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DEVELOPMENT OF TECHNOLOGY FOR THE PRODUCTION OF COOKED-SMOKED POULTRY PRODUCTS IN SMALL ENTERPRISES

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Annotation. Smoked meat production is a profitable business, and the question arises of choosing a technology that will allow you to produce quality products. Nowadays, many manufacturers are returning to the classic smoking technology and positioning their products as a traditional item. However, they do not avoid mistakes, because the smoking technology is simple and unpretentious only at first glance. This is especially true for small businesses, which sometimes neglect to comply with the technology and, as a result, the quality of the final product deteriorates. The article highlights the urgent issue of developing an optimal technology for the production of cooked and smoked poultry products in small enterprises. The aim of the work was to establish the optimal parameters of the technology for the production of boiled and smoked chicken products (wings, drumsticks and thighs) in small enterprises using mini equipment. Experimental studies were conducted using chilled meat raw materials using the «ANUKA» mini-smoker. 3 groups of products were formed, at the first stage, group 1 was cooked at 100°C for 10 minutes, group 2-20 minutes, group 3-30 minutes. Then the raw materials were cooled to 20 ^{0}C. At the second stage, each group was divided into three subgroups A, B, C. Products from each subgroup were smoked hot (100 ^{0}C), subgroup A for 20 minutes, subgroup B for 30 minutes, and subgroup C for 40 minutes. Quality studies were conducted on the following indicators: product yield, mass fraction of salt, readiness for consumption, appearance, external damage and color, consistency, taste and odor. It was found that the yield of smoked meats was within the normal range and amounted to: wings – 80.2-82.9%, drumsticks – 76.0-78.5%, thighs – 74.9-77.7%, regardless of the processing mode. Organoleptic evaluation showed that the total highest score was for products of group 2, subgroup B. They had the maximum score for all indicators. The products of group 3, subgroup A were slightly inferior to them. That is, the optimal time for cooking is 50 minutes. It was found that the products of all groups, which were smoked for 40 minutes, had a slight bitter taste. It was noted that the products of the 3rd group of subgroup C were too dry, and the 1st groups of subgroups A and B were slightly damp and watery, sometimes with a pinkish tint, indicating insufficient heat treatment. There were no significant differences in salt content, and its percentage was at the level of 1.98-2.11%. Therefore, for the production of cooked smoked chicken products in small processing enterprises, the optimal heat treatment would be the following: 20 minutes of cooking and 30 minutes of smoking. This allows to obtain products with high organoleptic characteristics, pleasant presentation and the highest possible yield of the finished product, and smoking for 40 minutes is unacceptable as it significantly worsens the taste of the products.

Key words: *smoking, meat products, chicken, organoleptic characteristics, quality characteristics.*

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ВІДПРАЦЮВАННЯ ТЕХНОЛОГІЇ ВИГОТОВЛЕННЯ ВАРЕНО-КОПЧЕНОЇ ПРОДУКЦІЇ ПТАХІВНИЦТВА В УМОВАХ НЕВЕЛИКИХ ПІДПРИЄМСТВ

