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MICROBIOLOGICAL QUALITY AND SENSORY ATTRIBUTES OF SAUSAGES FROM DIFFERENT PRODUCTION MODELS

Miroslav Jůzl[1], Anna Seidlová[2], Jan Slováček[1], Veronika Čábelová[1], Růžena Vávrová[1], Petra Dvořáková[3], Monika Zemanová[3], Alena Saláková[1], Zdeněk Havlíček[3], Libor Kalhotka[1,2]*

Address(es): Associate Professor Libor Kalhotka, Ph.D.
[1]Mendel University in Brno, Faculty of AgriSciences, Department of Food Technology, Zemědělská 1, 613 00 Brno, Czech Republic, phone number: +420 545 133 190.
[2]Mendel University in Brno, Faculty of AgriSciences, Department of Agrochemistry, Soil Science, Microbiology and Plant Nutrition, Zemědělská 1, 613 00 Brno, Czech Republic, phone number: +420 545 133 054.
[3]Mendel University in Brno, Faculty of AgriSciences, Department of Morphology, Physiology and Animal Genetics, Zemědělská 1, 613 00 Brno, Czech Republic, phone number: +420 545 133 146.

*Corresponding author: libor.kalhotka@mendelu.cz

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ABSTRACT

An experiment was conducted to evaluate the microbiological, color and sensory attributes of sausages produced by different production modes. The sausages in control group (C) were made in a meat pilot plant laboratory, which is under the supervision of Veterinary State Authority and meets all the requirements for the production and sale of meat products on the market. Three hobby manufacturers simulated house-hold production mode (HMA, HMB and HMC) and made sausages from the same meat and using the same recipe in three different procedures for filling, cooking and smoking sausages. The results confirmed the correctness of the requirement for heat treatment inside the meat product (70 degrees Celsius for 10 minutes). Significant differences between production modes ($P < 0.05$) were found in basic chemical composition and in colour measurements of the sausages while significant effect on microbiological findings and sensory traits were not determined. An important requirement is to prevent cross-contamination when handling heat-treated meat products.

Keywords: meat products, house-hold production, quality attributes, smoking, sensory quality, colour, hygiene, microorganism

INTRODUCTION

Central European countries, and specifically the Czech Republic, have seen significant changes in the competitiveness of the meat industry after accessing the EU. The role of agriculture and food industry in rural areas have been emphasised, because the local agriculture and food production could maintain cultural heritage of rural areas (**Beňuš, 2019**). Agriculture, through the crop and animal production in different regions of the world, imprinted its influence on the local production of food raw materials, food processing and gastronomy, and thus laid the qualitative and quantitative requirements for this raw material. The requirements are largely linked to different cultural practices and religion (**Mullen *et al.*, 2017).** Cooked and smoked sausages are very popular for consumption in Central Europe, and this also applies to their house-hold production. Pork is most consumed meat in Czech Republic but for many years, pig farmers suffered from low pork meat prices because of regional overproduction and massive competition, so that many farmers were forced to stop production and consequently lost all their pigs (**Havlíček *et al.*, 2020**). On the other hand, people in the countryside traditionally produce this food for themselves and regular household consumption, but the approach is different among the older population compared to the younger generation who have moved from the cities. In recent years, residents of small towns and villages have focused on buying food and therefore also meat products in large retail chains. Along with this, a local production has reduced and a reorientation towards purchasing occurred, because of the low price of food. However, the hobby production of meat products in the Czech Republic is most often associated with the maintenance of family customs, being connected with the domestic slaughter of farmed animals, mostly pigs.

The foodborne pathogens transmission linked to consumption of pork is considered the main source of autochthonous infection (**Montone *et al.*, 2019**). Raw meat is due to its biological and chemical composition prone to rapid colonization by microorganisms. This is further accelerated by some internal factors, such as a suitable pH range and very favourable values of the meat's water activity (above 0.85) (**Halagarda and Wójciak, 2022; Veselá *et al.*, 2022**). Microbiological quality of meat is highly dependent on preslaughter handling of livestock and post slaughter handling of meat. It depends on the employees and their awareness of food safety and compliance with the principles given by the legislation (**Tomasevic *et al.*, 2020**). Meat and meat products may be contaminated with microorganisms from equipment, environment and manufacturing personnel, from fresh meat, spices and other ingredients (**Güngör and Gökoğlu, 2010**). After the *post-mortem* veterinary inspection of slaughter animals, the most significant risk is cross-contamination of the meat during handling. The microflora of fresh meat is composed mainly of mesophilic microorganisms and the total microbial count is in the range from 10^2 to 10^5 CFU/cm^2. Only about 10% of the microorganisms are able to continue to grow after meat chilling (**Sperber and Doyle, 2009**). During meat chilling *Pseudomonas* spp., *Acinetobacter* spp. and *Psychrobacter immobilis* begins to prevail. Their psychotropic character and high affinity for oxygen are the main reason for the dominance on the meat packed in air or oxygen-rich atmosphere and stored under low temperature conditions (**Forsythe and Hayes, 2000**).

