

EFFECT OF SWISS CHARD POWDER AND STARTER CULTURE ON SENSORY PROPERTIES OF DRY-CURED PORK LOIN

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Abstract: Nowadays, the modern consumer is starting to take more care of his health and change his eating habits. He reduces the consumption of processed meats or wants to consume natural processed meats that contain lower quantity of additives. In order to determine the efficiency of swiss chard powder, as a natural source of nitrite, and usage the starter culture in industrial conditions, in two replications, two groups of cured pork loin were produced, as follows: Group I: control group using nitrite salt and group II: swiss chard powder and using the starter culture SafePro EasyCure LC (*Debaryomyces hansenii*, *Lactobacillus curvatus*, *Staphylococcus carnosus* and *Staphylococcus vitulinus*) without usage of nitrite salt. The usage of swiss chard powder in combination with the starter culture results in obtaining the desired color of the surface and the cross section of cured pork loin. The other sensory characteristics have been improved, and, at the same time, the overall quality of the finished product has been improved.

Generally, the usage of swiss chard powder and the starter culture SafePro EasyCure LC (*Debaryomyces hansenii*, *Lactobacillus curvatus*, *Staphylococcus carnosus* and *Staphylococcus vitulinus*) produces a natural, durable product, produced in industrial conditions. Further research is needed to determine the safety and feasibility of extending the shelf life of the product.

Keyword: nitrite, starter culture, swiss chard powder, pork loin, sensory properties

1. INTRODUCTION

In the Stone Age, the existence of prehistoric people largely depended on the possibility of gathering food in nature and hunting wild animals. After catching the wild animals, people sought to find a way to extend the viability of excess meat. At first, they used caves and natural shelters to dry meat (Alahakoon et al., 2015; Savić et al., 2007; Zukál and Incze, 2010). Traces dating back to the Old Stone Age were found around the Don River, where locals dried the meat in the sun, which was then cut into thin strips (Savić et al., 2007).

Meat preservation and the knowledge of the preservation processes became an essential factor for human survival. Therefore, people were constantly looking for new ways of preserving meat.

From the ancient records from around 3000 BC, the ancient Sumerians in Mesopotamia enjoyed the consumption of dried salted meat and fish. The inhabitants of ancient Babylon considered salt to be a very important ingredient. Salt became widely used in 1600 BC in the Jewish Kingdom due to its proximity to the Dead Sea, a natural source of salt. The Chinese were also familiar with the technology of producing sea salt in about 1600 BC.

Salt preservation was practiced in deserts and coastal areas of Asia. Desert salt contained nitrates and borax in powder form. Phoenician sailors traded salty fish in the eastern Mediterranean around 1200 BC, because it did not spoil as quickly as fresh fish (Binkerd and Kolari, 1975). The technologies of smoking, salting, and drying were widespread in ancient Greece long before the time of Homer (1000 BC) (Savić et al., 2007; Vuković, 2012). The Romans learned from the Greeks how to use salt. They learned how to cure different types of meat. The cure, in addition to salt, contained other ingredients (Binkerd and Kolari, 1975). It was known that even as early as 301, the Roman emperor Diocletian was able to distinguish between cured-and-smoked ham from uncured ham (Vuković, 2012).

The meat is salted in order to reduce the water content, to prevent the growth of microorganisms, to prolong its viability and to achieve an appropriate texture and flavour of the product. In the 19th century, some salts were found to have better preserving effects than others, and they formed a stable red color. Saltpetre (KNO_3) is recognized as such salt, but the chemical mechanism of its action was not known for a long time (Škaljac, 2014).

Historical records do not provide accurate data on when nitrites were first used for curing meat. However, it is safe to say that for centuries meat was originally treated with salt, which was the precursor to nitrites (Binkerd and Kolari, 1975, Sindelar and Milkowski, 2011).

Today, the modern way of producing meat products can hardly be imagined without the use of additives. Nitrites are one of the additives currently widely used in the production of meat products along with salt, sugar, ascorbate, and polyphosphates (Goswami et al., 2014). They are used mainly to maintain the safety and quality of products (flavour, color, as well as to prevent lipid oxidation) (Alahakoon et al., 2015; Данев, 1999 Vuković, 2012).

The development of a characteristic, typical, stable, reddish-pink color in meat products, except for myoglobin (Mb), which is present in meat, is the result of the use of nitrites and nitrates. They are added to meat products as a source of nitric oxide (NO) and thus provide the production of nitrosilmyoglobin (NOMb). If nitrates are used, they first must be reduced to nitrites with the action of the bacterial enzyme nitrate reductase (Arnau et al., 2007; Gøtterup et al., 2008).