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Анотація. Виробництво копченостей це прибутковий бізнес і виникає питання вибору технології, яка дозволить отримувати якісні продукти. Зараз багато виробників повертаються до класичної технології копчення і позиціонують свою продукцію як традиційний продукт. Однак вони не уникають помилок, бо технологія копчення лише на перший погляд проста і невибаглива. Особливо це актуально для невеликих підприємств, які іноді нехтують дотриманням технології і як слідство погіршується якість кінцевого виробу. В статті висвітлюється актуальне питання відпрацювання оптимальної технології виготовлення варено-копченої продукції з м'яса птиці в умовах невеликих підприємств. Метою роботи було встановлення оптимальних параметрів технології виготовлення варено-копченої продукції з курятини (крильця, гомілки та стегенця) в умовах невеликих підприємств с застосуванням міні обладнання. Експериментальні дослідження проводилось з використанням охолодженої м'ясної сировини за допомогою міні-коптильні «ANUKA». Було сформовано 3 групи виробів, на І етапі 1 група варилась при 100°С 10 хв, 2 група – 20 хв., 3 група – 30 хв. Потім сировина охолоджувалась до 20°С. На ІІ етапі кожна група була поділена на три підгрупи А, В, С. Продукти з кожної підгрупи коптились гарячим способом (100°С), підгрупа А протягом 20 хв., підгрупа В протягом 30 хв., а підгрупа С протягом 40 хв. Дослідження якості проводились за такими показниками: вихід продукту, масова частка солі, готовність до споживання, зовнішній вигляд, зовнішні пошкодження та колір, консистенція, смак та запах. Було встановлено, вихід продукту знаходився в межах норми і становив: крильця – 80,2-82,9 %, гомілки – 76,0-78,5%, стегенця – 74,9-77,7 % не залежно від режиму обробки. Органолептична оцінка показала, що сумарна найвища оцінка була у продуктів 2 групи, підгрупи В. Вони за всіма показниками мали максимальну оцінку. Їм трохи поступаються вироби 3 групи підгрупи А. Тобто оптимальним часом для приготування є час 50 хв. Встановлено, що вироби усіх груп, які коптилися 40 хв. мали легкий гіркуватий присмак. Відмічено, що вироби 3 групи підгрупи С були занадто сухими, а 1 групи підгруп А та В були трохи сируватими та водянистими, іноді з рожевим відтінком, що свідчить про недостатність термічної обробки. За вмістом солі суттєвих відмінностей не становлено, а її відсоток був на рівні 1,98-2,11 %. Отже для виробництва варено-копчених курячих виробів в умовах невеликих переробних підприємств оптимальним буде застосовування термічної обробки у наступному режимі: 20 хв. варіння та 30 хв. копчення. Це дозволяє отримати продукти з високими органолептичними показниками приємним товарним виглядом та максимально високим виходом готового продукту, а копчення на протязі 40 хв. є неприпустимим так як суттєво погіршує смак продуктів.

Ключові слова: *копчення, м'ясні продукти, курятина, органолептичні показники, якісні характеристики.*

Introduction. Historically, smoking food has been a part of humanity's life for many centuries. Drying salted foods and then smoking them is a long-standing human tradition on all continents. This is how people diversified the taste of food and extended its shelf life. Modern people, despite the diversity of their diet, often eat smoked products because they have their own special, unique taste (Lautenschlaeger, 2017; Fraqueza et al., 2020; Yin et al., 2021). Recently, however, the issue of the safety of smoked products has become a very popular topic of discussion between supporters and opponents of smoking (McDonald & Flavor, 2015; Lautenschlaeger,

2017; Afé et al., 2021). In this matter, first of all, attention should be paid to the technology of product manufacturing, because it is its violation or imperfection that leads to low-quality and sometimes harmful to human health smoked products (Lautenschlaeger, 2017; Gómez et al., 2020). Of course, smoked products cannot be classified as dietary foods, but moderate consumption of a well-made delicacy is not harmful to health (Tsutsumi et al., 2020; Starski et al., 2021; Bulanda & Janoszka, 2022). One of the most common is smoked chicken, and chicken meat is one of the most common food products around the world and is used by almost all peoples and cultures. Chicken meat is characterized by a fairly high protein content and low-fat content, which in turn does not contain trans fats (Ismail & Joo, 2017). To create a high-quality food product, it is very important to set the most optimal processing parameters, which will minimize all the shortcomings that may arise during production and obtain a high-quality final product.