Microbial growth can result in slime formation, off odors, and colour changes (**Dave and Ghaly, 2011**). Among the most common bacterial genera causing spoilage of meat and meat products belongs *Pseudomonas, Acinetobacter, Moraxella, Psychrobacter, Aeromonas, Shewanella, Brochothrix, Clostridium, Carnobacterium, Lactobacillus, Leuconostoc* and *Weissella*. Some of the members of the *Enterobacteriaceae* and *Micrococcaceae* families may also be involved in the spoilage of meat and meat products (**de Blackburn, 2006**).

In addition to the microbial spoilage of meat and meat products, the bacteria that cause foodborne illness are of particular concern in terms of health. Every year, serious cases of foodborne illness are reported worldwide. From a microbiological point of view, the most important stages in the production of heat-treated meat products include heat treatment, cooling and slicing. In commercially available smoking machines, the temperature for heat treatment is about 6 to 10 °C higher than the target core temperature. This difference provides a relatively rapid rise in the core temperature, which is important, because the product should pass the range 7 to 55 ° C as quickly as possible, to prevent excessive growth of bacteria (**Feiner, 2006**). Knowing that these heat treatment processes do not destroy bacterial spores, it is necessary to comply with the specific requirements for subsequent cooling, which must be fast. The most important point is to overcome the critical area of 20 to 40 ° C, which may possibly lead to propagation of surviving microorganisms, or germination of bacteria capable of sporulation (**Woods *et al.*, 2019**). Heat-treated meat may be cooled with water or cold air. If a cold water is used, it should be chlorinated and have the quality of drinking water, to prevent recontamination (**Fernandes, 2009**). If case of using water bath, the microbiological risk increases (**Feiner, 2006**). The factor of smoking is important for the microbiological quality of meat products. The study of **Bhuyan *et al.* (2018)** revealed that traditional hot

smoking was better in some selected quality parameters comparing with liquid smoke-treated sausages in terms of lipid oxidation, microbiological safety, and sensory panel ratings. Microbiological findings are interesting but need to be well interpreted. Traditional smoked sausages showed lower CFU counts only after 15 days of storage. However, it is far from reaching the importance of heat treatment and subsequent treatment and handling of meat products according to HACCP principles (**Bhuyan *et al.*, 2018, Duma-Kocan *et al.*, 2020).** Storage time also could significantly ($p < 0.05$) affect TBARS values during sausage storage (**Bedrníček *et al.*, 2020**).

Another important factor influencing safety of meat products is related to hygienic status of fresh meat. Furthermore, it is established that microflora of chilled meat products will depend on whether the product is further processed after the heat treatment. The storage temperature and duration are also important factors. Spoilage of products, which were heat-treated in casings, is usually caused by microorganisms surviving the heat treatment. Spoilage of products that are packed and handled after cooking depends on microbial contamination originating from subsequent handling (**Pérez-Lavalle *et al.*, 2020).** Heat treated meat products can be further sliced and the slices microflora will consist of microorganisms occurring on the device used for cutting. Temperature of cutting room should be about 10 °C, and therefore the prevailing microflora is psychotropic (**Fernandes, 2009**). Hygienic quality is more fundamental than some other quality characteristics, as it is associated with consumer health. The basic pillars in the production of food in the European Union are the principle of food safety and proper food labeling (**Tomasevic *et al.*, 2020**).

The aim of the experiment was to produce sausages and compare individual procedures of hobby manufacturers with a control group. Further to specify which quality parameters have been influenced by different ways of production and evaluate any hygienic risk for consumers.

