meat technology
Founder and publisher:
Institute of Meat Hygiene and Technology, Belgrade

UDK: 637.525.034
COBISS.SR-ID: 196326153
https://doi.org/10.18485/meattech.2026.67.1.2

Original Scientific Paper

Quantifying heat intensity during thermal processing of smoked pork loin using p value kinetics

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A R T I C L E I N F O

Keywords:
Pasteurisation
Validation
Smoked pork loin
Thermal treatment
Thermocouple

A B S T R A C T

Smoked pork loin is a high-quality meat product available on the domestic and European markets. During production, it is subjected to a combination of smoking and roasting, while controlling the pasteurisation process remains a challenge. This smoked meat product is sold either packaged or unpackaged, and in retail, it is directly sliced in front of the consumer. During the thermal processing of smoked pork loin, food business operators typically validate temperature as a parameter for assessing process efficacy, with the introduction of heat continuing until 70 °C is reached at the thermal centre of the product, after which cooling begins. By using a thermocouple in the verification process of heat treatment, it was shown that the required temperature was achieved in all parts of the chamber. The initial temperature of the raw material, before the initiation of thermal processing, was 6.86–8.18 °C; the process itself lasted 6 hours and 20 minutes; and a temperature of 70 °C was achieved at all verification points (locations in the thermal processing chamber). The placement of probes significantly affected the measurement results, determining the pasteurisation value (P value), which ranged from 53.8 to 640.42 minutes. The results confirm the safety of the product, with probes placed in the peripheral parts of the product showing significantly greater P values of 478.16–640.42 minutes, compared to probes placed in the central region at 186.29–205.49 minutes, and in the thermal centre at 53.8–93.08 minutes. The validation of thermal processing for smoked meat products should be established and implemented through P values (a minimum of 40 minutes is required), rather than through temperature, as is currently the case in the meat processing industry in Serbia.

1. Introduction

Smoked pork loin is a popular meat product made from the finest, lean cuts of the pork loin; it has a pale red colour, a mildly salty taste, and an elongated shape. In accordance with national legislation (*Official Gazette RS*, 50/2019 and 34/2023), smoked meat products are produced from cuts of meat — with or without attached bones, skin, subcutaneous fat, and residual meat on vertebral bones after manual deboning — as well as from added ingredients. These products are smoked and heat-treated at pasteurisation temperatures. The production of smoked pork loin generally follows the standard procedure for smoked, pasteurised meat products: first, the pieces are dried at 60–70 °C with 30–40% relative humidity for 30–120 minutes (depending on size), then smoked at 65–75 °C with 50–70% relative humidity until the desired color is reached (*Polak et al*., 2020). Literature on pork quality perception is inconsistent, especially concerning sensory and intrinsic attributes and consumer familiarity; flavour, tenderness, and juiciness are the primary sensory factors shaping overall perceptions of pork loin quality (*Millán, Á. et Retamosa*, M., 2025). Validating sensory evaluation methods is essential to ensure that sensory science is based on objective data rather

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Paper received: December 3rd 2025. Paper accepted: March 13th 2026.
Published by Institute of Meat Hygiene and Technology — Belgrade, Serbia.

than subjective judgments (*Petrovic et al*., 2024). We must also take into account that sensory measurements are subjective judgments rather than objective physical measurements, making quality attributes harder difficult to define and assess (*Nute*, 2010). Heat treatment significantly affects the properties of pork loin (tenderness/soft texture, juiciness, and salty notes), which primarily shape perceived its quality (*Watanabe et al*., 2019). Pasteurisation-range heat treatment (typically 55–75 °C) effectively reduces microbes in pork products, but also alters sensory traits, like tenderness and drip loss. Around 65 °C has been reported to best balance sensory quality preservation with safety (*Moeller et al*., 2010). Pasteurisation heats the product to a precise temperature for a set time to destroy harmful microbes-bacteria, parasites, and viruses, while largely preserving its flavour, texture, and nutrients. In meat processing, this step is essential for food safety and for prolonging the product's shelf life (*Banu*, 2023).

The pasteurisation value (P value) is calculated from the lethality observed at the product's coldest point during heat treatment. Pasteurisation is validated by tracking F_{70} values against the heat-resistant microorganism *Enterococcus faecium*, using temperature data exceeding 55 °C at the geometric centre of the meat product (*Vuković*, 2012). The P value limit is determined by measuring how long it takes to reduce a specified microorganism's count by one log cycle, using an assumed average contamination level of 10^6 cfu per gram, multiplying this by the product's mass, and reporting the result in minutes (*Rašeta et al.*, 2021). The P value (analogous to the F value but using 70 °C as reference and z = 10 °C) is increasingly cited as a more product-relevant metric for moderate heat treatments than the classic F_0 (121.1 °C, z = 10 °C). The z value is the temperature increase required for a tenfold (1 log) reduction in a microorganism's decimal reduction time (D value) during pasteurisation (*Holdsworth and Simpson*, 2016). Incorporating P values into the optimisation process for a pasteurised meat product verifies that the pasteurisation intensity is adequate and that the product will remain safe under the specified storage conditions. This approach also allows heat-treatment levels to be compared across different products. The food business operator can then monitor and manage every stage of thermal processing, maintaining tight control throughout and guaranteeing the safety of the meat product, regardless of location inside the pasteurisation chamber (*Rašeta et al*., 2025).