Sindelar and Milkowski, (2011) point out that nitrates and nitrites, in combination with other factors, in addition to reducing or inhibiting the growth and reproduction of *Clostridium botulinum*, prevent the growth and multiplication of other pathogenic microorganisms such as: *Salmonella spp.*, *Staphylococcus aureus*, *Listeria monocytogenes*, *Escherichia coli* and *Bacillus cereus*.

Nitrites play an important role in the development of a specific aroma in cured meat products, whether or not they are heat-treated (Noel et al., cit. Пејковски, 2000). According to Shahidi and Pegg, 1992 nitrites affect aroma with the power of their antioxidant properties and the stabilization of microsomal lipids and heme pigments.

The potentially dangerous effects of nitrates and nitrites were discovered in the 1960s, when the debate over the safety of meat products began. Nitrates and nitrites are the most common additives in meat products. The biggest concern about nitrates and nitrites in food is about the potential ability of nitrites to form carcinogenic N-nitroso compounds (Govari and Pexara, 2015).

During the processing of meat and meat products, a reaction occurs between nitrites and meat proteins, and as a product of the nitrosation reaction, many harmful carcinogenic compounds (N-nitrosamines) are produced (Bošnjir, et al., 2003; Hui, 1992; Pearson and Dutson, 1990). N-nitrosamines, as reported by Vombergar et al., 1989) cause changes in the liver, lungs, stomach, brain, and the peripheral nervous system. The toxicity and carcinogenicity of nitrosamines have been demonstrated and described in a number of published papers over the past thirty years Jakszyn et al., 2004. Nitrites can be potentially carcinogenic when added to high-protein foods that are subsequently treated at high temperatures. Therefore, the addition of nitrites and nitrates in food is associated with carcinogenicity Bouvard et al., 2015.

Numerous studies have been conducted in the past forty years in order to reduce the use of nitrites, and thus reduce the risk of the formation of harmful carcinogenic N-nitroso compounds in meat products. Several scientists have come up with the idea of reducing their content. García et al., (2011) point out that there are two alternatives to solve this problem: complete or partial replacement of nitrites by natural or other means, and the use of agents that block the formation of N-nitrosamines in products containing conventional nitrite concentrations.

Nitrates and nitrites are naturally present in some vegetables. Beets, broccoli, celery, cabbage, lettuce, radish, and spinach contain high concentration of nitrates (more than 1000 mg / kg), while nitrites in fresh vegetables are present in very low concentrations (less than 1 mg / kg) (Gassara, 2016). Vegetable juice and powder contain a much higher concentration of nitrates compared to fresh vegetables (Eisinaite et al., 2016).

Alternative natural sources of nitrates, present in high concentrations in some vegetables, and the use of starter cultures, which reduce nitrates to nitrites, can be used in the production of meat products. Finished products have acceptable sensory properties (Sebranek and Bacus, 2007b).

Today, modern requirements for a high level of safe and quality food impose complete control over the production process. Therefore, the scientific focus of research is on the potential use of starter cultures. Previous research has yielded good results in preventing the proliferation of potential pathogens and improving sensory characteristics (Maksimović et al., 2015; Laranjo et al., 2017; Silva et al., 2018).

The aim of this paper is to test and analyse whether swiss chard powder, in combination with the starter culture SafePro EasyCure LC (*Debaryomyces hansenii*, *Lactobacillus curvatus*, *Staphylococcus carnosus* and *Staphylococcus vitulinus*), can give satisfactory results of the sensory characteristics in the production of dry-cured pork loin without the use of nitrite salt. On the other hand, it will be possible to see whether swiss chard powder will be a good substitute for nitrites, which are used in the production of durable meat products. Conducting research in industrial conditions aims to find practical application of the results obtained by meat processors, so that they could see the positive effect of the use of starter cultures and alternative sources of nitrites in meat products. This will meet the requirements and expectations of the modern consumer.

2. MATERIALS AND METHODS

2.1. Materials

Dry pork loin, produced in industrial conditions, was used in this research, composition of which is shown in table 1. During the production, swiss chard powder in combination with the starter culture SafePro Easy Cure LC was used as an alternative to nitrite salt.