MATERIAL AND METHODS

Experimental design

The work evaluates the quality of industrially produced and hobby sausages. The control group (C) was produced in Meat Laboratory (Meat Lab MEN), Faculty of AgriSciences, Mendel University of Brno (registered by Veterinary State Authority as a small meat factory, no. CZ22067), the other three in households of hobby manufacturers (HMA, HMB, and HMC). These hobby manufacturers produce sausages repeatedly and at least once a year produce for its own consumption and consumption in the family.

Meat for sausage production processing was delivered from local slaughterhouses (Ivančice) in accordance with Meat Lab MEN documents (for CZ22067). The recipe of all four groups was identical (Table 1), only the place of production and procedures for sausage processing and handling differed. The meat products were made in two batches (a - autumn, w - winter), when the first repetition took place in autumn (November) and second in winter (January).

Preparation of meat and other ingredients for sausage production and its processing

Meat, spices and all other ingredients including pork casings for hobby manufacturers was prepared and weighed in Meat Lab MENDELU, then was marked and delivered as prescribed storage conditions (4°C) in the cooling box directly to hobby manufacturers on the day they realized the experiment. The cooked (70°C, 10 min in core) and smoked sausages were produced in two repetitions according to the quality standard recipe of CZ22067-03 (Myslivecká klobása) with using lean or fat beef and pork, water, salt mixtures (with 0.5% sodium nitrite)**,** commercial spice mixture for hobby manufacturers (MASOPROFIT ltd., EAN: 859 235 561 6545; contain pepper, cumin, garlic, juniper, bay leaf, phosphate E451, antioxidant E316, monosodium glutamate E621), spices (caraway, black pepper, nutmeg, allspice) and aroma (garlic), and pork casings (30/32 mm diameter). All sausages (C, HMA, HMB, and HMC) were made after the process described in individual steps in Table 2.

Table 1 Recipe of the sausage (ingredients used to prepare 100 kg of final meat product)

Ingredient	kg
Lean beef – H2	10.40
Lean pork – V2	26.40
Fat pork – V5	53.20
Water	6.820
Salt mixture	1.760
Spice mixture	1.000
Garlic aroma (liquid)	0.360
Caraway (*Carum carvi*)	0.024
Black pepper (*Piper nigrum*)	0.020
Nutmeg (*Myristica fragrans*)	0.012
Allspice (*Pimenta dioica*)	0.006
Total	**100.0**

Legend: Classification for beef (H1-H5) or pork (V1-V10) according to its fat content, as part of carcass and its determination for a particular group of meat products by Czech Meat Processors Association.

Table 2 Sausage processing

Groups	C	HMA	HMB	HMC
Grinding - device	Meat cutter TMP 23-98	Hand-drive meat grinder	Hand-drive meat grinder	Electric meat grinder
Grinding - particle size	Beef 8 mm Pork 13 mm	Beef 3 mm Pork 18 mm	Beef 3 mm Lean pork 4.5 mm Fat pork 12 mm	Beef 8 mm Pork 12 mm
Method of mixing meat batter	MANCA RC-100	Mixer + hands	Hands	Hands
The time required to grind the meat	10 minutes	20 minutes	15 minutes	15 minutes
The temperature of the meat batter after mixing	5°C	12°C	18°C	15°C
Cooling	No	Yes	No	Yes
The temperature of the meat batter after cooling	4°C	5°C	18°C	6°C
Rest time before filling	No	30 minutes	No	10 hours
Filling	Vacuum filler HTS 95	Hand-drive meat grinder with filling device	Hand-drive meat grinder with filling device	Piston filler
Smoking – device	Chamber smoker with liquid smoke developer	Ceramic grill	Electric smoker	Chamber with a fireplace in a smokehouse
Smoking – kind	Liquid smoke	Beech wood and briquettes	Beech chips of 1-4 mm in size	Beech wood
Final temperature in the smokehouse	80°C	75 to 110°C	72 to 80°C	68 to 80°C
Temperature in the sausage cores	70°C	72°C	67°C	68°C
Smoking time	56 minutes	3 hours 15 minutes	5 hours	2 hours 30 minutes
Cooling in water with ice	Yes, after shower	Yes	Yes	Yes

Legend: C – control group; HMA, HMB, HMC – hobby manufacturers

Sausage analysis

After the production, the sausages were taken in the cooling box (6 °C) to the Mendel University in Brno, where they were analysed in accordance with the procedures in laboratories (**Komprda *et al.*, 2021** Generally available and appropriate methods were used for chemical and sensory analysis (**Jůzl *et al.*, 2018**).

