# Effect of Packaging Methods and Storage Time on Oxidative Stability of Traditional Fermented Sausage

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***Abstract*—**In this paper influence of packaging method (vacuum and modified atmosphere packaging) on lipid oxidative stability and sensory properties of odor and taste of the traditional sausage *Petrovská klobása* were examined. These parameters were examined during storage period (7 months). In the end of storage period, vacuum packed sausage showed better oxidative stability. Propanal content was significantly lower ($P<0.05$) in vacuum packed sausage compared to these values in unpacked and modified atmosphere packaging sausage. Hexanal content in vacuum packed sausage was 1.85 µg/g, in MAP sausage 2.98 µg/g and in unpacked sausage 4.94 µg/g. After 2 and 7 months of storage, sausages packed in vacuum had the highest grades for sensory properties of odor and taste.

***Keywords*—**Lipid oxidation, MAP, sensory properties, traditional sausage, vacuum.

## I. INTRODUCTION

IN many European countries, the demand for traditional food products has increased. Moreover, food and gastronomy form an inherent link with tourism in Europe, with a renewed interest of consumers in typical and regional food [1]. One of the most representative traditional Serbian sausages is *Petrovská klobása*. It is a traditional dry fermented sausage from municipality of Bački Petrovac (Province of Vojvodina, Serbia). Due to its specific and recognizable quality (texture, flavor and taste), this product has been granted PDO (protected designation of origin), under Serbian law [2]. Fermented sausages are products that contain a high percentage of fat. Fat is responsible for numerous properties of the fermented sausages. From a physiological aspect, fat is an important source of energy as well as of essential fatty acids and liposoluble vitamins [3]. Products formed during lipolysis and lipid oxidation have an important role in the formation of odor, taste and texture of the final product. However, fermented sausages also show some negative properties as a consequence of high content of animal fat [4]. Lipolysis is the first step in the process of auto-oxidation of free fatty acids [5]. Moreover, the oxidative degradation of lipids of meat and meat products involves the oxidation of unsaturated fatty acids, especially polyunsaturated fatty acids and cholesterol [6]. Polyunsaturated fatty acids having three or more double bonds are primarily tied to phospholipids and are important for the development of the characteristic flavor state of food. The free radicals formed in lipid oxidation (R•) react with oxygen producing peroxy radicals (ROO•). In this initial process ROO• react with several RH resulting in lipid hydroperoxides (ROOH), which are the main primary products of oxidation [7], [8]. Moreover, during secondary oxidation changes in free fatty acids, compounds such as aldehydes, ketones, carboxylic acids are being created.

Aldehydes are the main products formed during the lipid oxidation. Even in small amounts aldehydes disturb the favorable sensory properties of food [9], [10]. Also, many aldehydes formed during the smoking process or from lipid peroxides are carcinogenic and can cause diseases of the digestive tract [11]. Propanal and hexanal are the most commonly used indicators of lipid oxidation in food due to their higher oxidative stability in detection compared to unsaturated aldehydes [12]. Propanal is a typical product of the n-3 oxidation and hexanal is a product of oxidative degradation of n-6 polyunsaturated fatty acids [13].

In the modern food chain system, it is hardly conceivable to distribute foodstuff without packaging. Food packaging preserves and protects food from environmental factors including chemical, physical and biological influences up to the point of consumption. This emphasizes retarding spoilage, extending shelf-life, and preserving the quality of packaged food [14].

Retail storage of dry fermented sausages is usually done in aerobic conditions, the product being exposed to oxygen and, in consequence, to a potential oxidation process. Packaging in modified atmospheres (vacuum and gas packaging) has also been introduced as a commercial way for the retail selling of meat products. Vacuum packaging (VP) has been used in the meat industry for quite a long time and has been accepted by the consumers [11]. The bags used in VP are typically made from a flexible plastic film that has low gas and water vapor permeability and the plastic film generally adheres closely to the product and it may also be called skin tight [15]. In modified atmosphere packaging (MAP), gases normally used for preservation of dry cured meat products, include combinations of $CO_2$ and $N_2$, because in dry cured products colour is mainly determined by nitrosylmyoglobin, the usual pigment of uncooked cured meat, which is unstable in air.

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Therefore, besides oxidative rancidity, the presence of O2 may cause a rapid discolouration, in these products. For dry cured meat products, the gas mixture included in packs is usually 20% $CO_2$/80% $N_2$ [16].