In many instances, taste is the biggest driver of consumer satisfaction with meat products, often outweighing factors like tenderness or juiciness (*Garmyn*, 2020). While juiciness and tenderness play a role, they are only supporting elements in determining overall consumer approval (*Lees et al*., 2024). In smoked meats, visual appeal and scent shape provide the first impressions and set expectations for quality, while the distinctive smoky hue and aroma are highly prized (*Abdullah et al*., 2022). However, the meat industry faces difficulties in the heat treatment of meat products, frequently leading to overheating as food safety concerns take precedence. This overheating can result in considerable cooking losses and considerable variability between products. Consequently, there is significant potential to enhance heat treatment methods to prevent unnecessary heating. Thermal pasteurisation plays an essential role in the meat sector, enabling the creation of premium sausage products that can enjoy a prolonged shelf life when stored properly at designated refrigeration temperatures. Pasteurisation of smoked pork loin with temperature management is essential to secure and maintain product safety.

For meat products that undergo pasteurisation heat treatment, the complex thermal process includes not only heating but also steps like drying, smoking, and cooling until the temperature in the thermal centre drops below 55 °C. This overall heat burden results in the peripheral parts of the product being subjected to a very intense thermal regime. Nonetheless, to validate pasteurisation, food business operators in Serbia typically apply a critical limit temperature of 70 °C in the thermal centre of the product as a critical control point (CCP) within the food-safety management system (*Official Gazette RS*, 50/2019, 34/2023). This exposes the product to significant stress during processing and leads to substantial energy consumption, high thermal treatment loads, and sensory deterioration of the product. When achieving a temperature of 70 °C at all points in the chamber in the thermal centre of the product, the P values have already exceeded the set limit for pasteurised products (a minimum of 40 minutes).

However, both domestic (Official Gazette RS, 50/2019, 34/2023) and European (*EC Regulation*, 2004) legislation also allows pasteurisation to be assessed by means of the P value, which must be at least 40 minutes, while the temperature at the thermal centre of the product must be no lower than 65 °C, provided the heat-treatment time is sufficiently long. The same legislation also stipulates that pasteurisation must be validated and controlled as a CCP under the hazard analysis and critical control points (HACCP) system to ensure safety and consistent quality. A fully executed heat-treatment process, apart from its primary function of ensuring the safety of the final product through the preservative effect of heat, also prevents irreversible discoloration and maintains hygiene standards throughout. The most direct way to validate pasteurisation is to place thermocouple probes in the product's thermal centre at different positions within the heating chamber. By positioning probes outside the thermal centre, one can assess the heat load in the product's peripheral areas while still targeting a core temperature of 70 °C. These peripheral sections, particularly in meat products such as smoked pork loin that is subjected to prolonged heating, experience excessive thermal exposure, which could lower their nutritional value and drive-up energy costs.

To examine the approach to ensuring the CCP through direct measurement of achieving 70 °C at the thermal centre of smoked pork loin, as was documented in the food safety assurance system and designated as a critical control limit by the expert team of the food business entity, temperature measurements inside the smoked pork loin were also taken throughout the pasteurisation process. This meat product was specifically selected for the study because it has a thermodynamically homogeneous matrix, and differences in temperature primarily arise from the product zones (thermal centre, central zone, and periphery) wherein the thermocouple sensor is placed. The primary objective of this work was to present the thermal burden of the product, since the validation of pasteurisation is set only to achieve 70 °C in thermal centre of the product. Also, by using statistical analysis methods, we generated a proposal for optimising the pasteurisation process of smoked pork loin at 65 °C, while ensuring a minimum P value of 40 minutes in the product's thermal centre.

2. Materials and Methods

2.1 Pork Loins

During operations, the butchers adhered to all requirements in the prerequisite programs of the food safety assurance system (good hygienic and manufacturing practices, standard operating procedures, and sanitation standard operating procedures). The procedure for cutting and processing pork was carried out in the meat cutting room at temperatures up to 12 °C, in accordance with national (*Official Gazette RS*, 25/2011, 27/2014 and 86/2023) and European (*EC Regulation*, 2004) regulations. To produce pork loin, pork carcasses were chilled to a core temperature below 4 °C, split lengthwise, and the middle section (which included the loin) was separated from the shoulder and ham. The loin, identified as the muscle running along the back of the pig, from the shoulder to the hip, was separated from the belly by cutting along the natural seam between the two muscles. The bones were removed using a boning knife, and the tenderloin was removed. Using the size of the *spinalis dorsi* as an anatomical landmark, each loin was transacted near the 7th rib. A thick slice was then cut immediately posterior to the 7th rib, and subcutaneous fat, connective tissue was removed.

2.2 Producing smoked pork loins

Boneless loins were taken from the fabrication line about 24 hours post-mortem. Properly shaped pork loins were wet-brined and then mechanically processed in a tumbler. Afterwards, they were tied with twine and hung on the trolley rods. The prepared pieces were left in the ante-room and, according to the first-in–first-out (FIFO) principle, were sent for pasteurisation-level thermal treatment in the Maurer chamber (Figure 1) that accommodated two carts filled with product, with a total weight of 431 kg (Figure 2). Weight was equally distributed between two carts.

