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Original scientific paper

PHYSICAL-CHEMICAL AND SENSORIAL CHARACTERIZATION OF MACEDONIAN DRY FERMENTED SAUSAGE (SUCUK)

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Abstract

In this study, the influence of ripening on some physical-chemical and sensory properties of the Macedonian sausage produced under controlled conditions has been investigated. Fermentation time has an influence on the quality characteristics of Macedonian fermented dry sausage products. The effect of smoking and drying on physicochemical, sensory and microbiological properties of sucuk was determined during fermentation and after smoking application. Optimum fermentation period was determined for sucuk samples with desirable characteristics. Dry smoked sucuks were fermented at different fermentation intervals (0, 2, 4, 6, 8 and 15 days). Five days of smoking were applied for sucuks. All process parameters were applied under industrial conditions. Weight loss during the processing is not very high (up to 35 %). Smoking and drying processes increased the lipolysis (g oleic acid /100g) and dry matter contents (protein, fat, salt and ash) of sucuks while decreasing the pH values, moisture content and all bacterial counts (total viable bacteria) ($P< 0.05$). Significant differences in the pigment concentration of smoked sucuk were found ($p< 0.05$). In terms of physicochemical, sensory and microbial properties, fermentation period resulted in sucuk samples with good acceptability and quality characteristics.

Keywords: Sucuk, dry fermented, pigment concentration, lipolysis

1. Introduction

Macedonian sucuk is dry fermented sausage and is produced in larger quantities in all areas of the country in a traditional and commercial way. Traditionally, it is produced during the winter period by filling the bovine fillet meat and loins of elderly animals with the addition of kitchen salt, black pepper and garlic in thin beef wraps, and then drying it in a classic smoke without controlling the atmospheric conditions. However, the commercial sucuk is produced from beef and tallow with the addition of salts, spices, antioxidants, nitrites and starter cultures. As such, the sucuk is filled with artificial, usually collagen wrappers and subjected to controlled atmospheric conditions of drying and ripening. However, few meat industries own chambers for production of sucuk in controlled conditions, so the sucuk is dried in classic smokers, and very often, they afterwards undergo a short heat treatment. According to the Rulebook on quality, products are manufactured according to the manufacturer's specification. The tradition of production and consumption of sucuk in the territory of Macedonia and beyond has taken place since the Ottoman Empire. (Gasparik-Reichardt et al., 2005) The fermented sausage is known under the name "soudjuk" or "sucuk", which in the past was produced only from beef meat, and today also of sheep and buffalo meat. Today, a variety of fermented meat products are produced. These products vary in maturity (slow, medium, fast), depending on the carbohydrates used during drying. At the same time, the final pH of the product (pH 4.7-5.5) aroma and hardness of the product are also different between fermented meat products (Kröckel, 1995).

Fermentation, salting and smoking are one of the oldest preservation methods and sausage types are one of the oldest meat products (Petaja-Kanninen and Puolanne 2007; Vuković, 2012). Fermented dry sausage is a high quality product in the meat industry, valued and demanded by consumers. The first data of fermented sausage turn us back to 3000 BC, and more information comes from China and the Mediterranean region around 2000 BC (Petäjä-Kanninen and Puolanne, 2007). Sugars (glucose, sucrose, sometimes lactose) are added to fermented meat products in industrial production. In the fermentation and maturation stages, lactic acid bacteria turn to glucose, the primary energy source, in lactic acid, the main ingredient that provides the pH reduction. This acidification in the environment is important in obstructing undesirable pathogenic bacteria that are low pH-resistant and ensures the development of typical organoleptic character of the fermented meat product (Bover-Cid et al., 2001).