Relevance of the topic. The production of smoked products, both in Ukraine and abroad, is a fairly profitable business and its production does not decrease from year to year. Large enterprises and small private meat, milk, and fish processing shops are increasingly including smoked products in their product line (Lautenschlaeger, 2017; Popova et al., 2020; Iko Afé et al., 2021). However, the question of choosing the optimal technology often arises. It is known that there are several types of smoking, depending on the temperature regime and the method of preparing the product directly for smoking (salting, drying, baking, cooking, cooling, etc.). It is the observance of certain technological parameters that allows to obtain products of high quality in terms of taste that do not contain excessive amounts of harmful substances (Yang et al., 2019; Afé et al., 2021; Nizio et al., 2023). Of course, the quality of the finished product is also affected by the type of wood used during smoking (Prudnikov et al., 2013; Hokkanen et al., 2018; Malarut & Vangnai, 2018). The use of certain types of wood in combination with various technological methods allows to obtain safe products with high taste properties (Min et al., 2018; Škaljac et al., 2018; Puljić et al., 2019). This is especially relevant and important for small private enterprises that have rather simple non-industrial equipment and sometimes do not have professional technologists on their staff. Unfortunately, a certain number of small enterprises during smoking, in pursuit of the amount of product output, process speed and economic super-profits, neglect compliance with the technology and, as a result, the quality of the final product deteriorates (Malarut & Vangnai, 2018; Akakpo et al., 2020; Halagarda & Wójciak, 2022). It should be noted that recently, more and more private producers have begun to return to the traditional classical smoking technology and position their products on the market as natural, authentic (craft) and traditional products. Unfortunately, such producers do not always avoid mistakes, because the technology of smoking meat is very simple and unpretentious at first glance. Therefore, the issue of developing the most optimal technology for the production of artificial cooked and smoked poultry products in small enterprises is a very relevant and interesting issue.

Analysis of the latest research and publications. Many scientific papers in many countries have been devoted to the production of smoked poultry products. This includes both industrial technologies for manufacturing the product and the study of small-scale production (Adomeh, 2018; Akakpo et al., 2020; Cho & Choi, 2021; Murthy et al., 2021; Zhang et al., 2022; Ellsworth et al., 2023). In addition, a lot of information is now available on the Internet that highlights the experience of certain private owners who smoke the product at home using artisanal equipment. Sometimes they give radically opposite recommendations that do not help to master the technology, but are frankly confusing and harmful. Unfortunately, there are also not enough recommendations from scientists on the optimal technology for the production of cooked-smoked poultry products in small enterprises.

Aim of the study. The aim of the study was to establish experimentally the optimal parameters of the technology for the production of cooked-smoked poultry products (wings, drumsticks and thighs) in small enterprises using mini-equipment.

Objectives of the study. To determine the quality of cooked-smoked products made from broiler chicken meat (wings, drumsticks and thighs) produced under different heat treatment regimes.

Material and methods of research. Experimental studies were conducted in the laboratory of the Department of Processing Technology and Quality of Livestock Products of the State Biotechnological University and in the laboratories of private processing enterprises. The production of cooked smoked products (wings, drumsticks and thighs) was carried out using chilled meat raw materials using the ANUKA smoker, manufactured in New Zealand.

All experimental samples of chicken meat were grouped by weight: wings 128-145 g (136.43±0.8); drumsticks 139-155 g (146.93±0.9); thighs 188-204 g (196.96±0.8). Three groups were formed, each group included 30 wings, 30 drumsticks and 30 thighs. At the first stage of the experiment, group 1 was cooked for 10 minutes, group 2 - 20 minutes, group 3 - 30 minutes. Cooking was carried out in open water, the temperature at the time of loading the raw materials was 100°C. After cooking, the raw materials were cooled to a temperature of 20°C. At the second stage of the study, each group was divided into three subgroups A, B, C with 10 wings, 10 drumsticks and 10 thighs in each. The products from each group were smoked hot (100°C): subgroup A for 20 minutes, subgroup B for 30 minutes, and subgroup C for 40 minutes. The general scheme of the study is shown in Fig. 1.

