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Validation of pasteurization of finely chopped, cooked sausages with a small diameter

Mladen Rašeta[1], Ivana Branković Lazić[1], Boris Mrdović[1], Nikola Betić[1], Becskei Zsolt[2], Jelena Jovanović[1] and Radivoj Petronijević[1]*

[1] *Institute of Meat Hygiene and Technology, Kaćanskog 13, 11000 Belgrade, Serbia*
[2] *University of Belgrade, Faculty of Veterinary Medicine, Bulevar Oslobodjenja 18, 11000 Belgrade, Serbia*

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A B S T R A C T

Pasteurization is a physical food preservation technique that effectively destroys microorganisms and inactivates tissue enzymes by applying moderate temperatures below 100°C. The safety and shelf-life of finely ground sausages, which are packaged in polyamide casings diameter 50 mm, weighing 220 grams, and produced by a food business operator, are ensured through pasteurization which lasted a total of 47 minutes. The standard pasteurization was performed in chamber at 80°C, in a saturated steam environment. Following this, the sausages underwent a cooling phase lasting 25 minutes in the same chamber immediately after the termination of pasteurization. During the pasteurization at 80°C and the cooling thereafter, pasteurization values (Pv) were ascertained in the thermal center of the sausages (thermocouple channels 2, 4, 5, 7, 8, 10, and 11), and ranged from 61.45 min (channel 10) to 81.07 min (channel 8). By achieving these Pv values, the temperature of 74°C in the thermal center of the cooked sausages was validated as adequate for ensuring the safety of the sausage product under the already-defined conditions of the cold chain storage.

1. Introduction

Thermal processing remains a primary technology for ensuring the safety of some foods. For cooked sausages, pasteurization as a traditional physical conservation method is generally used to kill microorganisms through heat introduction into the meat product structure that reaches the thermal center (*Basumatary et al.*, 2020). Quality and safety are paramount throughout the entire meat production and processing cycle. Meat and meat product processing focuses on enhancing quality, achieving desired sensory characteristics, improving digestibility, and prolonging shelf life (*Onopiuk et al.,* 2021). Pasteurization involves a gentle heat treatment applied to food, usually at temperatures below 100°C, designed to eliminate the vegetative cells of both pathogenic and most non-pathogenic microorganisms (*Benattouche et al.,* 2020). In the food industry, thermal pasteurization employs a range of techniques to guarantee microbiological safety (*Kamilla et al.*, 2024). For sausage products with a small diameter, safety is ensured by verifying the required temperature at the thermal center of the product, rather than by checking pressure-velocity values. To maintain the safety and quality of pasteurized, cooked sausages throughout their defined shelf life, it is essential that they are kept under specified cold chain conditions (between 0° and 4°C) during storage, transportation, and distribution (*Raseta et al.*, 2021).

Thermal processing can alter the flavor, taste, color, and nutritional values of the product. As a result, both the food industry and consumers are interested in developing new techniques

***Corresponding author:** Mladen Rašeta, *mladen.raseta@inmes.rs*

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that preserve the taste, colour and nutritional value of products, and that are also more energy-efficient than standard thermal methods (*Lalabadi et al*., 2023).

However, the growing consumer demand for convenient, easy-to-prepare foods that retain their nutritional value is shaping the current food market. Nowadays, there is growing demand for convenient food products that are minimally processed, high-quality, contain fewer additives, and have an extended shelf life. Thermal processing is utilized to reduce health risks from harmful microorganisms in low-acid foods and to prolong the shelf life for several days or weeks by eliminating spoilage microorganisms and/or inactivating enzymes. Special attention is devoted to the elimination of pathogenic microorganisms such as *Salmonella* spp, *Listeria monocytogenes* and *Escherichia coli* (*Ziyaina et al*., 2020, *Bermudez-Aguirre and Niemira B.*, 2022). Bacteria that cause product spoilage (*Enterococcus* spp., *Lactobacillus* spp., *Micrococcus* spp.) are more heat-resistant than pathogenic bacteria (*Salmonella* spp., *Staphylococcus* spp.), and therefore, *Enterococcus faecium* is used as a reference microorganism to assess the effectiveness of pasteurization, as it is more thermoresistant than pathogenic microorganisms (*Vuković I*., 2012). Proper pasteurization effectively removes *Salmonella* from sausage batter (*Silva F. and Gibbs P.*, 2012).

During the logarithmic microbial destruction, different points are found on the resulting curve, whose distance determines the decimal reduction time, i.e., the D value. This is the heating time in minutes required to reduce the initial number of bacteria in suspension by 1/10, so is also the time in minutes required for the curve to pass through one logarithmic cycle. The guidelines for pasteurization processes are determined by the specific target bacterium (*Enterococcus faecium*) and the necessary heat treatment to achieve a minimum five-log reduction of that microorganism. The pasteurization process necessary to destroy *Enterococcus faecium* according to the 5D concept should produce a pasteurization value (*Pv, further Pv*) of > 40 min (*Vuković I.*, 2012).