There are many different types of fermented sausage and its diversity varies by country, region, climate, heritage and culture (Lebert et al, 2007; Talon et al, 2007; Roseiro et al, 2011, Santos et al., 2011). Fill forms are numerous, even for products of the same name; some are kept secret. Time, temperature, drying humidity and the process of smoking are processes that influence and control the quality of the finished product (Ockerman and Basu, 2007; Tabanell et al, 2012). Thus, the traditional sausage that originated in the Mediterranean areas is mainly preserved only by drying, while sausages originating from central and northern Europe are dried and smoked (Toldrá et al, 2004; Latorre-Moratalla et al, 2008). It is difficult to carry out the classification and grouping of all the additives used in the industrial production of fermented dried sausage, but the most important additives are: cooking salt and GDL, which are the basic substances of meat products (Čavlek 1993, Vukovic, 2012). Preservation of meat products is among the oldest technologies since ancient times. The meat smuggling has been discovered since ancient times when hunters hunted, fried and smoked meat, believing that this meat stays longer and smells better.

A few studies have focused on the manufacturing technology, microbiology and compositional characteristics of the Macedonian dry fermented sausage (Stojanova et al. 2017), but the effect of ripening on the lipolysis, pigment concentration and microbiology have not yet been studied. The objective of this research was to evaluate the effect of fermentation on the physical-chemical properties of dry fermented sausage during its maturation. Smoke is produced from wood residues such as sawdust (Feiner, 2006).

2. Material and methods

Meat used in Macedonian sucuk production was purchased from Austria. Sucuk dough was prepared from cattle meat trimmings (80%) mixed with fat from ribs (20%) as base material. Then, salt (2.0 %), sugar with GDL (1 %), potassium nitrate (E 252) nitrates (0,02 %) spices (0,1-0,5%) were added. The meat was minced to 2 cm then decreased to 3 mm at 0˚C with speed of 1300 rotation / minute and the spices were added and mixed. No starter culture was added. The meat mixture was stuffed into artificial casings (Kutezin, Czech Republik, 40 mm diameter), with the final weight of each sausage being around 700 g. The filling speed is 10 pieces per minute. After conditioning (12 hours at 18-20 °C and air humidity 58-60%), the products are subjected in fermentation, drying, smoking and ripening under the following regimen: drying and smoking at 18-19 °C, 86-92% RH, air circulation 0.2-0.5 m / s, duration of 5 days ripening at 17 °C, 78% RH, air circulation 0.5-0.8 m / s, duration of 10 days. The smoke was poured during 5 days in duration of 3 hours at microclimate 19 °C and 80-85% RH.

2.1. Sampling and sample preparation

From two replications, sucuk samples were taken before and after heat treatment on the 0, 2, 4, 6, 8, and 15 of fermentation. pH, moisture, salt, ash, fat, protein, free fatty acidity, total pigment concentration analyses and microbial counts were determined in sucuks. Sensory analyses were determined only for heat-treated products. All analyses were carried out in duplicates.

2.2. Chemical analyses

Ten grams of sample was homogenized in 100 ml of distilled water, and pH of this mixture was determined by a pH meter (Metler Toledo). Moisture, salt, ash, protein, fat and residual nitrite contents measurements were determined according to the methods described by AOAC (1990). The determination of free fatty acids, respectively lipolysis was performed according to Kurt and Zorba (2010) while the free fatty acid content was expressed as g oleic acid / 100g (Egan et al., 1981). FFA analysis was done according to the alkaline titration method and the FFA was calculated as mg KOH/g fat.

2.3. Microbiological analysis

Microbiological analyzes were performed according to the ISO 4833: 2003 method, determining the total number of aerobic mesophilic bacteria at 30 ° C (Official Gazette, 2013)

2.4. Statistical analyses

One way (ANOVA), Post-hoc (Duncan test) was performed, using the software package SPSS program for Windows, version 9.0 (SPSS Inc., Chicago, IL, USA). Differences were considered significant at $P < 0.05$.

3. Results and Discussion

Temperature during heat treatment plays an important role in lowering humidity. As can be seen from the presented results, the moisture content in the sausage is in the range of 55.71% - 38.43%. During this process, it is noted that the moisture decreases faster due to the drying process. Gökalp & Ockerman (1985) stated that the decrease of the moisture content in the sausage produced at high temperature is faster, which can be explained by the rapid pH drop at high temperature. Soyer et al. (2005) found

higher levels of moisture produced at different temperatures. Lizaso et al. (1999) found initial moisture of 56.26% in the fermented sausage at room temperature then decreased until 39.49% after fermentation and drying processes.