*Petrovská klobása* is a traditional product that is currently being transferred from small-scale production to industrial. At this point, preservation of product during distribution and storage phases is very important. Thus the aim of this research was to investigate effects of two currently most used packaging systems (vacuum and modified atmosphere) on intensity of oxidative changes, as well as on sensorial properties during long time storage.

## II. Materials And Methods

### A. Preparation of Sausages

Sausages were produced in the winter period by using traditional manufacturing technology. Stuffing for the experimental sausages was made from chilled lean pork and fat in relation 85:15. Pork and firm fat tissue were grounded to pieces the size of 10 mm, and then the following ingredients were added: 2.50% red hot paprika powder, 1.80% salt, 0.20% raw garlic paste, 0.20% caraway and 0.15% crystal sugar. Starter cultures were not added so the sausages were subjected to spontaneous fermentation. Stuffing was hand-mixed, using a specific technique of tipping over and squashing for 10 minutes. The made stuffing was then filled into collagen casings (diameter of 55 mm). The sausages were subjected to straining during 24h.

The *Petrovská klobása* sausage was subjected to the traditional conditions of smoking (5°C–10°C and RH = 75%–85%), and drying (8°C–10°C, RH = 90%–75%), during 60 days. After that time, sausages were divided in three groups. The first group consisted of unpacked sausages, while the sausages from the second and the third group were packed under vacuum and in MAP (75% $N_2$ and 25% $CO_2$), respectively.

After packing, sausages were stored in a chamber with controlled temperature (15°C) and relative humidity (75%) for seven months. Analyses of oxidative changes were conducted at the end of drying and after two and seven months of storage. Sensory evaluation of odor and taste was conducted after 0 (end of drying process), 2 and 7 months of storage.

### B. Aldehydes Determination

Static headspace gas chromatographic (SHS–GC) analyses were performed on Agilent 7890A GC System (Agilent Technologies, Santa Clara, California, USA) equipped with a capillary split/split less inlet, total electronic pneumatic control of gas flow, headspace auto sampler and FID. Static headspace (SHS) sampling was performed with the headspace sampler, CombiPAL System (CTC Analytics, Zwingen, Switzerland). A 2.5 mL HS syringe for CombiPAL was used, for the injection of 2.0 mL of vapor phase from the 10 mL headspace vials. Chromatographic conditions and aldehydes standard preparation is performed according to Mandić et al. [17]. Homogenized sample was accurately weighed (2.00 g) into 10 mL scruecapped headspace vial.

### C. Sensory Evaluation of Odor and Taste

A panel consisting of seven trained members of different ages performed sensory evaluation of odor and taste. The casing was removed; the sausages were cut into slices of approximately 4 mm thickness and served at room temperature on white plastic dishes. Three slices were served from each batch. Water and unsalted toasts were provided to cleanse the palate between samples. Evaluation was performed according to quantitative descriptive analysis (QDA), using a scale from 0 to 5, with a sensitivity threshold of 0.25 points [18].

Each mark means distinctive quality level, described as follows: 5 – extraordinary, typical, optimal quality; 4 – observable deviations or insignificant quality defects; 3 – drawbacks and defects of quality; 2 – distinct to very distinct drawbacks and defects of quality; 1 – fully changed, atypical properties, product unacceptable; 0 – visible mechanical or microbiological contamination, atypical product.

### D. Statistical Analysis

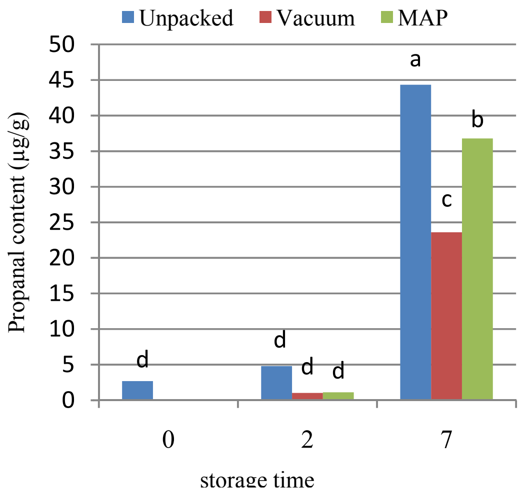
Statistical analysis was carried out using STATISTICA 8.0 (StatSoft, Inc., Tulsa, OK, USA). All data were presented as mean value with their standard deviation indicated (mean ± SD). Variance analysis (ANOVA) was performed, with a confidence interval of 95% ($P<0.05$). Means were compared by t-test and Duncan's multiple range test.