The aim of thermal pasteurization is to extend the shelf life of food by destroying pathogenic microorganisms and decreasing the overall microbial load compared to raw food products (*Daelman et al*, 2013). An inadequate heating process could lead to degradation of proteins, vitamins, and other vital nutritional elements (*Hernández-Hernández et al.*, 2019). Therefore, the pasteurization process in the production facility must be reviewed by the HACCP team to maintain a high level of process control and ensure product safety without unnecessary energy losses or losses in value of food and nutrients.

Pasteurized meat products are subjected to the preservative effects of temperatures below the boiling point of water during production, ensuring that a minimum temperature of 70°C is reached in the thermal center. Alternatively, if the thermal treatment process allows for a temperature of at least 65°C to be reached in the thermal center, it must be maintained for a time duration sufficient to achieve a pasteurization value (Pv) $\geq$ 40 (*Serbia*, 2023). In the meat industry in Serbia, canned, smoked, and cooked sausages and other meat products are pasteurized at 75–85°C, and in the thermal center of the product, at least 70°C must be achieved (*Vukovic I.*, 2012). Previous production practices in the meat industry indicate that the median chamber temperatures are usually not higher than 82°C during sausage pasteurization (*Oluški V.,* 1973).

For many years, industrial practices in thermal pasteurization have relied on heat treatments deemed “safe harbors.” A safe harbor process is one that manufacturers can implement without requiring detailed information about the product or potential contamination risks.

To reduce costs and perhaps produce more desirable sausage products, these safe harbor treatments can be reduced, but any novel pasteurization treatment must be validated. Validation provides evidence that food hygiene control measures achieve effective and continuous management of food hazards at an appropriate level (*Serbia*, 2011). As *Codex alimentarius* stated, validation of control measures is needed to obtain evidence that a control measure or combination of control measures, if properly implemented, is capable of controlling the hazard to a specified outcome (*Codex alimentarius*, 2022). For the validation of pasteurization, it is crucial to position the control probe correctly at the thermal center of the product within the heating chamber. The personnel responsible must possess the necessary skills to consistently repeat this procedure during each pasteurization cycle to ensure accurate results. When commercializing an optimized pasteurization process, conducting shelf life studies on the optimized product is also essential. Additionally, maintaining the specified cold chain after production and during retail is critical to preserve product quality.

Sausage is made from ground meat or a mixture of different meats, combined with seasonings and spices, and then encased in a casing or container. According to current national legislation (*Serbia*, 2023), cooked sausages are defined as meat products made from meat, fatty tissue, connective tissue, offal, blood products, and additives. The filling can include meat dough, and these products are filled into casings or moulds before undergoing heat treatment at pasteurization temperatures, which may or may not include smoking. Various additives, such as salt, brining salts, water, spices, spice extracts, sugars, and flavourings, can be incorporated into the production of cooked sausages, including smoke and natural aromas. Finely chopped cooked sausages are produced by stuffing fillings into natural or artificial casings. The sausages are firm and juicy to the extent that they do not release water, with a pleasant characteristic flavor that is complemented by the aroma of smoke and spices. The sausage casing should be well filled with the filling, without damage, deformations, or folds (*Vukovic I*, 2012).

The objective of this work was to validate a pasteurization heat treatment of 74°C in the thermal centre of a commercial cooked sausage product, to determine whether the sausages are appropriately pasteurized.

Figure 1. Schroter chamber with thermocouple probes observed from the side in the thermal processing room.

2. Materials and Methods

The food business operator wanted to validate using a temperature of 74°C in the thermal centre of the sausages as part of its implemented food safety assurance system that involved hazard analysis and critical control points (HACCP). The validation of thermal treatment was conducted during the pasteurization of finely ground cooked sausages, 220 g in weight, stuffed into polyamide casings with a diameter of 50 mm. During the filling process, great care was taken to ensure that the casing was filled properly with the stuffing, avoiding any deformations or creases.

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 utilized, and temperatures were recorded at one-minute intervals. During the regular sausage production process, probes were placed in the thermal centres of multiple sausages and in the chamber medium. Measurements were obtained during regular production in a Schroter-type chamber (Figure 1). Four carts of product were placed in the chamber, with a total weight of 1040 kg (Figure 2). All probes were placed in the middle of the cart viewed from above, while a side view of probe placement is shown in Figure 2.

A total of 11 probes were used (thermocouple channels: 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, and 12), to record temperature and *Pv* value every minute, with seven probes placed in the thermal centres of sausages (thermocouple channels 2, 4, 5, 7, 8, 10, and 11) (Figure 3), while four probes were positioned in the chamber medium (thermocouple channels 3, 6, 9, and 12). Pasteurization was performed in the chamber at 80°C, in a saturated steam environment.