As can be seen from the results shown, the pH in the sausage at the beginning is 5.08, then it goes down to 4.85. The fermented sausage pH at various levels of temperature and drying begins to significantly decrease. The pH reduction is due to the formation of lactic acid. Similar results were obtained from Ensoy et al. (2010). Increasing the level of fat slowly increases the pH of other samples; this fits with other studies by Ahmad (2005). pH plays an important role in preserving foods, generally the most acidic foods. Another parameter for lowering the pH is the GDL, with the addition of an excessive amount of GDL can result in the deterioration of the sensory properties.

Tabel 1. Changes in chemical composition and microbiological properties during ripening of dry fermented sausage

Parameters	**Ripenig (days)**					
	0	2	4	6	8	15
Moisture (%)	55,71±0,36^{d}	52,62±0,44^{c}	52,53±0,09^{c}	48,47±0,31^{c}	40,39±1,73^{b}	38,43±0,03^{a}
Salt (%)	6,25±0,49^{a}	8,35±0,92^{b}	7,65±0,21^{ab}	8,60±2,69^{b}	8,45±0,07^{b}	9,00±0,28^{b}
pH	5,08±0,01^{d}	5,04±0,01^{c}	4,92±0,01^{b}	4,85±0,01^{a}	4,95±0,01^{c}	4,94±0,01^{c}
Acidity	8,55±0,78^{a}	10,35±0,49^{c}	12,40±0,57^{c}	9,40±0,28^{b}	14.10±0,28^{d}	14,05±0,35^{d}
Ash (%)	4,45±0,01^{a}	/	5,31±0,10^{ab}	/	/	5,96±0,80^{c}
Protein (%)	7,26±0,18^{a}	/	11,25±0,36^{b}	/	/	22,57±1,37^{c}
Fat (%)	24,44±0,01^{a}	/	25,06±0,01^{b}	/	/	40,41±0,01^{c}
TAPC	6,58	/	/	/	/	1,47

ppm (mg/kg), Lipolysis g/ oleic acid/100 g fat, $^{a-c}$ Means within the same row with different superscript letters are different ($p < 0.05$), TAPC- total aerobic plate counts.

Proteins are the most valuable ingredients of meat products. Hence, protein content is used as an objective criterion based on which product quality can be assessed (Vukovic, 2012). The protein content was of a high average in the Macedonian sausage. The results of this research show that Macedonian sucuk contains significant proteins (Soyer et al., 2005).

As can be seen from the presented results, the protein content in the sausage revolves around the 11.25 range and goes by increasing the percentage in the range of 22.57. As can be observed during production, the amount of protein depends on the production temperature and the drying of the product (Table 1). The total fat content of sausage filling ranges from 24.44, which goes up and reaches 40.41%. In Table 5, there are differences (p<0.05). Dropping in the flesh does not affect much the fat growth. The results obtained in this study are consistent with the results of other studies related to the change in the amount of fermented sugar fat during production.

The ash content in the Macedonian sausage is conveyed to the filling stage, the smoke ranging from 4.45 raises to 5.31 and the last day marks the highest value of 5.96. The grace is followed in three days, even on the first day (0), on the fourth and fifteenth day. Table 5 shows changes (P<0.05).

Salt is the main flavouring agent used in the production of sausage and contributes to the basic characteristics of the taste of the final product. The amount of added salt depends on the type of sausage and especially on the fat content. The acceptable level of salt in the sausage depends on the country and the laws. However, the highest and lowest levels of salt are often used. Although the salt is not generally used in concentrations sufficient to maintain it, it performs an antimicrobial activity. Some bacteria are restrained. Other microorganisms tolerate a much higher concentration of salt. Salt also performs other functions in the sausage; it is digested in water and helps with water capacity and emulsifying capacity of meat proteins. The use of salt only gives a dry salty product that has a non-attractive color. Today, salt is commonly used in combination with sugar. The salt should be clean and sufficient to spread easily in the flesh. Analysis of the lipolysis results are summarized in the Table. The linear effect of the fermentation and maturation period was found to be important (P <0.05) for lipolysis.

