02^{b}	0.90±0.02^{d}	6.00±0.02^{a}	0.910±0.006^{a}	0.06±0.01^{c}	0.52±0.02^{c}	5.39±0.01^{a}	0.881±0.002^{a}
105	0.13±0.01^{c}	1.05±0.02^{e}	5.82±0.04^{a}	0.869±0.006^{b}	0.09±0.01^{d}	0.68±0.02^{d}	5.25±0.04^{a}	0.868±0.004^{b}
120	0.15±0.02^{d}	1.30±0.01^{f}	5.75±0.02^{a}	0.874±0.008^{b}	0.11±0.02^{e}	0.93±0.04^{e}	5.21±0.04^{a}	0.871±0.006^{b}
135	0.15±0.02^{d}	1.58±0.02^{g}	5.73±0.02^{a}	0.866±0.010^{b}	0.13±0.02^{f}	1.20±0.04^{f}	5.19±0.02^{a}	0.869±0.008^{b}
150	0.15±0.01^{d}	1.68±0.01^{g}	5.73±0.02^{a}	0.865±0.006^{b}	0.15±0.02^{g}	1.75±0.06^{g}	5.16±0.02^{a}	0.866±0.006^{b}
165	0.19±0.01^{e}	1.80±0.01^{h}	5.62±0.04^{a}	0.866±0.006^{b}	0.19±0.04^{h}	1.78±0.04^{g}	5.40±0.04^{a}	0.863±0.005^{b}
180	0.20±0.01^{e}	1.92±0.02^{i}	5.64±0.04^{a}	0.879±0.006^{b}	0.20±0.01^{h}	1.86±0.06^{g}	5.32±0.01^{a}	0.897±0.006^{b}

[1] TBARS – thiobarbituric acid reactive substances;
[2] PV – peroxide value;
[3] a_W – water activiey;
[4] LOQ – limit of quantification of the method applied;
[a, b, c, d, e, f, g, h] within column values – mean±SD (standard deviation) – that do not share a letter are significantly different (p≤0.05).

The average pH and a_w values obtained for beef prosciutto in MAP were 5.79, and 0.885, respectively. These results are similar to results obtained by *Garriga et al.* (2004) (pH 5.81; a_w 0.890), during 120 days at 4°C. *Rubio et al.* (2007) found that pH value was 5.85, and a_w value was 0.900 in a typical Spanish dry-cured beef product. There were no statistically significant differences in pH values during the storage period for the two products ($p>0.05$). Significant differences regarding TBARS and PV mean values were registered within the first half of the storage period (between 1, 35, 60 and 90 days) and also in relation to periods within 105-150, 165 and 180 days ($p\leq0.05$) for both of the products. TBARS and PV values differed significantly on all days within the first half of storage period for both of the products ($p\leq0.05$) (Table 1).

Statistically significant differences in measured a_w values were registered ($p\leq0.05$) between results obtained in the first half of the storage period and on all other days until the end of the study (105,120,135,150,165 and 180 days). The a_w values in the two products did not differ significantly within the first half of storage period ($p>0.05$). The water activity of meat products is that part of the water that is available for biochemical reactions and microbial growth. Keeping the a_w value below 0.910 is a key factor in prolonging shelf life of meat products (*Karolyi*, 2004).

The average pH value (5.33) of pork prosciutto in MAP during the 180 day storage period was lower in comparison to Spanish dry-cured ham (pH 5.84; a_w 0.880) reported by *Bover-Cid et al*. (2011) and also by *De Alba et al.* (2012) (pH 5.80; a_w 0.900). The a_w measured in pork prosciutto in the current study was 0.877 on average and this value is similar to those mentioned above. The lower pH the product has, the more effective microbial inactivation is reached. On the other hand, a_w of the product plays an important quality trait due to its synergetic/antagonist role *(Hyperbaric*, 2014).