Chemical analysis

The dry matter ($g.100g^{-1}$) (**AOAC, 2005a**), protein content (**AOAC, 2002**), fat content ($g.100g^{-1}$) (**AOAC, 1996**), and the salt content ($g.100g^{-1}$) (**AOAC, 2005b**) were analysed after homogenization of the sample (250 g) for each group in duplicate.

Colour measurement

Colour parameters as lightness L*, and coordinates a*, for green (-a*) to red (+a*), and b*, for blue (-b*) to yellow (+b*), in CIELAB colour space was used to determination differences in colour. The CM 3500d spectrophotometer (Konica Minolta, Japan) was used and the samples were measured (D 65, 6500 °K) on the surface in centre and in the cut of the slices with SCE (Specular Component Excluded) and 8 mm slot in triplicate (3 pairs of measures and from 2 batches for each group). Colour variation was determined as total colour difference ΔE^*_{ab} (**Jůzl *et al.*, 2019).** Colour difference degree ΔE^*_{ab} (CIE1976) is counted due formula and compared with control group **(Saláková et al., 2012).**

Microbiological analysis

The following groups of microorganisms were determined in the samples of the meat and meat batter, in the spice mixture and the final meat product (**Kalhotka *et al.*, 2012**). Total count of microorganisms (TCM; PCA, Biokar diagnostics, France; 30°C/72 hours); psychrotrophic microorganisms (PCA, Biokar diagnostics, France; 6.5°C/240 hours), *E. coli* and other coliform bacteria (Harlequin® E. coli/Coliform Agar, Neogen; 37 °C/24 hours), Enterococci (Slanetz-Bartley Agar; Biokar diagnostics, France; 37°C/48 hours), micromycetes (yeasts and moulds; Chloramphenicol glucose Agar; Biokar diagnostics, France; 25°C/72 to 120 hours), *Bacillus cereus* (PEMBA, Neogen, with Polymixin B and egg yolk suspension; 37°C/24hours, *Staphylococcus aureus* (Baird-Parker RPF Agar; Biokar diagnostics, France; 37°C/24 hours). Presence of *Salmonella* ssp.: the inoculation was carried out in the buffer peptone water (25 g sample up to 225 ml) at 37°C for 18 hours, then 0.5 ml of the sample was inoculated into the selective Rappaport-vassiliadis medium (bio-RAD), incubation was 24 hours at 41.5°C. Subsequently, a 10 µl sample on the Petri bowl with chromogenic soil RAPID *Salmonella* (BIO-RAD), incubation took place 24 hours at 37°C.

Sensory analysis

As part of the experiment, sausages from production C, HMA, HMB, and HMC were evaluated by 10 evaluators (5 men, 5 women). All panellists buy and consume sausages regularly. Selection of evaluators was based on submitted questionnaires received from trained meat products consumers at Department of Food Technology (FA MENDELU). For the sensory analysis the graphical scale of 100 mm (in size with a minimum at point 0 and maximum at point 100) was used. Analysis was chosen as sensory panel with following hedonic descriptors: appearance on surface, colour on surface, appearance on cut, consistency in mouth, juiciness, odour, saltiness, and overall taste. The samples were presented to panellists randomly and marked with the four-digit codes. Water and non-salted bread were used as neutralizers. The evaluation was ongoing under ČSN ISO 6658 (560050) condition (**Jůzl *et al.*, 2019**).

Statistical analysis

The data has been sorted and processed by analysis of variance (ANOVA) and Tukey´s test to compare differences between groups of samples. The data from the chemical analysis, colour measurement, and sensory evaluation by the groups of panelists were processed in STATISTICA 12. The difference between samples were considered significant at 95% confidence level ($p < 0.05$) and the data were tested for normality by the Shapiro-Wilk test.