As shown in Figure 1, lipolysis was intensified by increasing the fermentation period. During the fermentation period, the level of free fatty acids in fermented dry sausage depends on the hydrolysis activity of lipase, microbial metabolic processes and oxidative reactions that alter the free fatty acids released on lipolysis (Soriano et al., 2006). Such lipases are mainly of endogenous origin and these enzymatic activities increase with reduced pH values in dry meat products (Vestergaard et al., 2000). Long process with light fermentation conditions allows a relatively higher enzymatic activity and therefore a larger production of fatty acid. An important percentage of the production of free fatty acids in dried meat products is the result of phospholipid hydrolysis (Toldrá, 2004).

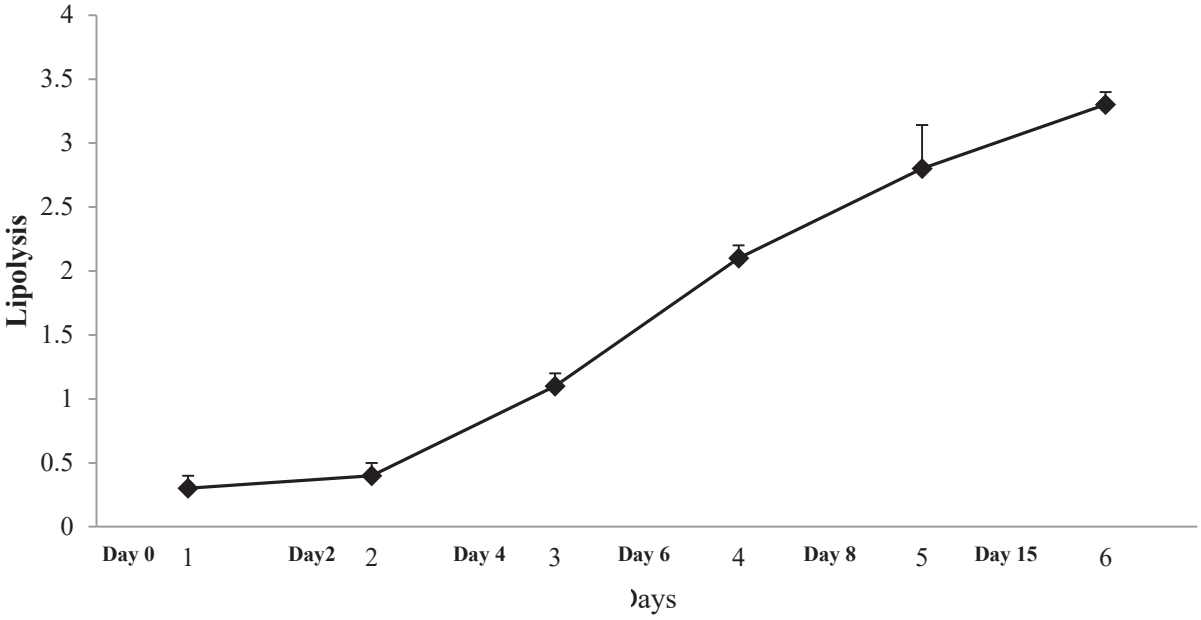

Figure 1. Lipolysis of traditional Macedonian sucuk produced under industrial conditions

The process of colour formation is very complex, especially in fermented dry sausage. During the production of the Macedonian sausage were examined the impacts of the production period, additives, fumigation, drying and packaging on the colour intensity of sausage (Figure 2). The aim is to follow all the parameters and movements that are made in the sausage, wanting to form the desired colour, flavour and taste accepted by consumers.