2.3 Thermal processing — pasteurisation

The food business operator wanted to validate pasteurisation using a temperature of 70 °C in the thermal centre of the smoked pork loin as part of its implemented HACCP-based food safety assurance system. The validation of pasteurisation was performed during regular production. Pasteurisation of the smoked pork loin product was carried out in the Maurer chamber in three stages: drying for 100 minutes at a chamber temperature of 70 °C; smoking for 30 minutes at a chamber temperature of 70 °C, and; cooking at a chamber temperature of 80 °C until the pasteurisation value required by the regulations (*Official Gazette RS*, 50/2019 and 34/2023) was reached. The entire thermal treatment of the smoked pork loin in the Maurer chamber lasted 380 minutes. After that time, the smoked pork loins were removed from the chamber and left to cool to 55°C (considered the end-point of thermal processing). Since the product was not packaged and had been exposed to smoke during the production process, it was not spray-cooled with water to lower the product temperature.

2.4 Validation of pasteurisation

Measurements were obtained using the thermal validation system Ellab (E-Val Pro, serial number 411982, validated software — US FDA, 21 CFR part 11, GMP, ver. 4.6.1.0), and the technical report was prepared using the Ellab ValSuite software, version 5.2.015. Thermoelements with compensating cables were utilised, and temperatures were recorded at one-minute intervals. All used probes were 20 cm long, with the measuring point located at the tip. During the measurements, probes were strictly calibrated to the designated thermocouple channels without damaging the probes' rubber sheaths. A total of 7 probes were used (thermocouple channels: 1, 2, 4, 6, 7, 8, 9) to record temperature and P value every minute (Figure 3). To completely assess the product's thermal load, probes were placed in the thermal centre of the product (probes 7 and 9), central zone in the region within 2 cm from the centre (probes 1, 6, and 8), and at the periphery of the pork loins, within 4 cm from the thermal centre (probes 2 and 4). A schematic layout of probe positions in one smoked pork loin is presented relative to the product's cross-section (Figure 4). The temperature monitoring was finished when 70 °C was reached at all measurement points.

Figure 1. Maurer pasteurisation chamber with one door, which can accommodate two carts

Figure 2. Pork loins prior to pasteurisation during placement of the tied pieces onto the carts

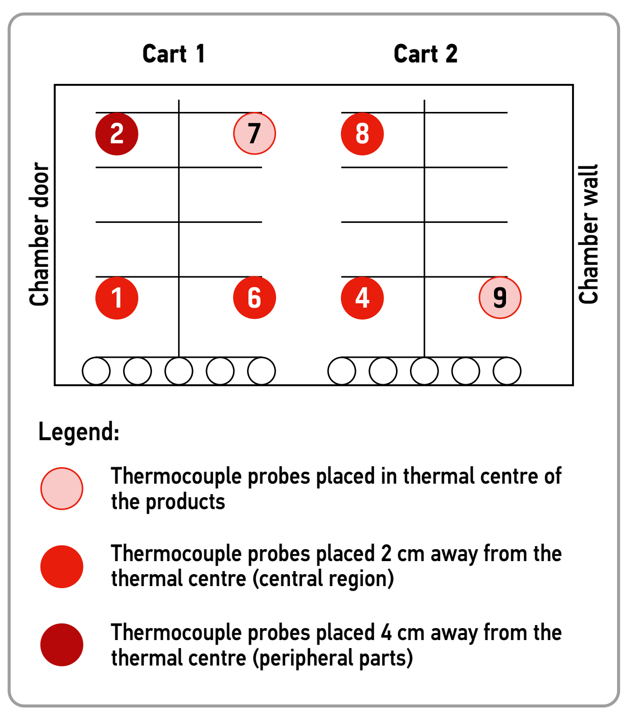

Figure 3. Positions of the probes installed in the Maurer chamber on carts, viewed from the side

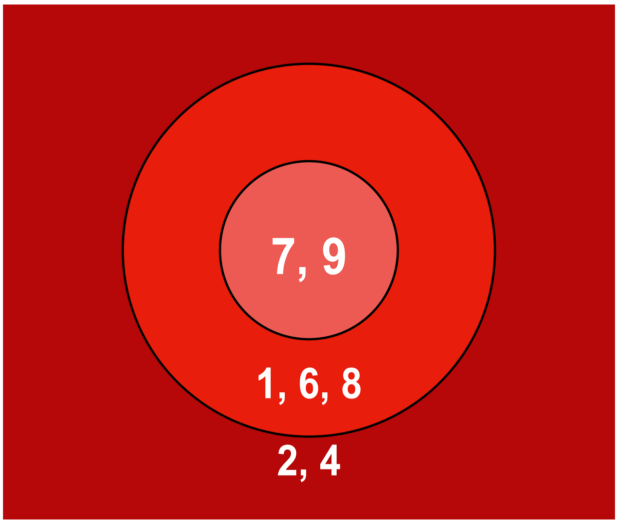

Figure 4. Probe position in a smoked pork loin in different heat regions of the product, seen from cross-section

2.5 Statistical modelling

Statistical modelling using multiple linear regression (MLR) was used to determine P value dependency of pasteurisation time and temperature. Models developed using full factorial design for screening the influence of the two parameters was applied. JMP Statistical Discovery 10 (SAS Institute Inc., USA https://www.jmp.com) was used for statistical analysis and presentation of results. MS Office 2016 Excel software was applied to prepare data for further analysis.