Determination of PV is one of the most important and commonly implemented quality control measurements for assessment of food quality and safety. The PV indicates the concentration of peroxides and hydroperoxides that are produced during the early stages of lipid oxidation (primary oxidation products) (*Ivanovic et al*., 2015). The PV of beef prosciutto gradually increased in the packs and ranged from 0.22 mmol kg^{-1} (day 1) to 1.92 mmol kg^{-1} (day 180). In pork prosciutto, the PV also gradually increased during the period of storage, and ranged from below the LOQ (limit of quantification of the method) (day 1) to 1.86 mmol kg^{-1} (day 180) (Table 1). These PVs indicate slight formation of primary oxidation products in both of the products. However, results for the content of malonaldehyde (TBARS) indicated that there were no signs of secondary lipid oxidation (Table 1). TBARS values increased slightly during the whole study and they ranged from below the LOQ (day 1) to 0.20 mg kg^{-1} at the end of storage period for both of the products. Values above about 0.5 are considered critical since they indicate a level of lipid oxidation of products which would produce a rancid odour and taste which can be detected by consumers (*Wood et al.*, 2008). The oxidation of unsaturated fats in high-fat products also results in unappetizing taste and smell. *Rhee and Ziprin* (1987) showed that lipid oxidation correlated with total pigment and myoglobin content of raw muscle.

In cooked meat products (e.g. cured ham), low residual levels of oxygen promote pigment denaturation which imposes a dull greyness to the meat surface (*Møller et al.*, 2000). Registered changes in surface colour of the two products examined in this

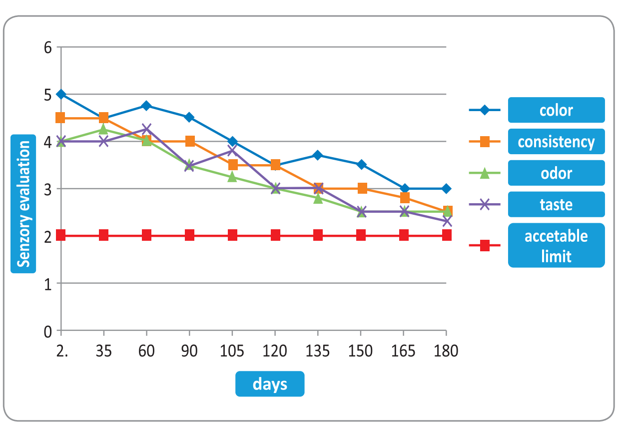

Figure 3. Sensory evaluation of beef prosciutto in MAP packaging during 180 days of storage

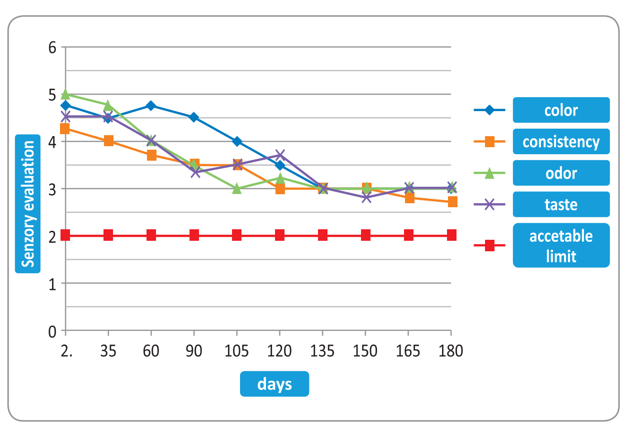

Figure 4. Sensory evaluation of pork prosciutto in MAP packaging during 180 days of storage

study were not particularly large, but they were detected towards the end of the storage period (Figures 3 and 4). Very low oxygen atmospheres minimise lipid oxidation and aerobic microorganism growth. Lipid oxidation in both products occurred at a slower comparative rate than discoloration and should not be the major determinant of shelf-life (*Kennedy et al.*, 2004).

During sensory evaluation, the ultimately acceptable level 2 was reached after 180 days storage for both of the products. The generally common limit of acceptability (3 in the 1 to 5 point scale), was reached after 135 days for beef prosciutto (Figure 3) and after 150 days for pork prosciutto (Figure 4).

Conclusions

Based on the obtained results and discussion, it can be concluded that beef and pork prosciutto packaged in this material for MAP, with 30% CO_2 and 70% N_2, can be stored between 4°C and 7°C for up to 180 days. At the end of that storage period, both the meat products were still of acceptable sensory quality.

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