RESULTS AND DISCUSSION

Physical-chemical quality parameters of sausages

The dry matter, fat, protein, and salt content in different groups of sausages are shown in Table 3. Although all groups used the same ingredients, components of basic chemical analysis differed significantly between groups ($P < 0.05$). This finding suggests that the different procedures in processing sausages had effect on chemical composition. The highest ($P < 0.05$) dry matter content was found in sample HMB (47.33 ± 0.10 %), and the lowest value was in the HMC sausages. This is due to the processing procedures, which differed in the duration of smoking. As the smoking time increased, the water content of the product decreased. This result is also influenced by the storage time (**Aydogan *et al.*, 2019**), and has a direct impact not only on descriptors suitable for sensory assessment, but also on the monetization of food as goods. **Bhuyan *et al.* (2018)** concluded that hot smoked sausages were found to be superior in terms of the prevention of lipid oxidation, microbiological, and sensory indices. The whole process of smoking takes place in three or four phases – coloring, drying, smoking, and cooking. In the meat industry, it is necessary to have equipment where the process regulation is possible and simple where each smokehouse/smoker has control of temperature, time and humidity. In household smoking, this is entirely dependent on the equipment and abilities of the person producing sausages (**Lešić *et al.*, 2020**). Other parameters, like fat, protein, and salt content depended on water content or dry matter in sausages. The legislation allows a variable range for chemical composition and manufacturers must comply with the labelling on the label in conjunction with the authorization. Hobby manufacturers are entirely dependent on adherence to the standard production process (**Jůzl *et al.*, 2018**).

Table 3 Chemical analysis of sausages

Group	Dry matter ($g.100\ g^{-1}$)	Fat ($g.100\ g^{-1}$)	Protein ($g.100\ g^{-1}$)	Salt ($g.100\ g^{-1}$)
C	46.28 ± 0.13b	25.22 ± 0.35b	17.69 ± 0.12a	2.68 ± 0.08c
HMA	46.99 ± 0.25bc	24.80 ± 0.45ab	20.14 ± 0.11c	2.52 ± 0.09c
HMB	47.33 ± 0.10c	25.28 ± 0.30b	19.95 ± 0.15c	2.32 ± 0.06b
HMC	43.79 ± 0.23a	23.93 ± 0.25a	18.65 ± 0.17b	2.19 ± 0.05a

Legend: C – control group; HMA, HMB, HMC – hobby manufacturers; a, b, c – letters in column show statistically significant difference between groups ($P < 0.05$)

Colour measurement is an instrumental method suitable to food samples evaluation. Scientists use color measurements as a supplement for sensory evaluation. It is particularly important for a large number of samples or in longer time intervals between sensory evaluation sessions (**Saláková *et al.*, 2012**). Colour analysis is important for feedback for producer and for meat product sale. A meat product that shows a different appearance or color than expected in consumers is unmarketable (**Jůzl *et al.*, 2019**). The color of a final meat product largely influences consumer preferences and is the main aspect of the product quality, so that a product may be rejected simply because of its color even before other properties are evaluated. As a quality parameter, color has been widely studied especially in fresh meat and cooked products (**Lešić *et al.*, 2020; Saleh *et al.*, 2017**). The colour results obtained in experiment are in Table 4 and Table 5. Consumers evaluate the surface of the sausage, especially when they buy it, and compare the quality parameters with their ideas of the standard. The appearance of the sausage when sliced is important for consumption at home. For hobby producers, these two characteristics are essential. The surface is controlled by them during smoking and at the end of production as cross-section cut check. It should be noted that sausages can be consumed as cold serving without further heating and slicing on a plate.

Table 4 Colour parameters measured on the surface of sausages

Group	L* (D65)	a* (D65)	b* (D65)	C* (D65)	h^0 (D65)	ΔE^*_{ab} (CIE1976)
C	43.77 ± 0.63b	16.57 ± 0.62b	22.40 ± 0,58b	27.88 ± 0.63bc	53.52 ± 1.20a	0
HMA	43.34 ± 1.08b	16.67 ± 0.58b	22.87 ± 0.59b	28.34 ± 0.46c	53.89 ± 1.40a	0.64
HMB	38.95 ± 0.53a	11.93 ± 0.53a	16.74 ± 0.33a	20.58 ± 0.35a	55.46 ± 1.44b	8.76**
HMC	46.49 ± 1.19c	14.99 ± 0.85b	21.72 ± 0.78b	26,42 ± 0.97b	55.46 ± 1.34b	3.22*

Legend: C – control group; HMA, HMB, HMC – hobby manufacturers; a, b, c – letters in column show statistically significant difference between groups ($P < 0.05$); *,** - indicates the degree of colour difference ΔE^*_{ab} (CIE1976) compared with control group (**Saláková *et al.*, 2012**).

The highest difference to control group in color on the surface of sausages ($P < 0.05$) was observed in the HMB group (Table 4). This is due to its longer smoking time, which was also reflected in the dry matter content (Table 3). This corresponds to the general results that lightness also decreases on the surface of the product with water content in the product (**Ali *et al.*, 2018**).