The temperature monitoring process continued after the active phase of pasteurization ended and during the first cooling phase until the temperature in the thermal center of the sausages was < 55°C (*Raseta et al.*, 2021). After completing the pasteurization process, the sausages were sent to the circulating air cooling room for further cooling. As the heat was transferred through the cooked sausages by

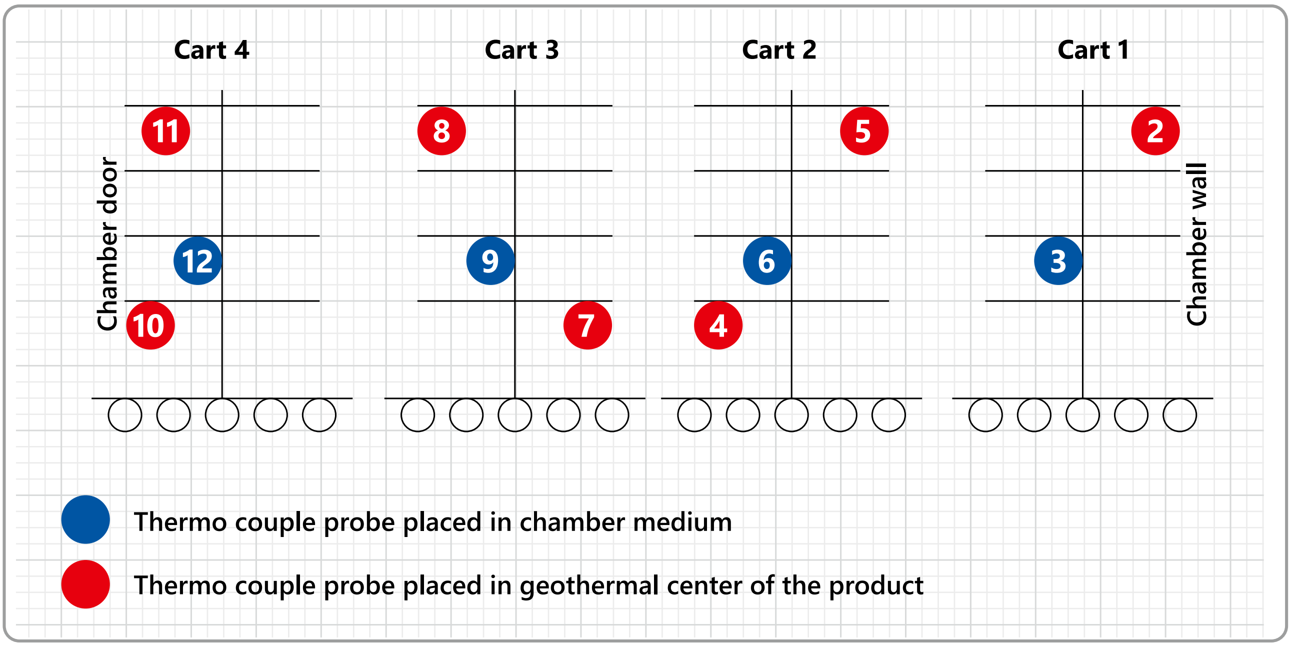

Figure 2. The positions of the probes installed in the Schroter chamber on carts, viewed from the side.

conduction, the temperature of the product should increase, both at the beginning of cooling and in the thermal center of the sausages, reaching about 74**°C.**

Statistical modeling using multiple linear regression (MLR) with prediction profiler was used to determine the time and temperature interval for achieving *Pv* > 40 min for all channels. JMP Statistical Discovery 10 (SAS Institute Inc. NC, USA https://www.jmp.com) was used for statistical analysis and presentation of results. MS Office 2016 Excel software was applied for exporting, sorting and preparing data for further analysis.

3. Results and Discussion

The thermal treatment process for finely ground cooked sausages (220 g in weight) packed in a polyamide casing, conducted in the Schroter chamber, lasted a total of 47 minutes, followed by a cooling phase of 25 minutes. The temperature of the filled sausage stuffing in the polyamide casing, prior to the start of thermal treatment, ranged from 16.71°C (channel 5) to 20.73°C (channel 7). At all verification points in the chamber, suitable *Pv* values of > 40 min were achieved in the thermal centres of the sausages (channels 2, 4, 5, 7, 8, 10, and 11), with values ranging from 61.45 (channel 10) to 81.07 (channel 8). The temperatures recorded in the sausages thermal centres during pasteurization, along with their corresponding *Pv* values, are presented in Table 1.

Temperature in the sausages' thermal centres and pasteurization values (*Pv*) achieved during pasteurization at 74°C.

The lowest *Pv* value in the red zone (Table 1, 40 min > *Pv* < 80 min) was recorded by channel 11 (41.78), while the highest was detected by channel 5 (79.29 min).

Theoretical modeling and predictive model for further improvement of the pasteurization process of the studied sausages.