3. Results and Discussion

To validate the thermal processing of smoked pork loin in the Maurer chamber, the temperature was recorded in real time every minute at various points within the product, observed transversely. The temperatures recorded in the products are presented in Figure 5, while P values are shown in Figure 6.

A full factorial design was used to model the pasteurisation of smoked pork loin and predict the time (minutes) required to achieve a specific P value at a given temperature (°C), with results shown in Table 1. The model was assessed by multiple channels (1, 2, 4, 6, 7, 8, and 9) and locations within the pork loin. R^2 values ranged from 0.92–0.95 across all channels, i.e., the models explained 92–95% of the variance in the pasteurisation time. These high R^2 values suggested

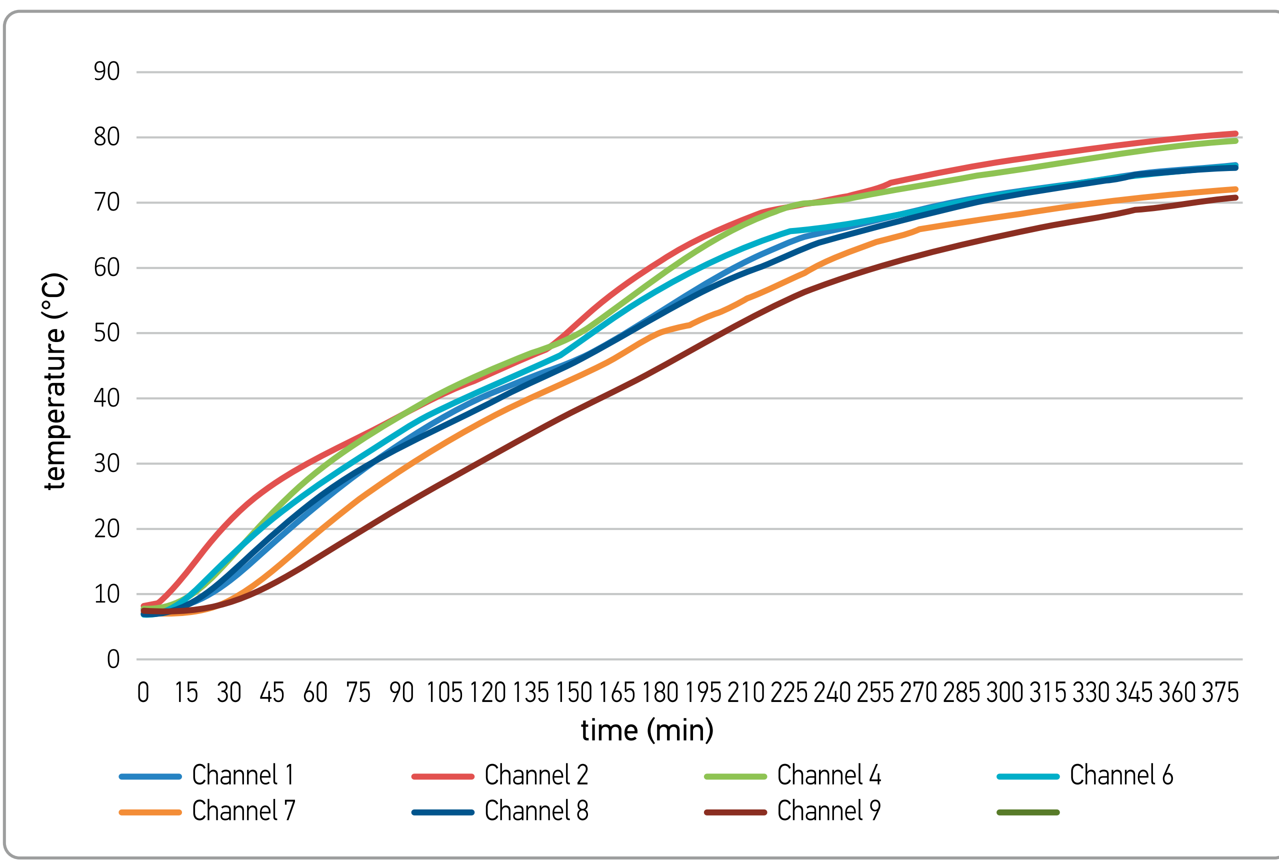

Figure 5. Temperatures achieved in the thermal centre of the smoked pork loin (probes 7 and 9), in central region (probes 1, 6, and 8) and in the peripheral region (probes 2 and 4).