## III. Results and Discussion

During storage time, propanal was the most abundant aldehyde and its content went from 1.03 μg/g in vacuum packed sausage after 2 months storage to 44.32 μg/g in unpacked sausage after 7 months storage (Fig. 1). These results are in good correlation with the results from our previous results concerning this sausage [19].

After two months of storage, propanal content did not change significantly ($P>0.05$). However, after seven months of storage, propanal content rose significantly ($P<0.05$) in all sausages (unpacked, vacuum and MAP). High values of propanal content are probably due to intense oxidative changes on linolenic acid during drying and storage time.

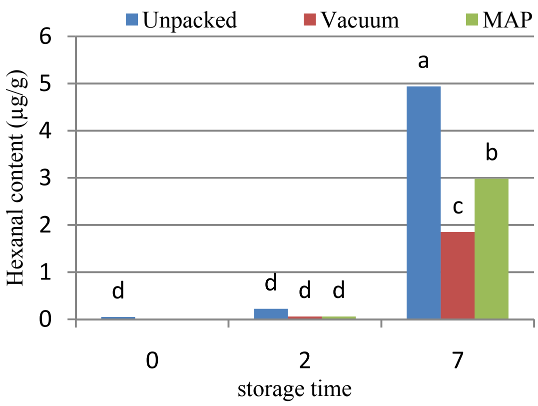
After 7 months of storage, propanal content in vacuum packed sausage was 23.60 μg/g and it was significantly lower ($P<0.05$) than in unpacked (44.32 μg/g) and modified atmosphere packed (36.79 μg/g) sausage.




Different letters abcde mark significantly different means with 95 % probability ($p$<0.05)

Fig. 1 Propanal content in *Petrovská klobása* sausage

Similar to propanal content, content of hexanal did not change significantly (P>0.05) during first two months of storage (Fig. 2).

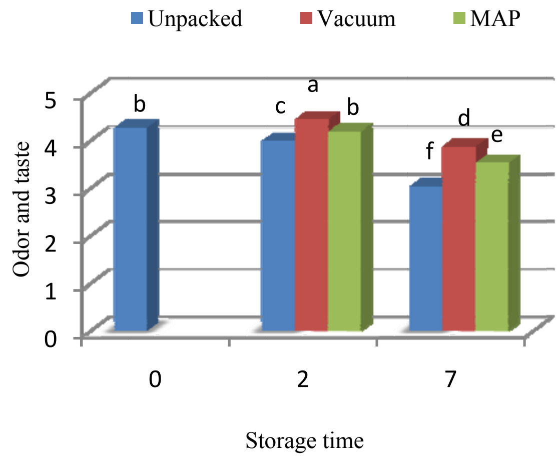



Different letters abcde mark significantly different means with 95 % probability ($p$<0.05)

Fig. 2 Hexanal content in *Petrovská klobása* sausage

Values for hexanal content during storage went from 0.05 µg/g to 4.94 µg/g. After 7 months of storage, clear difference in the content of this aldehyde between different packaging systems was observed. The same as for propanal, lowest content of hexanal was detected for VP sausage, than for MAP and highest level was detected in unpacked sausage. Similar values for hexanal content in fermented sausages during prolonged storage period were observed in literature data [20], [21].

After 2 months of storage, vacuum packaging showed superiority in preserving sensory properties of *Petrovskà klobàsa* (Fig. 3). This superiority was confirmed at the end of storage period, when sensory properties of odor and taste were: vacuum >MAP>unpacked.




Different letters abcde mark significantly different means with 95 % probability ($p$<0.05)

Fig. 3 Sensory evaluation of odor and taste in *Petrovská klobása* sausage

Sensory grade of odor and taste (Fig. 3) was highest for vacuum packed sausage after 2 months storage (4.54). After 2 and 7 months of storage, sausages packed in vacuum had significantly higher (P<0.05) grades for sensory properties of odor and taste, compared to both MAP and unpacked sausages. Obtained values are in negative correlation with propanal and hexanal contents. Lower values of these aldehydes probably affected better sensory properties of sausages packed in vacuum.

## IV. Conclusion

Vacuum packaging affected lowering lipid oxidative changes compared to both MAP and no packaging during long time storage (7 months). Sensory properties for odor and taste during storage were highest for vacuum packed sausage. Based on this research, vacuum packaging influenced the best oxidative and sensory stability of traditional sausage, *Petrovská klobása*.

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