Figure 3 was constructed from the data in Table 1. Prediction profiler indicated that an approximate temperature of 60°C is required to obtain *Pv* > 40 min after almost 47 minutes of heating. Also, as results of the prediction profiler demonstrated, any further temperature rise above 60°C would not have a further favourable effect.

3D scatter plots of *Pv* value vs time and temperature in sausage centers as recorded by thermocouple probe channels: a) channel 2; b) channel 4; c) channel 5; d) channel 7; e) channel 8; f) channel 10; g) channel 11. Colors of data points correspond to the colors in Table 1.

Figure 4 shows *Pv* vs temperature and time, as measured by thermocouple probes in the sausages. It is obvious that data in the red zone (from Table 1 and the red data points in Figure 4) covered the transitional range of *Pv* values for each channel. Upon analysing the results obtained, we can conclude that the heat treatment process for the studied sausages was consistent and uniform.

Table 1. Thermocouple measurements from probes 2, 4, 5, 7, 8, 10, and 11, placed in the geothermal center of the sausages over 73 minutes of process recording time

t (min)	T CH 2 (°C)	*Pv* CH 2	T CH 4 (°C)	*Pv* CH 4	T CH 5 (°C)	*Pv* CH 5	T CH 7 (°C)	*Pv* CH 7	T CH 8 (°C)	*Pv* CH 8	T CH 10 (°C)	*Pv* CH 10	T CH 11 (°C)	*Pv* CH 11
1	19.93	0	18	0	16.71	0	20.37	0	17.69	0	19.12	0	17.02	0
2	19.89	0	19.97	0	16.68	0	20.36	0	17.64	0	19.14	0	16.99	0
3	19.76	0	17.87	0	16.6	0	20.25	0	17.54	0	19.08	0	16.78	0
4	19.8	0	17.98	0	16.79	0	20.27	0	17.86	0	19.22	0	16.71	0
5	20.28	0	18.73	0	17.58	0	20.46	0	18.99	0	19.73	0	16.74	0
6	21.4	0	20.16	0	19.11	0	21.05	0	20.92	0	20.87	0	17.08	0
7	23.19	0	22.32	0	21.27	0	22.08	0	23.45	0	22.66	0	17.85	0
8	25.64	0	25	0	23.96	0	23.57	0	26.42	0	24.95	0	19.09	0
9	28.64	0	28.09	0	27.1	0	25.5	0	29.7	0	27.6	0	20.82	0
10	32.02	0	31.39	0	30.63	0	27.82	0	33.13	0	30.53	0	23.05	0
11	35.61	0	34.84	0	34.27	0	30.43	0	36.54	0	33.59	0	25.66	0
12	39.15	0	38.17	0	37.88	0	33.24	0	39.82	0	36.61	0	28.53	0
13	42.54	0	41.42	0	41.37	0	36.12	0	42.89	0	39.56	0	31.51	0
14	45.66	0	44.5	0	44.75	0	38.97	0	45.73	0	42.36	0	34.6	0
15	48.41	0	47.35	0	47.85	0	41.76	0	48.39	0	45.01	0	37.62	0
16	50.88	0.01	49.93	0.01	50.61	0.01	44.42	0	50.83	0.01	47.49	0	40.56	0
17	53.13	0.02	52.31	0.02	53.05	0.02	46.96	0	53.07	0.02	49.82	0.01	43.34	0
18	55.18	0.04	54.48	0.03	55.23	0.03	49.35	0.01	55.15	0.04	52.02	0.02	45.96	0
19	57.05	0.06	56.45	0.05	57.18	0.06	51.59	0.01	57.07	0.06	54.05	0.03	48.41	0
20	58.78	0.1	58.26	0.09	58.97	0.1	53.7	0.03	58.84	0.1	55.94	0.05	50.7	0.01
21	60.39	0.16	59.94	0.14	60.58	0.16	55.66	0.04	60.48	0.16	57.69	0.08	52.87	0.02
22	61.86	0.25	61.48	0.22	62.09	0.25	57.48	0.07	61.97	0.25	59.32	0.13	54.85	0.04
23	63.26	0.37	62.86	0.33	63.47	0.38	59.2	0.12	63.37	0.38	60.8	0.19	56.72	0.06
24	64.55	0.54	64.18	0.48	64.75	0.56	60.8	0.18	64.66	0.55	62.22	0.29	58.41	0.1
25	65.76	0.77	65.41	0.69	65.93	0.8	62.3	0.28	65.87	0.78	63.49	0.42	60.02	0.15
26	66.87	1.07	66.53	0.97	67.03	1.11	63.68	0.41	66.98	1.09	64.69	0.6	61.51	0.23
27	67.93	1.45	67.6	1.32	68.06	1.51	64.95	0.6	68.01	1.49	65.83	0.83	62.91	0.34
28	68.9	1.95	68.54	1.78	69.02	2.02	66.12	0.85	68.95	1.99	66.88	1.14	64.19	0.5
29	69.75	2.56	69.45	2.35	69.89	2.65	67.21	1.17	69.83	2.61	67.86	1.52	65.41	0.71
30	70.61	3.32	70.27	3.05	70.71	3.43	68.21	1.59	70.52	3.38	68.75	2.01	66.49	0.98
31	71.38	4.23	71.04	3.89	71.43	4.36	69.13	2.12	71.37	4.29	69.6	2.6	67.55	1.34
32	72.05	5.32	71.74	4.9	72.12	5.46	69.97	2.77	72.05	5.38	70.38	3.33	68.48	1.79
33	72.68	6.6	72.37	6.09	72.74	6.76	70.74	3.55	72.67	6.65	71.09	4.2	69.35	2.35
34	73.24	8.07	72.93	7.46	73.28	8.25	71.46	4.49	73.21	8.12	71.75	5.22	70.14	3.03
35	73.74	9.74	73.42	9.02	73.77	9.94	72.09	5.61	73.68	9.79	72.32	6.4	70.87	3.85
36	74.18	11.62	73.87	10.77	74.19	11.84	72.66	6.89	74.1	11.64	72.82	7.76	71.52	4.82
37	74.56	13.7	74.27	12.71	74.58	13.92	73.15	8.36	74.49	13.68	73.3	9.28	72.12	5.95
38	74.92	15.97	74.63	14.83	74.91	16.2	76.63	10	74.86	15.91	73.73	10.98	72.67	7.25
39	75.24	18.43	74.96	17.14	75.23	18.66	74.05	11.83	75.16	18.34	74.12	12.85	73.14	8.72