Table 5 Colour parameters measured on sausages cut

Group	L* (D65)	a* (D65)	b* (D65)	C* (D65)	h^0 (D65)	ΔE^*_{ab} (CIE1976)
C	56.86 ± 1.64ab	7.16 ± 0.72a	10.75 ± 0.25a	12.98 ± 0.50a	56.71 ± 2,54b	0
HMA	57.12 ± 1.28b	9.03 ± 0.55b	12.40 ± 0.31b	15.37 ± 0.41b	54.07 ± 1.79ab	2.51
HMB	59.56 ± 1.86b	7.97 ± 0.82a	11.39 ± 0.29a	13.96 ± 0.66a	55.53 ± 2.35ab	2.90
HMC	54.65 ± 1.31a	8.62 ± 0.48b	11.28 ± 0.20a	14.22 ± 0.38ab	52.78 ± 1.46a	2.70

Legend: C – control group; HMA, HMB, HMC – hobby manufacturers; a, b, c – letters in column show statistically significant difference between groups ($P < 0.05$);

The above-mentioned findings are not applicable to the color on the cross-cut. In Table 5, the results for the colour of the sausage on the cut surface are more similar between the groups (HMA, HMB and HMC) and do not differ as much as for the colour of the sausage surface.

Microbiological quality of sausages

The results of microbiological analysis of sausages are presented in Table 6 and Table 7. The results of the microbiological analysis of production meat (see Table 6 and Table 7) confirm that raw meat is an important source of microorganisms. Total counts of microorganisms (TCM) ranged from 5.421 to 6.4362 log CFU.g^{-1}. The numbers of psychrotrophic microorganisms also corresponded to these values. *E. coli* was detected only in beef, other coliform bacteria were found in all meat samples in relatively low numbers. Micromycetes counts were in the range from 3.58 to 4.21 log CFU.g^{-1} and were also detected in meat samples. *Bacillus cereus* was not detected in the corresponding dilution of the samples, which, however, did not mean its absence with regard to the dilution. However, *S. aureus* was detected in the meat samples in the order of thousands of CFU.g^{-1}. The presence of *Salmonella* has not been found in selected meat samples. Similarly, other analyzes have confirmed that the spice mixture is also a significant vector of microorganisms when the spice mixtures were found an average TCM value of 4.72 log CFU.g^{-1}. However, up to several times higher TCM log number (7.61 log CFU.g^{-1} of spices for Frankfurt sausages was found by **Güngör and Gökoğlu (2010)**. In our experiment, other coliform bacteria, enterococci, psychrotrophic microorganisms, micromycetes and *S. aureus* were found in relatively low numbers. The presence of *B. cereus* was not confirmed, but in small quantities their occurrence is probable. *E. coli*, nor *Salmonella* were not detected. Similar results for *E. coli*, with *S. aureus* and micromycetes were recorded by **Güngör and Gökoğlu (2010)**.

The numbers of microorganisms determined in the raw materials used are reflected in the number of microorganisms in the meat batter produced (Table 6 and Table 7), where TCM increased up to 7.68 log CFU.g^{-1} in some samples. *Salmonella* was not detected. The results of the microbiological analysis of finished products (see Table 6) from different manufacturers confirm the generally valid principle that sufficient heat treatment (min. 70 ° C, 10 min. In the product core) leads to the death of most contaminating microbiota. The presence of *Salmonella* has not been proven, *S. aureus* and *B. cereus* were found only in low numbers. The absence of pathogenic microorganisms *Salmonella* and *S. aureus* in heat treated meat products is confirmed by the results of the **Pexara *et al.* (2002)** and **Migowska-Calik *et al.* (2014)**. Even so, these representatives of microorganisms remain, together with Listeria monocytogenes, the biggest threats to food safety meat products (**Cabedo *et al.*, 2008**; **Roccato *et al.*, 2015**).