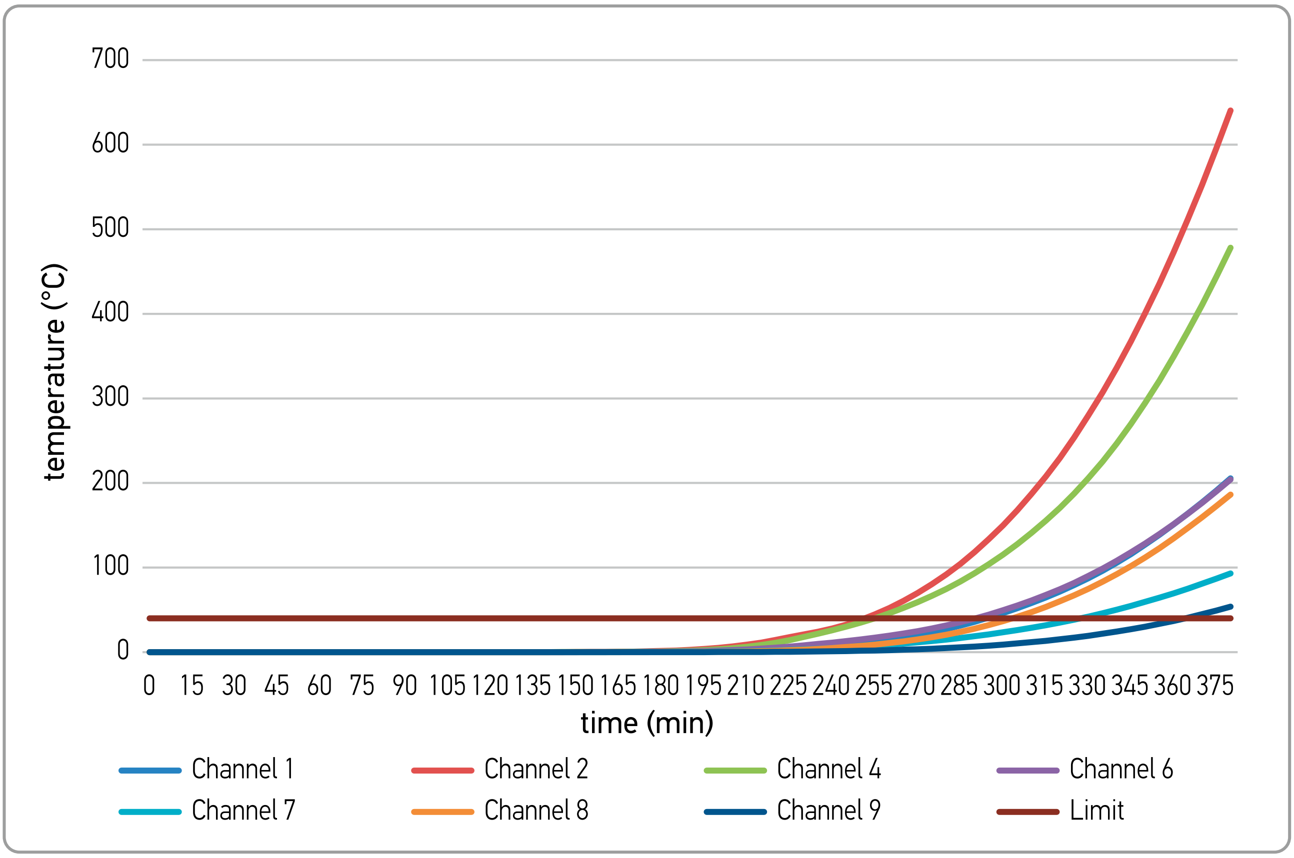

Figure 6. P values achieved in the thermal centre of the product (probes 7 and 9), in the central region (probes 1, 6, and 8) and in the peripheral region (probes 2 and 4) of the smoked pork loin

a very good fit of the model to the data. Time and temperature were strong predictors of pasteurisation effectiveness in the smoked pork loin, while the models captured most of the data variability.

Differences in intercept values across channels reflect variations in the initial microbial load, or physical location. The intercept value is the predicted pasteurisation time when both time and temperature are zero, and serves as baseline value for the model (Figure 7). The intercept values differed across the channels (from 7.06 to 436.4), and were statistically significantly different ($p < 0.0001$), except channel 9, which was significantly different at $p < 0.05$.

Longer processes have higher pasteurisation values, while the magnitude of coefficients indicates the sensitivity of the pasteurisation process to changes in time. The coefficients for the time were all positive and significant ($p < 0.0001$), ranging from 0.5–5.59, which shows that when the time increased, the predicted pasteurisation time also increased. The coefficients for temperature were all negative and significant ($p < 0.0001$), ranging from −2.21 to −24.3. This indicates

Table 1. Prediction model determination coefficients (R^2), intercept, and parameter coefficient values

Parameter	Channel						
	1	2	4	6	7	8	9
R^2	0.94	0.92	0.92	0.93	0.95	0.95	0.92
Intercept	143.46*	436.40*	311.55*	171.12*	41.34*	198.60*	7.06**
Time (min)	2.24*	5.59*	4.24*	2.08*	0.97*	2.65*	0.50*
Temperature (°C)	−10.18*	−24.30*	−18.32*	−9.78*	−4.35*	−12.78*	−2.21*
Time*Temperature	−0.011*	−0.021**	−0.021**	−0.013*	−0.004*	−0.016*	$4.3{\cdot}10^{-5}$***