t (min)	T CH 2 (°C)	*Pv* CH 2	T CH 4 (°C)	*Pv* CH 4	T CH 5 (°C)	*Pv* CH 5	T CH 7 (°C)	*Pv* CH 7	T CH 8 (°C)	*Pv* CH 8	T CH 10 (°C)	*Pv* CH 10	T CH 11 (°C)	*Pv* CH 11
40	75.53	21.09	75.27	19.63	75.51	21.3	74.44	13.85	75.46	20.95	74.49	14.9	73.55	10.35
41	75.79	23.93	75.52	22.3	75.76	24.13	74.78	16.06	75.71	23.75	74.83	17.14	73.99	12.15
42	76.02	26.94	75.77	25.13	75.98	27.13	75.07	18.44	75.92	26.71	75.1	19.55	74.35	14.14
43	76.2	30.11	75.96	28.13	76.13	30.27	75.33	21	76.1	29.81	75.33	22.12	74.67	16.31
44	76.36	33.43	76.1	31.26	76.27	33.53	75.55	23.7	76.26	33.05	75.55	24.84	74.96	18.63
45	76.49	36.86	76.25	34.5	76.39	36.9	75.76	26.56	76.37	36.4	75.74	27.68	75.18	21.12
46	76.59	40.4	76.35	37.85	76.48	40.35	75.93	29.55	76.46	39.84	75.89	30.66	75.41	23.74
47	76.66	44.02	76.42	41.27	76.55	43.88	76.07	32.66	76.53	43.36	76.03	33.74	75.58	26.5
48	76.74	47.71	76.5	44.76	76.62	47.47	76.17	35.88	76.6	46.93	76.14	36.93	75.72	29.37
49	76.81	51.46	76.59	48.31	76.7	51.12	76.33	39.16	76.66	50.56	76.28	40.2	75.86	32.34
50	76.8	55.27	76.55	51.93	76.72	54.84	76.37	42.57	76.65	54.25	76.28	43.57	75.98	35.4
51	76.57	59.07	76.32	55.52	76.65	58.57	76.22	46.02	76.47	57.92	75.96	46.94	76.09	38.55
52	76.06	62.68	75.79	58.92	76.42	62.24	75.78	49.34	76.09	61.44	75.26	50.07	76.11	41.78
53	75.31	65.89	74.99	61.93	76.01	65.72	74.99	52.35	75.53	64.67	74.18	52.74	76.05	45.02
54	74.35	65.58	73.96	64.44	75.48	58.89	73.88	54.85	74.83	67.51	72.76	54.82	75.85	48.22
55	73.27	70.74	72.82	66.42	74.8	71.69	72.57	56.79	74.02	69.92	71.25	56.32	75.56	51.27
56	72.19	72.43	71.58	67.94	74.07	74.09	71.25	58.23	73.05	71.93	69.83	57.38	75.1	54.13
57	71.13	73.75	70.31	69.08	73.34	76.12	69.99	59.28	72.03	73.53	68.52	58.14	74.45	56.7
58	70.15	74.78	69.1	69.93	72.62	77.83	68.85	60.08	71.05	74.8	67.3	58.7	73.68	58.91
59	69.3	75.6	67.96	70.58	71.94	79.29	67.8	60.89	70.1	75.81	66.27	59.13	72.83	60.77
60	68.55	76.28	66.98	71.08	71.28	80.53	66.86	61.17	69.17	76.62	65.37	59.47	71.93	62.29
61	67.89	76.85	66.11	71.47	70.61	81.6	66.03	61.55	68.35	77.28	64.63	59.74	71	63.53
62	67.29	77.33	65.32	71.8	70.01	82.51	65.28	61.87	67.61	77.82	63.99	59.97	70.05	64.53
63	66.77	77.76	64.67	72.07	69.44	83.31	64.64	62.14	66.99	78.28	63.42	60.17	69.12	65.33
64	66.31	78.14	64.1	72.3	68.9	84	64.08	62.37	66.48	78.68	62.96	60.35	68.27	65.98
65	65.93	78.48	63.63	72.5	68.43	84.62	63.63	62.57	66.05	79.03	62.58	60.5	67.5	66.51
66	65.6	78.79	63.23	72.69	67.98	85.18	63.24	62.76	65.69	79.35	62.25	60.65	66.8	66.96
67	65.31	79.08	62.93	72.85	67.58	85.67	62.92	62.92	65.39	79.64	61.96	60.78	66.24	67.34
68	65.03	79.35	62.63	73.01	67.22	86.13	62.65	63.08	65.11	79.92	61.72	60.9	65.72	67.67
69	64.8	79.6	62.4	73.16	66.85	86.55	62.42	63.23	64.84	80.18	61.49	61.02	65.26	67.97
70	64.59	79.84	62.18	73.29	66.54	86.93	62.23	63.36	64.6	80.42	61.33	61.13	64.87	68.24
71	64.38	80.07	62	73.42	66.23	87.29	62.05	63.5	64.38	80.65	61.15	61.24	64.52	68.48
72	64.19	80.29	61.84	73.55	65.94	87.62	61.92	63.62	64.18	80.86	61	61.35	64.19	68.71
73	64.02	80.49	61.69	73.67	65.67	87.94	61.81	63.75	63.99	81.07	60.84	61.45	63.91	68.92