This is evidenced by the absence of *E. coli* and other coliform bacteria, while the presence of salmonella has not again been detected and, with some exceptions, low number of microorganisms within other monitored groups. Of these, the highest numbers were found for TCM, which achieved hundreds of CFU.g^{-1} for most products. Similar values in the initial phase of the experiment were also recorded by **Pexara *et al.* (2002)** or **Migowska-Calik *et al.* (2014)** in Polish traditional cooked smoked meat products, confirming a significant scattering of TCM values, both among the types of meat products and within one type of product. The values below the detection limit of TMC and micromycetes and their relatively low numbers even after 15 days of storage are reported by **Bhuyan *et al.* (2018).** View of the efficiency of the heat treatment in the above -mentioned microorganism groups of secondary contamination in handling the finished product. This also corresponds to the findings of **Güngör and Gökoğlu (2010).** These microorganisms may then be the cause of the spoil of these products when storage. Pre-salting meat can also provide a certain positive effect on food safety. The using of protective microbial cultures and combined with spice mixtures can also play a positive role (**Kročko *et al.* 2019).**

Table 6 Microbiological analysis findings

Sample	Sample description, group	TCM	*E. coli*	Other coliform	Enterococci	Psychrotrophic
		log CFU.g^{-1}	log CFU.g^{-1}	log CFU.g^{-1}	log CFU.g^{-1}	log CFU.g^{-1}
meat	beef H2, autumn	5.42	1.61	2.48	2.60	5.41
	beef H2, winter	6.31	0.40	2.14	1.53	6.40
	pork V2, autumn	6.26	ND in 10^{-1}	3.45	3.06	6.06
	pork V2, winter	6.44	ND in 10^{-1}	2.66	1.85	6.67
	pork V5, autumn	6.23	ND in 10^{-1}	4.16	2.83	6.13
	pork V5, winter	6.36	ND in 10^{-1}	2.65	1.76	6.34
spice mixture	spice mixture, autumn	4.74	ND in 10^{-1}	0.70	1.40	ND in 10^{-1}
	spice mixture, winter	4.70	ND in 10^{-1}	ND in 10^{-1}	ND in 10^{-1}	3.00
meat batter	C - meat batter, autumn	6.70	0.70	3.04	2.84	6.35
	C - meat batter, winter	7.07	0.48	3.19	2.25	7.19
	HMA - meat batter, autumn	6.00	1.00	3.45	2.71	5.99
	HMA - meat batter, winter	7.07	1.18	3.69	3.19	7.31
	HMB - meat batter, autumn	7.68	1.51	3.77	2.79	7.29
	HMB - meat batter, winter	5.97	0.70	3.38	2.56	5.92
	HMC - meat batter, autumn	7.68	1.00	3.56	2.53	7.40
	HMC - meat batter, winter	7.68	1.00	3.56	2.53	7.40
sausages	C - sausages, autumn	ND in 10^{-3}	ND in 10^{-1}	ND in 10^{-1}	0.40	ND in 10^{-1}
	C - sausages, winter	ND in 10^{-3}	ND in 10^{-1}	ND in 10^{-1}	0.40	ND in 10^{-1}
	HMA - sausages, autumn	2.24	ND in 10^{-1}	ND in 10^{-1}	ND in 10^{-1}	ND in 10^{-1}
	HMA - sausages, winter	ND in 10^{-3}	ND in 10^{-1}	ND in 10^{-1}	0.40	2.40
	HMB - sausages, autumn	2.67	ND in 10^{-1}	ND in 10^{-1}	0.70	2.96
	HMB - sausages, winter	ND in 10^{-3}	ND in 10^{-1}	ND in 10^{-1}	1.24	2.40
	HMC - sausages, autumn	2.37	ND in 10^{-1}	ND in 10^{-1}	ND in 10^{-1}	1.30
	HMC - sausages, winter	2.75	ND in 10^{-1}	ND in 10^{-1}	0.90	0.70

Legend: TCM – Total count of microorganisms, ND – not detected, C – control group; HMA, HMB, HMC – hobby manufacturers

Table 7 Microbiological analysis findings (continuation)