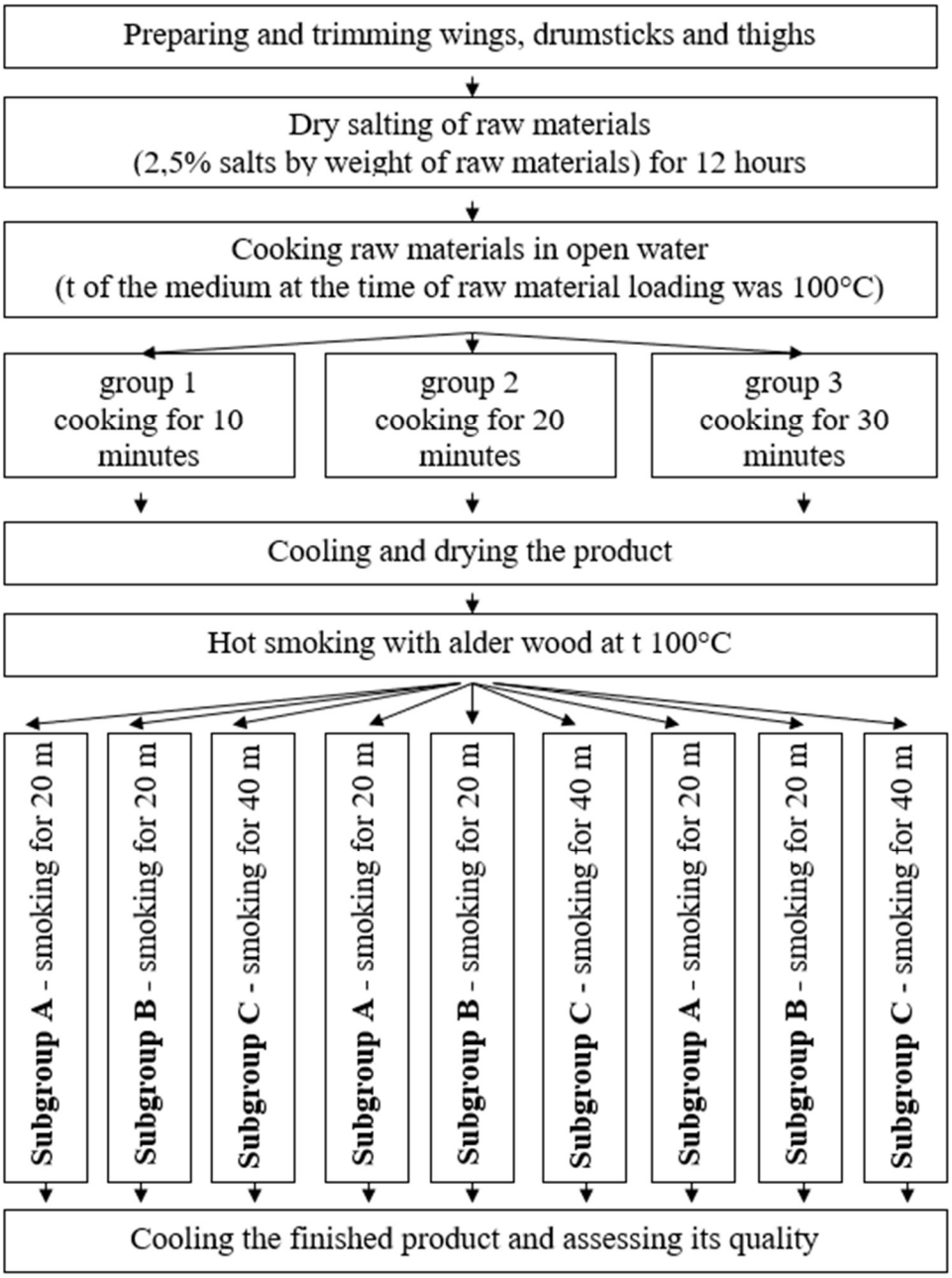

Fig. 1. **Technology of experimental production of boiled and smoked products.**

The quality of the finished product was evaluated according to the following indicators: product yield, mass fraction of salt, product readiness for consumption, appearance, external damage and color, consistency, taste and smell (tasting assessment was performed on a 9-point scale).

Research results and discussion. Smoked chicken delicacies are among the most popular types of poultry products. The assortment of smoked chicken products includes many groups: hot and cold smoked, raw-smoked, boiled-smoked, baked-smoked, etc. (Yang, et al., 2019; Yin, et al., 2021).

In the study, the production of cooked smoked chicken products consisted of the following operations: preparation and cleaning of chicken, dry salting (12 hours), cooking (time, according to the scheme), cooling and drying (2 hours), placing in a smoker, smoking at 100 ^{0}C (time, according to the scheme), cooling to 20°C and evaluation of the quality of the finished product. The profitability of any production depends on the yield of the finished product, so we studied these indicators (Table 1).

As can be seen from Table 1, the yield of smoked products is within the normal range and is: wings – 80.2-82.9%, drumsticks – 76.0-78.5%, thighs – 74.9-77.7%. In the comparison of products by thermal time, the lowest indicators were for products from Group 3, and the highest were for Group 1.