CH, thermocouple channel. For all channels, In the green zone, Pv values showed rapid gain with increasing temperature the Red zone represents the interval of 40 min < Pv < 80 min. In the blue zone, only slight or no further increases were recorded.

To effectively implement HACCP principles, it is crucial to utilize microbiological data gathered during the system's validation. Additionally, the HACCP system should be verified throughout the implementation process (*Konstantinos T et al.*, 2014).

It is necessary to compare the reported results with existing thermal profiles to determine the accuracy of the measuring instruments in the Schroter chamber. The P*v* values obtained in this study, i.e., 61.45 min – 81.07 min, were comparable to those found in other, similar research (*Raseta et al.*, 2021)

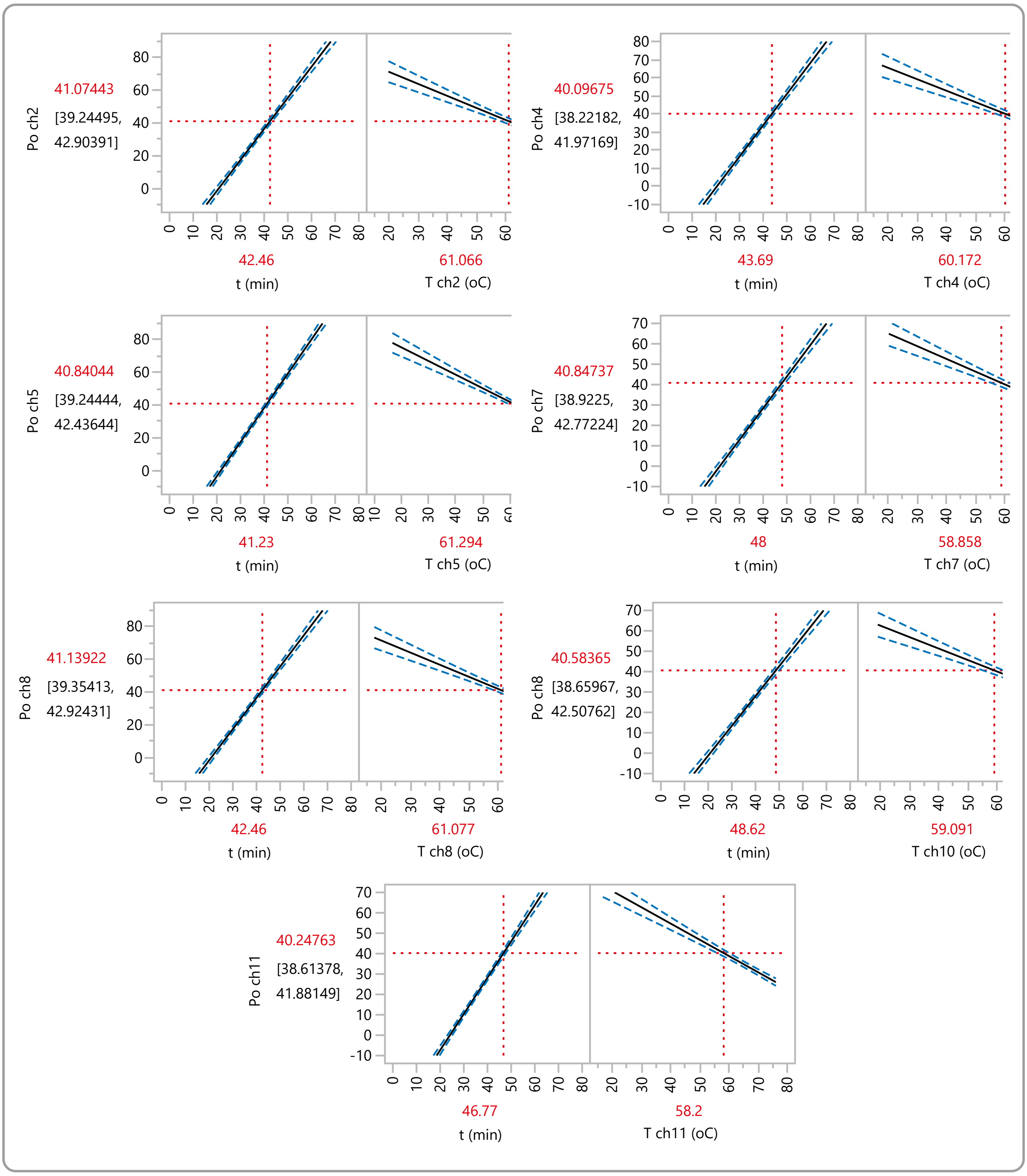

Figure 3. Theoretical modeling and predictive model for further improvement of the pasteurization process of the studied sausages

on optimized finely chopped cooked sausages with a wider diameter (75–90 mm), wherein *Pv* values were 58.4 min to 97.64 min.

Theoretically, according to the statistical model applied in the current study, it would be possible for the food business operator to further optimize the pasteurization process, by maintaining the chamber temperature at 60°C, which would achieve $Pv > 40$ min after 50 minutes of heating. This lower-tempreature pasteurization regime would expose the sausages to significantly lower temperatures, which 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.