Asterisks denotes following statistical significance: * $p < 0.0001$, ** $p < 0.05$ and *** no significance for confidence interval of 95% ($p = 0.05$).

that when temperature increased, the predicted pasteurisation time decreased. This is aligned with the understanding that higher temperatures require shorter processing times to achieve the same level of pasteurisation. Large negative coefficients suggest a strong inverse relationship between temperature and pasteurisation time. The coefficients for the time/temperature interaction were mostly negative and significant ($p < 0.0001$ or $p < 0.05$), except for channel 9, which was not significant. The values were close to zero. The significant negative interaction suggests that the effect of temperature on pasteurisation time depends on the processing time, and vice versa. The small values, close to zero, indicate the interaction has a very small effect.

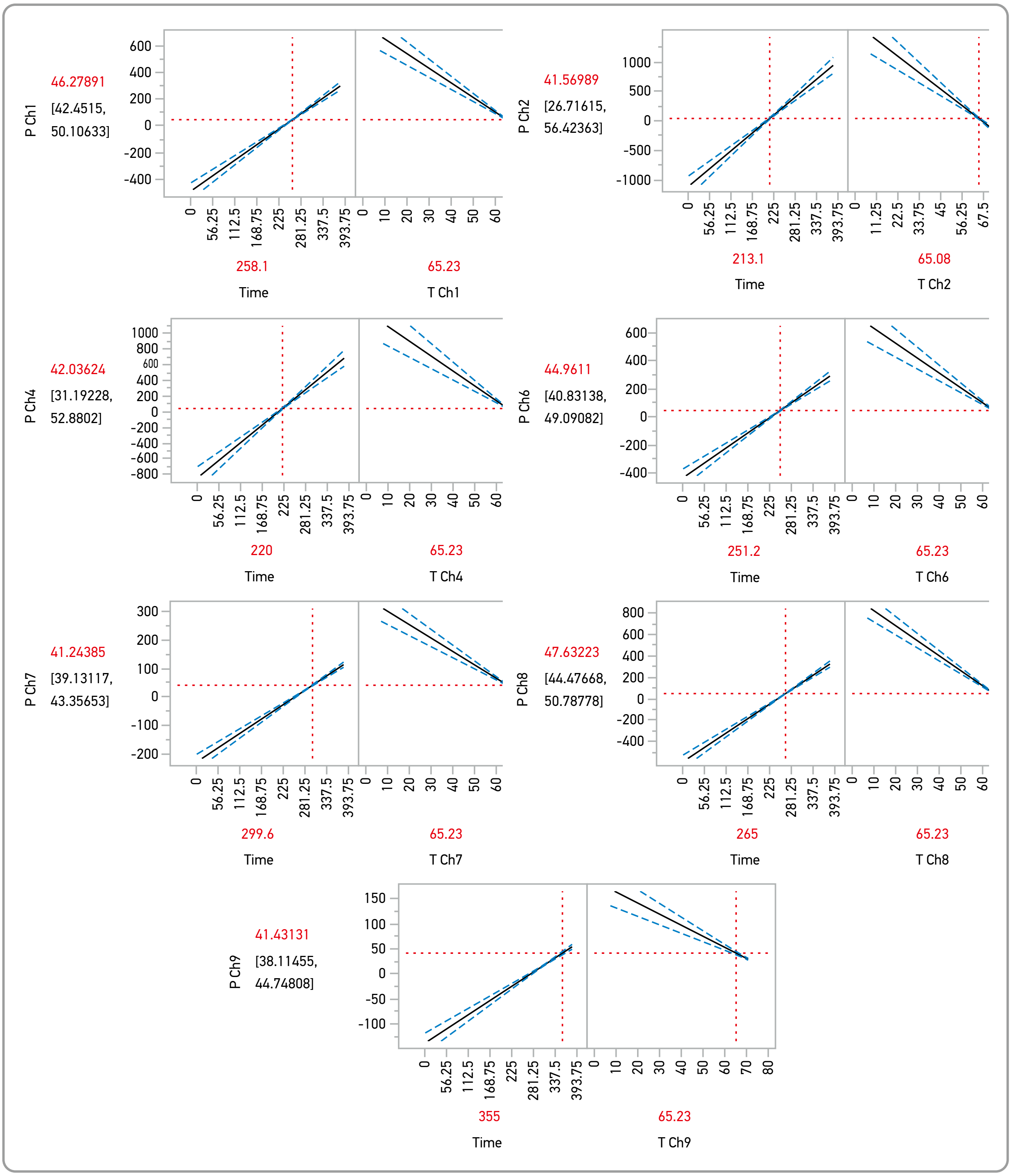

Figure 7. Prediction of pasteurisation time necessary to achieve a P0 value >40 at approximately 65oC