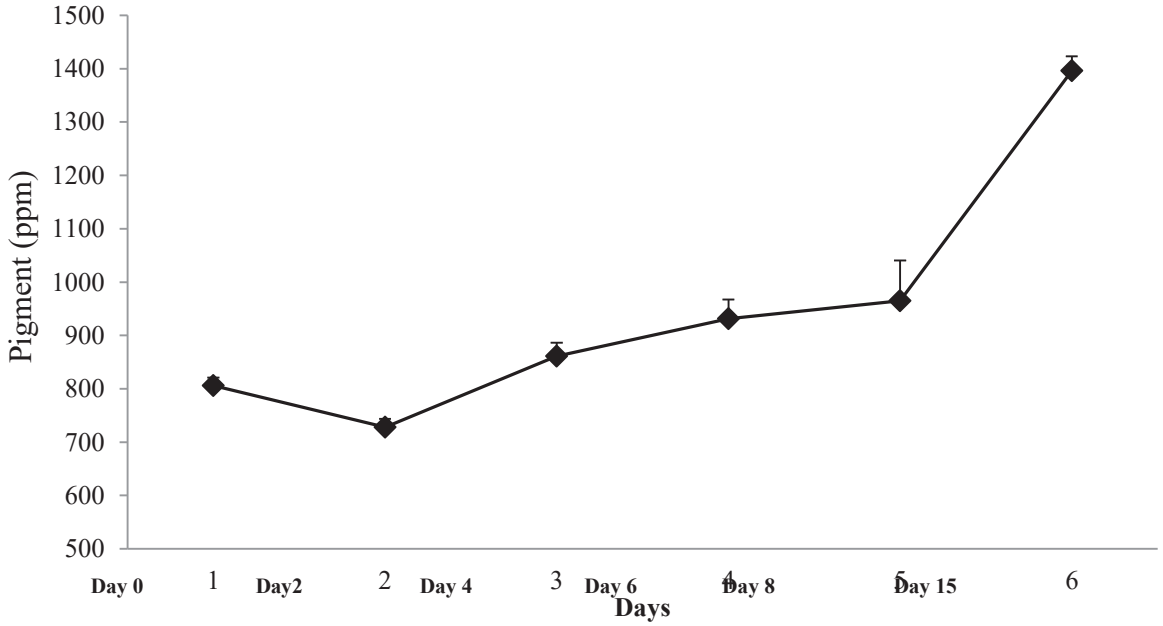

Figure 2. Pigment concentration of traditional Macedonian sucuk produced under industrial conditions

Oxidizing processes in meat and meat products lead to degradation of lipids and proteins (including pigments) which in turn contribute to the deterioration of colour, structure (bond connection) and aroma (Zanardi et al., 2002). Lipid oxidation products can interact with hematic pigment, resulting in increased iron sensitivity to oxidation and deterioration of the meat product (Alderon et al, 2003). Traditionally, lipolysis was thought to be related to bacterial lipase activity (Kenneally et al., 1998). Lipolysis, together

with proteolysis, is believed to play a central role in aroma formation (Chizzolini et al., 1998) and could be affected from the curing salts or ingredients such as nitrite-nitrate (Martin et al., 2006).

The growth of the bacteria was affected by acidification or by the inability of the starter to compete with the autochthonous microbes, which was in accordance with Lizaso et al. (1999) and Samelis et al. (1998) who considered acidification to be the main cause of micrococci-staphylococci inhibition in dry fermented sausages.

Bacterial lipases are produced during the growth phase and the production is influenced by growth conditions with maximum amounts formed at optimum temperatures and pH for growth. Total mesophilic bacteria could be responsible for lipolysis in the early stages of ripening, when conditions of temperature, pH and NaCl % would be more favourable (Makhzoum et al., 1995). The majority of bacterial lipases showed highest activity in a neutral to alkaline pH range and between the 30-40°C temperature ranges (Kenneally et al., 1998). Mesophilic bacteria grow best at moderate, not very hot or very cold temperatures, usually between 20 and 45 °C (68 and 113 °C). During the analysis it is noted that the number of aerobic mesophilic bacteria on the first day (0) was log 6,58. The maximum permissible number of mesophilic bacteria is 6.69 log (Official Gazette of R. of Macedonia No. 100 / 2013). During fermentation and drying the number begins to decrease until log 1,47 on the 15th day.