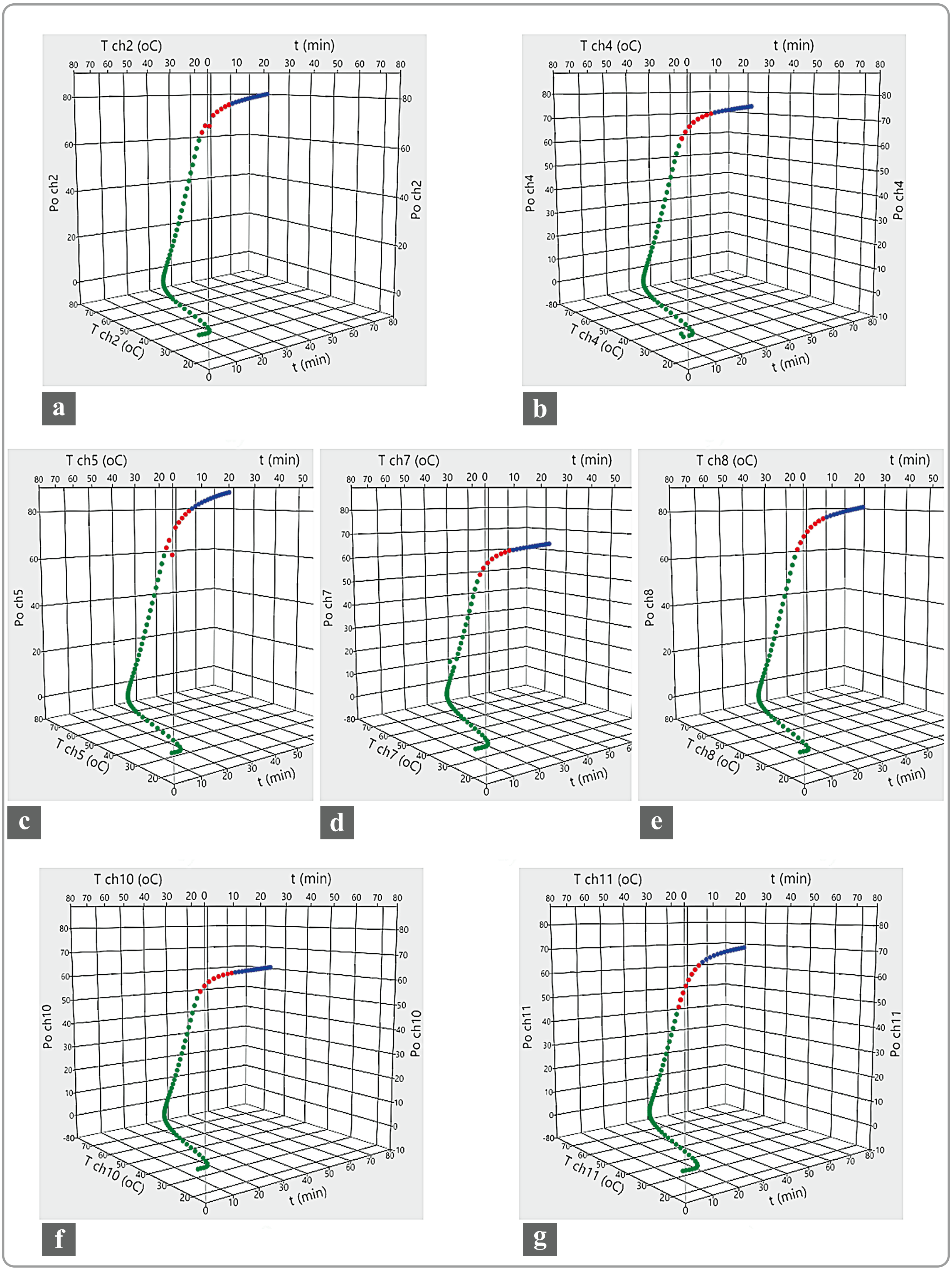

Figure 4. 3D scatter plots of pv value vs time and temperature in sausage centers as recorded by thermocouple probe channels: a) channel 2; b) channel 4; c) channel 5; d) channel 7; e) channel 8; f) channel 10; g) channel 11. Colors of data points correspond to the colors in Table 1

4. Conclusion

Thermal pasteurization is a crucial process in the meat industry for producing high-quality sausage products that have an extended shelf life if they are correctly stored at the specified refrigeration temperatures.

Validation of the pasteurization temperature of 74°C was performed by determining the *Pv* value achieved in the thermal centers of the studied sausages. The *Pv* values were within the range of 61.45 min – 81.07 min.

Theoretically for the studied sausages, the pasteurization process could be optimized. The suggested pasteurization regime suggested by the authors is 50 minutes of heating with the temperature maintained at 60°C, according to the applied MLR statistical model, which would achieve a *Pv* > 40 min. This suggested lower-tempreature pasteurization regime would expose the product to significantly lower temperatures than currently is the case, which 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.

The food business operator now has the opportunity to oversee the entire thermal processing process, with a good level of control over the entire process and ensuring the safety of their finely ground, cooked sausages in any zone of the pasteurization chamber. Nonetheless, validation of any change to the pasteurization regime is needed to produce documented evidence that provides a high degree of assurance that the specific process will consistently produce sausages that meet the business' predetermined specifications and quality attributes.