Sensory qualities like flavour, tenderness, and juiciness are the main drivers of consumer acceptance for pork loin products, including smoked products; pasteurisation and cooking parameters directly affect these attributes (*Millan and Retamosa*, 2025). The primary task during production of smoked pork loin by the food business operator is to obtain a safe product (*Official Gazette RS*, 41/2009 and 17/2019) within the specified shelf life (*Official Gazette RS*, 30/2024) and storage conditions of 0 °C to 4 °C (*Official Gazette RS*, 50/2019 and 34/2023). The shelf life of the final smoked pork loin, as a ready-to-eat (RTE) product, is primarily determined by the preservative effect of heat during pasteurisation. Aldehydes from smoke coagulate proteins and alter the meat's texture, and combined with phenols, organic acids, and alcohols, have limited antimicrobial effects, mainly on the product surface (*Vuković*, 2012). However, any preservative effect of smoke on the surface gradually diminishes due to evaporation, diffusion into deeper layers, and reactions with protein components. Smoke does not prevent the growth and reproduction of microorganisms. Applying steam pasteurisation to commercially slaughtered beef carcasses at 82.2 °C for 6.5 seconds markedly lowered the bacterial levels, and when the time-temperature settings were fine-tuned, the sensory quality was within acceptable limits (*Nutsch et al*., 1998). However, further pasteurisation process optimisation is necessary, as although smoking is highly effective for preserving food, it also contaminates products with carcinogenic polycyclic aromatic hydrocarbons (PAHs), levels of which climb steadily as temperatures increase from 55 °C to 95 °C and smoking times lengthen from 2 to 9 hours (*Racovita et al*., 2020). Including the P value in the optimisation process verifies that the required degree of pasteurisation has been reached and assures product safety under the specified storage conditions (*Rašeta et al.*, 2021).

It is necessary to compare the reported results with existing thermal profiles to determine the accuracy of the measuring instruments in the Maurer chamber. Once this is done, the food business operator will then be able to oversee the entire thermal processing process, maintaining comprehensive control and ensuring the safety of smoked pork loin throughout the entire thermal treatment.

Thermal processing of the smoked pork loin was optimised using MLR statistical modelling to ensure the required P value of > 40 minutes was reached. This was done for the coldest point in the studied Maurer chamber (channel 9), at a media temperature of 65 °C, over a total pasteurisation time of 355 minutes—which included the active heating phase and the cooling phase until 55 °C was reached in the thermal centre of the product (Figure 7). The MLR model allowed us to examine the possibilities for optimising the pasteurisation process. At the moment of completing the active heating, the probe in channel 9 recorded a P value of 53.8 for 380 minutes. However, we also needed to take into account the time required for the cooling phase to 55 °C, which, according to records from the food business operator, required an additional 120 minutes. Therefore, the total time reduction was the sum of the difference in duration between the regular process (70 °C is reached in the thermal centre, taking 375 minutes), and the optimised process of 355 minutes, plus the product cooling time. Mathematically, this was a reduction in the pasteurisation time of smoked pork loin of 20 + 120 = 140 minutes. This reduction in pasteurisation time would be highly meaningful in terms of time savings and energy consumption.

The circulation routes within the chamber are designed to create uniform temperature fields, which is essential for achieving consistent heat penetration from the surface to the thermal centre of the meat product. The positioning of products within the chamber significantly affects their temperature profiles during processing (*Feyissa and Frosch*, 2023). For this reason, the P value in the product placed in the thermal centre located at the upper position (channel 7) was greatest, at 93.08 minutes. Considering that the channel 7 probe was located in the thermal centre of the product, we assessed the safety of the pasteurisation process. Using the MLR model, the entire pasteurisation process lasted 303 minutes at the channel 7 location. Generally, though, the approach to ensuring the safety of the entire process should be oriented towards the coldest location in the Maurer chamber, which in our case was the product measured by channel 9, corresponding to a total pasteurisation duration of 355 minutes. The defined time refers to the processing in the chamber until 65 °C is reached in the thermal centre of the smoked pork loin, encompassing the total time of active heating, plus cooling time for the product's thermal centre to reach 55 °C.

The minimum temperature at which pasteurisation begins in the thermal centre of a meat product generally starts around 55 °C, but the process depends on both temperature and holding time to achieve microbial lethality (*Baldwin*, 2012; *Hwang et al*., 2019). Research indicates that the processes of curing and smoking pork loin, followed by heat treatment to internal temperatures of approximately 65–70 °C for periods ranging from 30 seconds to several minutes, affect the texture, purge loss, and shelf life of the product (*Granados*, 1984). A temperature of 65° C is high enough to destroy most microorganisms, including bacteria, viruses, and fungi, thus extending the shelf life of the products and reducing the risk of infections (*Azizpour et al*., 2024). Pasteurisation does not kill spores (*Cockey and Tatro*, 1974), nor all vegetative forms of bacteria. However, it is a thermal treatment sufficient to ensure limited shelf life of meat products in the presence of brine ingredients and under cold chain storage conditions (*Oluški*, 1973).

To assess the intensity of pasteurisation in the smoked pork loin, probes were also placed in the central zone 2 cm from the thermal centre (channels 1, 6 and 8). P values obtained ranged from 186.29 to 205.49 minutes. Greater values were obtained for products located on the lower parts of the carts, which was consistent with the chamber's circular heat circulation during operation. Two probes (channels 2 and 4) were placed in peripheral parts of the product (4 cm from the thermal centre), and they achieved P values ranging from 478.16 to 640.42 minutes. These results indicate a significant difference in the intensity of thermal treatment at the product periphery compared with the thermal centre.