Of course, the yield of the product is important from an economic point of view, but the main indicator of quality is its organoleptic evaluation. We investigated the quality of the finished product according to the following indicators: product readiness for consumption, appearance and damage, color, consistency, taste and smell (tasting assessment was conducted on a 9-point scale). The data are shown in Table 2

According to Table 2, the products of group 2, subgroup B, had the highest total score. They had the maximum score for all indicators. The products of group 3, subgroup A are slightly inferior to them. That is, it can be stated that the optimal time for cooking boiled and smoked chicken products is 50 minutes.

Table 1.

Yield of the finished product

Group	Subgroup	Product type	Weight before processing	Weight of the final product	Finished product yield, %
1 cooking for 10 min	**A** smoking for 20 min	wings	136,0±1.6	112.7±1.6	82.9
		drumsticks	145,9±1.6	114.5±1.5	78.5
		thighs	198.7±2.9	154.4±2.7	77.7
	B smoking for 30 min	wings	136.5±1.7	112.6±1.6	82.5
		drumsticks	146.5±1.6	114.7±1.4	78.3
		thighs	199.1±2.9	153.9±2.7	77.3
	C smoking for 40 min	wings	138.0±1.7	113.4±1.5	82.2
		drumsticks	147.3±1.6	114.7±1.6	77.9
		thighs	196.2±1.4	151.1±1.5	77.0
2 cooking for 20 min	**A** smoking for 20 min	wings	136.1±0.9	111.3±1.1	81.8
		drumsticks	148.1±1.7	115.2±1.4	77.8
		thighs	196.6±0.9	150.4±1.0	76.5
	B smoking for 30 min	wings	137.2±1.5	112.1±1.3	81.7
		drumsticks	146.8±1.7	113.9±1.6	77.6
		thighs	198.8±2.5	151.8±2.1	76.4
	C smoking for 40 min	wings	138.4±1.8	112.7±1.7	81.4
		drumsticks	147.3±1.6	113.8±1.6	77.3
		thighs	196.8±1.3	149.8±1.3	76.1

3 cooking for 30 min	**A** smoking for 20 min	wings	136.8±1.4	111.5±1.3	81.5
		drumsticks	147.5±1.5	112.3±1.3	77.2
		thighs	196.1±1.6	149.2±1.6	76.1
	B smoking for 30 min	wings	139.4±1.4	112.9±1.2	81.0
		drumsticks	146.8±1.5	112.4±1.6	76.6
		thighs	197.5±1.5	149.1±1.4	75.5
	C smoking for 40 min	wings	137.8±1.6	110.5±1.7	80.2
		drumsticks	148.3±1.2	112.7±1.1	76.0
		thighs	196.6±1.7	147.2±1.6	74.9

The tasters noted that products of all groups that were smoked for 40 minutes had a slightly noticeable unpleasant bitter taste, which is unacceptable for production. It was also noted that the products of the 3rd group of subgroup C were too dry, and the 1st group of subgroups A and B were slightly damp and watery, sometimes with a pinkish tint, indicating insufficient time for heat treatment.

Table 2.