Validacija pasterizacije fino usitnjenih barenih kobasica užeg dijametra

Mladen Rašeta, Ivana Branković Lazić, Boris Mrdović, Nikola Betić, Becskei Zsolt, Jelena Jovanović i Radivoj Petronijević

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

Pasterizacija je fizički metod konzervacije proizvoda od mesa, koja efikasno unišata vegetativne oblike mikroorganizama i inaktivira tkivne enzime, primenom temperature ispod 100°C. Bezbednost i održivost fino usitnjenih kobasica, pakovanih u poliamidni omotač dijametra 50 mm, težine 220 grama je osigurana postupkom pasterizaicje u trajanju od 47 minuta. Pasterizacija je u komori sprovedena po definisanom programu termičke obrade koja podrazumeva izlaganje proizvoda delovanju zasićene vodene pare na temperaturi medijuma od 80°C. Nakon postupka toplotne obrade u istoj komori proizvod je hlađen u vremenu od 25 minuta. U svim mestima provere postignuta je temperatura od 74°C u termalnom centru (Kanali termokapla 2, 4, 5, 7, 8, 10 i 11), uz postizanje *pv* vrednosti u opsegu od 61,45 min (Kanal 10) do 81,07 min (Kanal 8). Postizanjem navedenih *pv* vrednosti validovana je temperatura od 74°C u termalnom centru fino usitnjenih barenih kobasica užeg dijametra, pakovanih u poliamidni omotač, kao adekvatna za osiguranje bezbednosti pod definisanim uslovima čuvanja hladnog lanca.

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Authors info

Mladen Rašeta, https://orcid.org/0000-0001-9860-6681

Ivana Branković Lazić, https://orcid.org/0009-0005-5844-9278

Boris Mrdović, https://orcid.org/0009-0006-9964-4317

Nikola Betić, https://orcid.org/0000-0002-7375-6752

Becskei Zsolt, https://orcid.org/0000-0001-8724-5892

Jelena Jovanović, https://orcid.org/0000-0003-0301-729X

Radivoj Petronijević, https://orcid.org/0000-0002-3901-3824