The results of this study should serve as a basis for further optimisation of the pasteurisation process, with the mandatory assurance of the CCP through P values instead of temperature, which is the current practice among food business operators in Serbia. Additionally, sensory evaluation of the smoked pork loin was not conducted, so this study limitation should be addressed in the future. The topic is relevant, the methodology is sound, and the findings have practical implications for the meat processing industry. The use of P values for pasteurisation validation is a novel approach in Serbia that warrants further investigation and dissemination.

4. Conclusion

This study was conducted on smoked pork loin commercially produced by a food business operator, and for which a critical limit was set of 70 °C in the thermal centre, exposing the product to significant stress during processing. Overly stringent thermal treatment leads substantial and unnecessary energy consumption, a high thermal treatment load, and results in sensory deterioration of the product. While achieving a temperature of 70 °C at all points in the chamber in the thermal centre of the product, the P values had already exceeded the minimum limit for pasteurised products, i.e., 40 minutes. Those long P values were added to by the cooling process (the hold until the temperature in the thermal centre drops below 55 °C).

During validation at a core temperature of 70 °C, the pasteurisation value (P value) in the thermal centre ranged from 53.8 to 93.08 minutes, depending on the product's location on the chamber carts (these values did not account for the fact that the P value continued to rise during cooling). At the same time, our monitoring of the two more peripheral layers in the product also showed very high readings (that will also increase while the product cools): the intermediate central zone reached P values of 186.29–205.49 minutes, and the outermost peripheral layer, 478.16–640.42 minutes.

These results indicate that the pasteurisation of smoked pork loin should be validated primarily by the P value — which must be at least 40 minutes for a pasteurised product — rather than by temperature alone. Relying solely on temperature exposes the product to an overly long pasteurisation process, likely resulting in diminished final quality and greater yield losses.

Theoretically for the studied smoked pork loin, the pasteurisation process could be optimised. The suggested pasteurisation regime suggested by the authors is 355 minutes of complete thermal treatment (heating and cooling), with 65 °C achieved in thermal centre of the product. According to the applied MLR statistical model, this would still achieve a P value > 40 min. This suggested lower-temperature pasteurisation regime will expose the product to significantly lower temperatures for shorter times than currently is the case, which likely would positively affect the biological value, the presence of nutrients, and the degree of degradation of the additives used in the production of these sausages.

Kvantifikacija intenziteta toplote tokom termalne obrade dimljene svinjske pečenice korišćenjem p-vrednosti

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I N F O R M A C I J E O R A D U

Ključne reči:
Pasterizacija
Validacija
Barene kobasice
Toplotna obrada
Termokapl

A P S T R A K T

Dimljena svinjska pečenica je visokokvalitetan mesni proizvod dostupan na domaćem i evropskom tržištu. Tokom proizvodnje izlaže se kombinaciji dimljenja i pečenja, pri čemu kontrola postupka pasterizacije ostaje izazov. Ovaj dimljeni proizvod od mesa se prodaje upakovan ili neupakovan, i u prodaji se pred potrošačem direktno narezuje.. Tokom termičke obrade dimljene svinjske pečenice, subjekti u poslovanju hranom, obično validuju temperaturu kao parametar za procenu efikasnosti procesa, pri čemu se uvođenje topolote nastavlja sve dok se ne dostigne 70 °C u termalnom centru proizvoda, nakon čega se započinje sa hlađenjem.. Korišćenjem termokapla u procesu verifikacije postupka toplotne obrade, pokazano je da je zahtevana temperatura postignuta u svim delovima komore. Početna temperatura sirovine, pre inicijacije toplotne obrade, iznosila je 6,86–8,18 °C; dok je sam postupak trajao 6 sati i 20 minuta; gubitak težine tokom termalne obrade bio je 15,8–18,3%; a temperatura od 70 °C postignuta je na svim tačkama provere. Postavljanje sondi značajno je uticalo na rezultate merenja, određena je vrednost pasterizacije (p-vrednost), koja se kreće od 53,8 do 640,42 minuta. Rezultati potvrđuju bezbednost proizvoda, pri čemu su sonde postavljene u perifernim delovima proizvoda pokazale znatno više P vrednosti 478,16–640,42 minuta, u odnosu na sonde koje su postavljene u središnjim delovima 186,29–205,49 minuta, do sondi koje su postavljene u termalnom centru proizvoda 53,8–93,08 minuta, Verifikacija termalne obrade za dimljene mesne proizvode trebala bi biti uspostavljena i implementirana kroz p-vrednosti (potreban minimum je 40 minuta), umesto kroz temperaturu, kao što je to trenutno slučaj u industriji prerade mesa u našoj zemlji.

Disclosure Statement: No potential conflict of interest was reported by the authors.

Funding: The results of the research presented in this paper were funded by the Ministry of Science, Technological Development and Innovation of the Republic of Serbia, based on the Agreement on the implementation and financing of scientific research work in 2025, No. 451-03-136/2025-03/200050 dated 02/04/2025.

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