Organoleptic evaluation of the quality of the finished product

Group	Subgroup	Product type	Appearance	Product readiness for consumption	Smell	Taste	Consistency	Juiciness	Overall score
1 cooking for 10 min	**A** smoking for 20 min	wings	7.3	7.5	8.3	7.1	6.8	7.7	44.7
		drumsticks	7.4	7.3	8.4	7.0	6.7	7.8	44.6
		thighs	7.6	7.1	8.2	6.9	6.7	7.8	44.3
	B smoking for 30 min	wings	8.2	8.7	8.7	8.5	7.7	8.4	50.2
		drumsticks	8.2	8.6	8.7	8.5	7.7	8.3	50.0
		thighs	8.3	8.5	8.6	8.4	7.7	8.3	49.8
	C smoking for 40 min	wings	7.5	9.0	8.7	7.5	8.0	8.5	49.2
		drumsticks	7.5	9.0	8.7	7.5	7.9	8.5	49.1
		thighs	7.7	9.0	8.7	7.5	7.8	8.5	49.2
2 cooking for 20 min	**A** smoking for 20 min	wings	8.5	9.0	8.8	8.9	8.9	9.0	53.1
		drumsticks	8.5	9.0	8.8	8.9	8.9	9.0	53.1
		thighs	8.5	9.0	8.7	9.0	8.9	9.0	53.1
	B smoking for 30 min	wings	9.0	9.0	9.0	9.0	9.0	9.0	54.0
		drumsticks	9.0	9.0	8.9	9.0	9.0	9.0	54.0
		thighs	9.0	9.0	9.0	9.0	9.0	9.0	54.0
	C smoking for 40 min	wings	7.5	9.0	9.0	8.0	9.0	8.6	51.1
		drumsticks	7.5	9.0	9.0	8.1	9.0	8.6	51.2
		thighs	7.6	9.0	9.0	8.1	9.0	8.7	51.4
3 cooking for 30 min	**A** smoking for 20 min	wings	8.8	9.0	8.9	9.0	9.0	9.0	53.7
		drumsticks	8.8	9.0	8.9	9.0	9.0	9.0	53.7
		thighs	8.8	9.0	8.8	9.0	9.0	9.0	53.6
	B smoking for 30 min	wings	8.9	9.0	9.0	9.0	8.7	8.7	53.3
		drumsticks	9.0	9.0	9.0	9.0	8.7	8.7	53.4
		thighs	8.8	9.0	9.0	9.0	8.7	8.8	53.3
	C smoking for 40 min	wings	7.5	9.0	8.8	7.4	8.5	7.8	49.0
		drumsticks	7.5	9.0	8.9	7.5	8.6	7.8	49.3
		thighs	7.5	9.0	8.9	7.6	8.6	7.8	49.4

The appearance of the products also had some differences in color saturation. The most pleasant in appearance were those that had been smoked for 30 minutes (Figs. 2, 3, 4). They had a moderately pleasant color and good presentation.

Fig. 2. **Cooked-smoked products, group 1, subgroup B.**

Fig. 3. **Cooked-smoked products, group 2, subgroup B.**

Fig. 4. **Cooked-smoked products, group 3, subgroup B.**

During hot smoking, the product actively loses moisture and the salt concentration in the product increases. As part of the study, we analyzed the salt content and found that its concentration was within the normal range and amounted to 1.98-2.11%. The least salty were the products of Group 1, subgroup A, and the highest salt concentration was in the products of Group 3, subgroup C, but the difference was not significant.

Thus, for the production of cooked smoked chicken products from chicken carcass parts on low-capacity equipment in small processing enterprises, the use of heat treatment in the following mode will be optimal: 20 minutes of cooking and 30 minutes of smoking. This allows to obtain products with high organoleptic characteristics, pleasant presentation and the highest possible yield of the finished product.

Conclusion

1. For the production of cooked-smoked chicken products (wings, shaved and thighs) in small meat processing enterprises using mini-equipment, it is advisable to use the following heat treatment parameters: cooking the product for 20 minutes in open water or steaming at 100 °C, followed by smoking at 100 °C for 30 minutes. These parameters allow to obtain products of high consumer quality and with the highest possible yield of the finished product.

2. Smoking of cooked-smoked chicken products for 40 minutes (regardless of the time of preliminary cooking) leads to a defect such as a bitter taste, which is unacceptable in a quality product.

References

1. Adomeh, E. E. (2018). Influence of Drum Kiln Models on Meat Quality Evaluation of Smoked Chicken Thighs. *Asian Food Science Journal*, 2(3), 1–6. https://doi.org/10.9734/AFSJ/2018/41104

2. Afé, O. H. I., Kpoclou, Y. E., Douny, C., Anihouvi, V. B., Igout, A., Mahillon, J., Hounhouigan, D. J., & Scippo, M. (2021). Chemical hazards in smoked meat and fish. *Food Science & Nutrition*, 9(12), 6903–6922. https://doi.org/10.1002/fsn3.2633

3. Akakpo, A., Edikou, S., Diantom, A., & Osseyi, E. (2020). Diagnostique des pratiques de fumage de la viande de poulet (Gallus gallus) dans la ville de Lome au Togo. *African Journal of Food, Agriculture, Nutrition and Development*, 20(06), 16738–16760. https://doi.org/10.18697/ajfand.94.19230