Sample	Sample description, group	Micromycetes	*Bacillus cereus*	*Staphylococcus aureus*	*Staphylococcus aureus*
		log CFU.g^{-1}	log CFU.g^{-1}	log CFU.g^{-1}	log CFU.g^{-1}
meat	beef H2, autumn	3.58	ND in 10^{-2}	3.27	ND
	beef H2, winter	3.48	ND	ND in 10^{-1}	ND
	pork V2, autumn	4.16	ND in 10^{-2}	3.65	ND
	pork V2, winter	4.00	ND	ND in 10^{-1}	ND
	pork V5, autumn	4.21	ND in 10^{-2}	3.73	ND
	pork V5, winter	3.98	ND	ND in 10^{-1}	ND
spice mixture	spice mixture, autumn	2.26	ND in 10^{-2}	1.30	ND
	spice mixture, winter	2.37	ND in 10^{-1}	ND in 10^{-1}	ND
meat batter	C - meat batter, autumn	4.48	ND in 10^{-2}	3.58	ND
	C - meat batter, winter	4.60	1.83	ND in 10^{-1}	ND
	HMA - meat batter, autumn	4.08	1.18	2.45	ND
	HMA - meat batter, winter	4.48	ND	ND in 10^{-1}	ND
	HMB - meat batter, autumn	4.31	1.00	ND in 10^{-1}	ND
	HMB - meat batter, winter	3.95	1.15	2.57	ND
	HMC - meat batter, autumn	5.47	ND	ND in 10^{-1}	ND
	HMC - meat batter, winter	5.47	ND	ND in 10^{-1}	ND
sausages	C - sausages, autumn	ND in 10^{-1}	1.60	ND in 10^{-1}	ND
	C - sausages, winter	ND in 10^{-1}	1.60	ND in 10^{-1}	ND
	HMA - sausages, autumn	0.95	ND in 10^{-2}	ND in 10^{-1}	ND
	HMA - sausages, winter	1.08	0.70	ND in 10^{-1}	ND
	HMB - sausages, autumn	1,26	0.70	1.70	ND
	HMB - sausages, winter	ND in 10^{-1}	1.30	ND in 10^{-1}	ND
	HMC - sausages, autumn	ND in 10^{-1}	0.70	1.78	ND
	HMC - sausages, winter	ND in 10^{-1}	1.26	ND in 10^{-1}	ND

Sensory evaluation of sausages

Sensory evaluation of meat product (sausages) was carried out at the end of storage period, on 21st day after being produced (according to documents CZ22067) and the results are presented as Figure 1. Within the sensory evaluation, there was no statistically significant difference in any descriptor ($P > 0.05$). The evaluators evaluated all the submitted sausages similarly. The sausages were rated above average by all groups in the hedonic descriptors (over 80% on average). The control group achieved better results in overall taste compared to other groups. For sensory evaluation of meat products experiments, it is important that they are not assessed worse than the control group (**Jurčaga *et al.*, 2022**). From this point of view, it can be concluded that the process of home-made sausage production did not affect the final quality of the product.

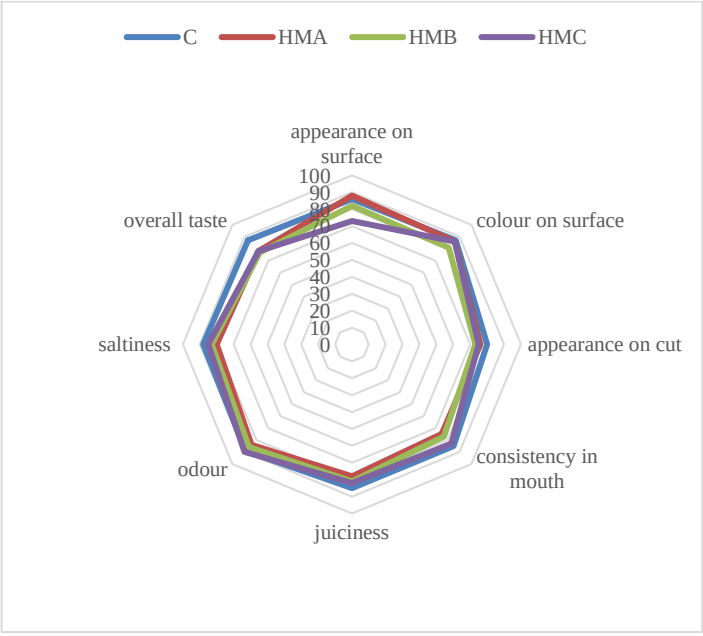

Figure 1 Sensory scores of control and experimental groups
C – control group; HMA, HMB, HMC – hobby manufacturers

CONCLUSION

The dry matter and salt content in sausages correlated with the losses during smoking. The microbiological analysis of sausages showed that the difference in total count of microorganisms was not high between hobby production and registered production mode. This means, that domestic conditions in hobby productions are able to create as sufficiently hygienic as in the case of a registered production. Considering microbiological quality of the final products, it was found that heat processing was sufficient in all cases. In the sensory evaluation and comparison of the control group with the others, there was no statistically significant difference between the sausage groups and the products were rated similarly. It can be stated that domestic production can achieve a similar level of quality as in industrial conditions. However, caution in production, proper hygiene and sufficient heat treatment are required.

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