The experiment was conducted in the meat industry "Rimes MS Group". Their usual technological way of producing dry pork loin was taken as a basis. In order to determine the effectiveness of swiss chard powder as a natural source of nitrite, and the use of the starter culture SafePro EasyCure LC (*Debaryomyces hansenii*, *Lactobacillus curvatus*, *Staphylococcus carnosus* and *Staphylococcus vitulinus*) on the sensory characteristics of the dry pork loin, two groups of dry pork loin were produced, as follows:

- Group I: Control, with nitrite salt (conventional production);
- Group II: with swiss chard powder and starter culture SafePro EasyCure LC (*Debaryomyces hansenii*, *Lactobacillus curvatus*, *Staphylococcus carnosus* and *Staphylococcus vitulinus*);

Table 1. Composition of dry-cured pork loin.

Components	Groups of dry-cured pork loin	
	I	II
	%	%
Frozen pork loin	95.15	94.83
Nitrite salt	4	
Table salt		4
Dextrose	0.8	0.8
Sodium ascorbate	0.05	0.05
Starter culture SafePro EasyCure LC		0.025
Swiss chard powder		0.3
Total	100	100

A frozen outer part of the pork loin (*m. longissimus dorsi*) was used, from which the bones, the connective and the adipose tissue were previously removed. The raw material was thawed by dry defrosting. Then the pieces were shaped, so that the finished product would have a characteristic shape with finely cut edges and incisions, and the residual blood was removed. After shaping the pieces, the next technological operation was dry curing. The temperature of the meat in the middle part was 1°C. The previously measured mixture for dry curing was evenly applied and rubbed on the surface of the pieces of pork loin. The salted pieces were left in carts for 14 days in a dark room, with a constant mode of calm cooling, with a temperature of 0 - 4°C and a relative humidity of 85 to 90%. Every three days, the pieces were rearranged, i.e. turned over, and then arranged in another cart, so that the upper pieces reach the bottom, for better diffusion of salt. The formation of the color was monitored in cross section, during each rearrangement of the pieces. On the fourteenth day the cross-sectional color was formed and evenly distributed.

The pieces of pork loin were hung on sticks and arranged on carts. The carts were taken to an air conditioning chamber to be drained for 24 hours at a temperature of 24°C and relative humidity of 85%. After the draining was completed, the temperature in the chamber was 22 °C and the relative humidity was 82% for a period of 4 hours. This was followed by cold smoking for 40 minutes. During the remaining 19 hours and 20 minutes, it was smoked twice more for 40 minutes, the chamber temperature was 22 °C, and the relative humidity 82%. The carts were then transferred to an air conditioning chamber where fermentation took place. In the beginning, the temperature was 22°C and the relative humidity was 82%. Then the temperature was gradually lowered to 12°C and the relative humidity was lowered to 72%. After the ripening, one part of the dry pork loin was cut into smaller pieces of 500 g, while the rest was cut into thin pieces of 2 mm. They were vacuum packed in polyethylene bags and stored at a temperature of 4 °C.

2.2. Method

The sensory analysis of the dry pork loin was performed after the maturation process. The evaluation of the sensory properties: external appearance, color and its intensity on the surface and in the cross section, cross-sectional appearance, texture profile, smell, flavor and aroma of the dry pork loin are determined by a simple descriptive method. The results of the application of the descriptive method of testing the sensory properties of dry pork loin are

presented in a specially selected way. Appropriately selected descriptive terms are used in the description of the sensory properties of dry pork loin.

3. RESULTS AND DISCUSSION

Sensory analysis plays an important role in conducting daily quality control of meat products. It is also important in the process of developing and improving the quality of meat products Silovska et. al., (2019).

The sensory properties of dry pork loin depend on several factors: the choice, the quality of the raw material and the basic ingredients, the way of processing, external factors, etc.

The external appearance of the two analyzed samples of dry pork loin is with a characteristic shape, with finely cut edges and incisions, and a clean and dry surface. The color of the fleshy parts of the surface in both groups of dry pork loins is typical, inherently dark red and even, there is no discoloration. It can be noticed that the dry pork loin produced with a combination of swiss chard powder and starter culture (BS) has a slightly more pronounced dark red color on the surface, compared to the control (K). The present adipose tissue has a characteristic and typical yellowish color with optimal intensity in both groups.