4. Akakpo, A., Spéro, E. K., Diantom, A., Hanvi, D. M., & Osseyi, G. E. (2020). Quality characteristics of artisanal smoked chicken meat sold in street food in Togo. *Journal of Culinary Science & Technology*, 20(5), 389–408. https://doi.org/10.1080/15428052.2020.1848684

5. Bulanda, S., & Janoszka, B. (2022). Consumption of Thermally Processed Meat Containing Carcinogenic Compounds (Polycyclic Aromatic Hydrocarbons and Heterocyclic Aromatic Amines) versus a Risk of Some Cancers in Humans and the Possibility of Reducing Their Formation by Natural Food Additives—A Literature Review. *International Journal of Environmental Research and Public Health/International Journal of Environmental Research and Public Health*, 19(8), 4781. https://doi.org/10.3390/ijerph19084781

6. Cho, W., & Choi, J. (2021). Sensory quality evaluation of superheated steam-treated chicken leg and breast meats with a combination of marination and hot smoking. *Foods*, 10(8), 1924. https://doi.org/10.3390/foods10081924

7. Ellsworth, S., Crandall, P. G., Seo, H., & O'Bryan, C. A. (2023). Consumers' willingness to pay for safer, more environmentally friendly smoke flavored chicken breasts. *Journal of Sensory Studies*, 38(2). https://doi.org/10.1111/joss.12812

8. Fraqueza, M. J., Laranjo, M., Alves, S. P., Fernandes, M. H., Agulheiro-Santos, A. C., Potes, M. E., & Elías, M. (2020). Dry-Cured meat products according to the smoking regime: Process optimization to control polycyclic aromatic hydrocarbons. *Foods*, 9(1), 91. https://doi.org/10.3390/foods9010091

9. Gómez, I., Janardhanan, R., Ibáñez, F. C., & Beriain, M. (2020). The effects of processing and preservation technologies on meat quality: sensory and nutritional aspects. *Foods*, 9(10), 1416. https://doi.org/10.3390/foods9101416

10. Halagarda, M., & Wójciak, K. M. (2022). Health and safety aspects of traditional European meat products. A review. *Meat Science*, 184, 108623. https://doi.org/10.1016/j.meatsci.2021.108623

11. Hokkanen, M., Luhtasela, U., Kostamo, P., Ritvanen, T., Peltonen, K., & Jestoi, M. (2018). Critical effects of smoking parameters on the levels of polycyclic aromatic hydrocarbons in traditionally smoked fish and meat products in Finland. *Journal of Chemistry*, 2018, 1–14. https://doi.org/10.1155/2018/2160958

12. Iko Afé, O. H., Kpoclou, Y. E., Douny, C., Anihouvi, V. B., Igout, A., Mahillon, J., Hounhouigan, D. J., & Scippo, M.- L. (2021). Chemical hazards in smoked meat and fish. *Food Science & Nutrition*, 9, 6903-6922. https://doi.org/10.1002/fsn3.2633

13. Ismail, I., & Joo, S. (2017). Poultry meat quality in relation to muscle growth and muscle fiber characteristics. *PubMed*, 37(6), 873–883. https://doi.org/10.5851/kosfa.2017.37.6.87

14. Lautenschlaeger, R.H. (2017). "Smoking Technology in Meat Processing from a Future Perspective". In 63rd International Congress of Meat Science and Technology. Leiden, The Netherlands: Wageningen Academic. https://doi.org/10.3920/9789086868605_451

15. Malarut, J., & Vangnai, K. (2018). Influence of wood types on quality and carcinogenic polycyclic aromatic hydrocarbons (PAHs) of smoked sausages. *Food Control*, 85, 98–106. https://doi.org/10.1016/j.foodcont.2017.09.020

16. McDonald, S. T., & Flavor, P. (2015). Comparison of health risks of smoked foods as compared to smoke flavorings: Are smoke flavors "Healthier"? *Advanced in Food Technology and Nutritional Sciences*, 1(6), 130–134. https://doi.org/10.17140/aftnsoj-1-122

17. Min, S., Patra, J. K., & Shin, H. (2018). Factors influencing inhibition of eight polycyclic aromatic hydrocarbons in heated meat model system. *Food Chemistry*, 239, 993–1000. https://doi.org/10.1016/j.foodchem.2017.07.020