From the sensory point of view, the sausage from the last day was in compliance with the specific regulations. The 15th day had the largest number of points compared to other days (Figure 3).

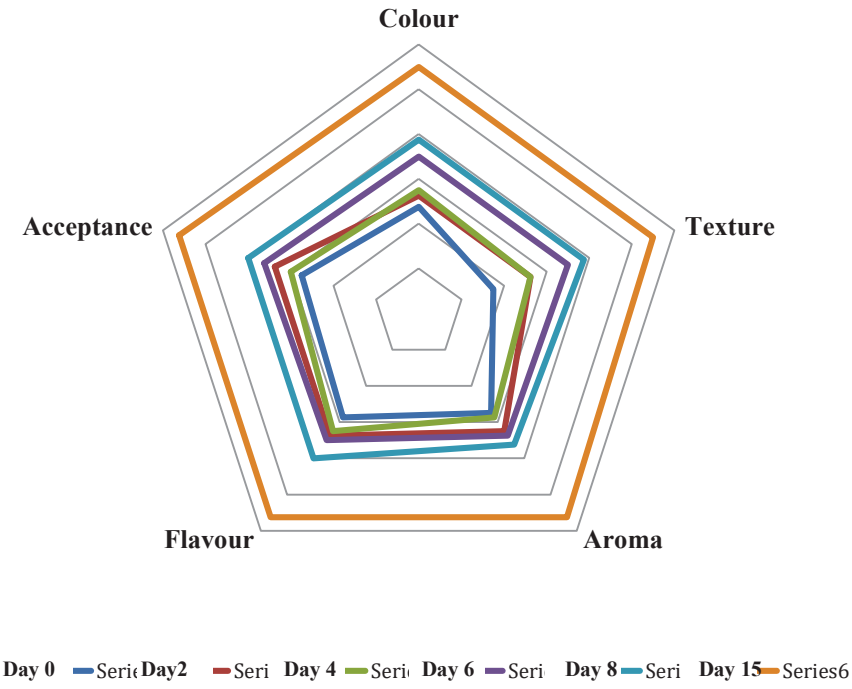

Figure 3. Changes in sensory properties of Macedonian sucuk during the ripening

4. Conclusions

Based on the presented results obtained in this study it can be concluded that the total chemical composition and the sausage pH from different fermentation periods were significantly different (p<0.05). The highest pH value was determined in the sausage samples from the first day (5.08) and the lowest in the sausage from the eighth day (4.85). The moisture content during fermentation is significantly reduced (p < 0.05) from zero day by 55.71% on the fifteenth day to 38.43% at the end of the drying process (15 days). That represents a decrease from 55.71% to 38.43%. The protein content is increased by the fermentation and drying process, from 7.26% on the first day to 22.57% on the last day (15 days). The total salt content in the Macedonian sausage grows in the fermentation period from zero day of 6.25% to the ninth day of 9.00%. The content of kitchen salt in the Macedonian sausage varied from 6.25% (zero day) to 9.00% (fifteenth day). With an increase in the fermentation time until the fifteenth day, the amount of lactic acid increases from 8.55% to 14.10%. The highest percentage of fat was determined on the fifteenth day (40.41%), and the highest protein content on the fifteenth day with (22.57%). The profile of the sausage color during the 15 days of fermentation was studied in detail, with a significant influence of the fermentation on the pigment concentration. There are recent researches and legislations on additives, regarding the negative health effects of chemical preservatives, especially nitrite in

meat products, thus the behavior of natural starters against competitive natural flora in the absence of antimicrobial additive could be an advantage in ripening.

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