The fresh cross section of the two groups of dry pork loin is shown in Picture 1. In addition, it can be concluded that both groups of dry pork loin have a typical reddish color that is optimally expressed. There is no discoloration and there isn't a pronounced dark ring on the periphery of the pieces. A very small pale dark ring towards the periphery can be seen in the control sample. It can be concluded that the dry pork loin from the group (BS) has a slightly darker and more pronounced red color in the fresh cross section, compared to the control group. This indicates that the use of swiss chard powder in combination with the starter culture can successfully capture the desired color in dry pork loin, while avoiding the use of nitrites. Tae-Kyung et al. (2019), who worked on a semi-durable dry pork loin, concluded that the swiss chard powder can be an excellent nitrite substitute. They also came to the conclusion that a beautiful characteristic color developed on the cross-section of the semi-durable pork loin.

Picture 1. View of the cross section and the cut pieces of both groups of dry pork loin



The cross section in both groups of dry pork loin shows a slight marbling, the adipose tissue has a characteristic whitish color with optimal intensity.

When it comes to sensory assessment, the assessment of the texture profile is very complex. Here, the following things are assessed: degree of dryness, structure, consistency, juiciness, softness, tenderness.

The degree of dryness, seen from the aspect of sensory analysis, is considered to be an opportunity for easy and fine cutting of dry pork loin into thin slices. As can be seen from Picture 1, both samples have an appropriate degree of dryness, because the pieces of dry pork loin can be easily and nicely cut into thin pieces with a thickness of 2 mm, without being damaged.

In both analyzed samples of dry pork loin, a fine structure of muscle fibers can be seen. The fine structure and the appropriate degree of dryness enable the development of appropriate juiciness and tenderness of the finished product. The presence of adipose tissue has a great impact on greater tenderness and juiciness. The outer part of the pork loin is a part of the carcass which has a minimal presence of adipose tissue. However, tenderness and juiciness are acceptable and inherent in the analyzed groups of dry pork loin. Still, it can be concluded that the dry pork loin from the BS group has a slightly better juiciness and tenderness.

A firm and elastic consistency can be observed in both groups of dry-cured pork loin. The cross section shows compactness and absence of cracks (Picture 2).

Picture 2. View of the cross section shows compactness and absence of cracks and the cut pieces of both groups of dry pork loin



The feeling of chewing is typical in both groups of dry pork loin. It can be said that the sample of dry pork loin produced with a combination of swiss chard powder and starter culture has a slightly better feeling than the chewing compared to the control sample, which is produced with nitrite salt.

The smell and flavour of both groups of dry pork loin are excellently pronounced. However, for a slight nuance, the smell and flavour are better pronounced in the group of dry pork loin BS. The presence of an unusual smell and flavour was not found in both analyzed samples. The samples also have a clear, excellent, typically pronounced aroma with a slight hint of smokiness. The sample of dry pork loin BS has a slightly more pronounced aroma. Tae-Kyung et al., (2019) found that chard prevented lipid oxidation in semi-durable pork loin. They point out that swiss chard powder can be used as a natural alternative source of synthetic nitrite.

The degree of saltiness in both groups of dry pork loin is optimal and exemplary.

Dry pork loin produced with swiss chard powder in combination with the starter culture has superior sensory characteristics. The same conclusion was reached by Nuang and Huan, (2016), who found that fermented sausages, to which a combination of three starter cultures had been added, exhibited superior sensory characteristics compared to the control ones. Ikonić et al. (addition of starter cultures has a positive effect on the sensory characteristics of the traditional fermented sausage (Petrovska klobasa) produced in a traditional and industrial way. Стојанова, (2018) achieved positive results in the production of Macedonian traditional sausages. She used nitrate-reducing bacteria in combination with a natural source of nitrates (swiss chard powder and leeks).

4. CONCLUSION

Based on the obtained results, the following conclusions can be made:

- The use of swiss chard powder in combination with the starter culture SafePro Easy Cure LC can successfully capture the desired color on the surface and in the cross-section of dry pork loin, and thus avoid the use of nitrites that are harmful to human health. Other sensory characteristics have also been improved, and at the same time the overall quality of the finished product has been improved, as well;
- By using swiss chard powder and the starter culture SafePro Easy Cure LC in the production of durable meat products, the presence of E-numbers on the declaration can practically be reduced or omitted;
- Meat processors and producers need to think about using starter cultures and alternative sources of nitrites in the future, in order to offer consumers natural meat products of standard quality. This would satisfy the demands and expectations of the modern consumer, and the main goal of every manufacturer is to meet the wishes, requirements and needs of consumers;
- Further research is needed to determine the safety and feasibility of extending the shelf life of the finished product.

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