18. Murthy, K. R. S., Nath, D., Kumari, N. R. K., & Kumar, D. S. (2021). Effect of ginger and garlic supplement on biochemical profile and sensory meat quality of japanese Quail. *Journal of Meat Science* (Print), 16(1and2), 31–36. https://doi.org/10.5958/2581-6616.2021.00007.4

19. Nizio E, Czwartkowski K, & Niedbała G. (2023) Impact of Smoking Technology on the Quality of Food Products: Absorption of Polycyclic Aromatic Hydrocarbons (PAHs) by Food Products during Smoking. Sustainability, 15(24):16890. https://doi.org/10.3390/su152416890

20. Popova, V. O., Syromiatnykova, N. A., Vasylieva, Y. O., & Leppa, A. L. (2020). Experimental research of the influence of different types of smoked wood on the quality f hot-smoked mackerel. *Veterinary Science, Technologies of Animal Husbandry and Nature Management*, 5, 121-126. https://doi.org/10.31890/vttp.2020.05.22

21. Prudnikov, V. H., Popova, V. O., & Leppa, A. L. (2013). Vplyv netradytsiinykh vydiv koptylnoi derevyny na yakist skumbrii hariachoho kopchennia ta yii vidpovidnist standartu [The influence of non-traditional types of smoking wood on the quality of hot-smoked mackerel and its compliance with the standard]. *Problems of Animal Engineering and Veterinary Medicine*, (27 (1)), 91-95. http://nbuv.gov.ua/UJRN/pzvm_2013_27%281%29__15

22. Puljić, L., Mastanjević, K., Kartalović, B., Kovačević, D., & Vranešević, J. (2019). The influence of different smoking procedures on the content of 16 PAHs in traditional dry cured smoked meat "Hercegovačka Pečenica." *Foods*, 8(12), 690. https://doi.org/10.3390/foods8120690

23. Škaljac, S., Jokanović, M., Tomović, V., Ivić, M., Tasić, T., Ikonić, P., Šojić, B., Džinić, N., & Petrović, L. (2018). Influence of smoking in traditional and industrial conditions on colour and content of polycyclic aromatic hydrocarbons in dry fermented sausage "Petrovská klobása." Lebensmittel-Wissenschaft + Technologie. *Food Science & Technology*, 87, 158–162. https://doi.org/10.1016/j.lwt.2017.08.038

24. Starski, A., Kukielska, A., & Postupolski, J. (2021). Occurrence of polycyclic aromatic hydrocarbons in human diet – exposure and risk assessment to consumer health. *Roczniki Państwowego Zakładu Higieny*, 253–265. https://doi.org/10.32394/rpzh.2021.0178

25. Tsutsumi, T., Adachi, R., Matsuda, R., Watanabe, T., Teshima, R., & Akiyama, H. (2020). Concentrations of polycyclic aromatic hydrocarbons in smoked foods in Japan. *Journal of Food Protection*, 83(4), 692–701. https://doi.org/10.4315/jfp-19-486

26. Yang, D., He, Z., Gao, D., Qin, F., Deng, S., Wang, P., Xu, X., Chen, J., & Zeng, M. (2019). Effects of smoking or baking procedures during sausage processing on the formation of heterocyclic amines measured using UPLC-MS/MS. *Food Chemistry*, 276, 195–201. https://doi.org/10.1016/j.foodchem.2018.09.160

27. Yin, X., Chen, Q., Liu, Q., Wang, Y., & Kong, B. (2021). Influences of smoking in traditional and industrial conditions on Flavour Profile of Harbin red sausages by Comprehensive Two-Dimensional Gas Chromatography Mass Spectrometry. *Foods*, 10(6), 1180. https://doi.org/10.3390/foods10061180

28. Zhang, L., Chen, Q., Liu, Q., Xia, X., Wei, Y., & Kong, B. (2022). Effect of different types of smoking materials on the flavor, heterocyclic aromatic amines, and sensory property of smoked chicken drumsticks. *Food Chemistry*, 367, 130680. https://doi.org/10.1016/j.foodchem.2021.130680