Scientific Papers. Series D. Animal Science. Vol. LXVIII, No. 1, 2025
ISSN 2285-5750; ISSN CD-ROM 2285-5769; ISSN Online 2393-2260; ISSN-L 2285-5750

ENHANCING PORK TENDERLOIN QUALITY PARAMETERS THROUGH SOY PROTEIN ISOLATE BRINE-INJECTION

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Abstract

This study aimed to evaluate the influence of soy protein isolate on the quality parameters of pork tenderloin to obtain a product with improved characteristics. Four experimental batches were prepared: a control batch (without soy protein isolate) and three batches injected with brine containing 1%, 2%, and 3% soy protein isolate, based on the weight of the meat. The injection process was carried out under controlled conditions. All batches were analysed from a physico-chemical perspective, and sensory evaluation was conducted by a panel of 50 semi-trained evaluators to assess product acceptability. The addition of soy protein isolate had a positive effect on water retention capacity and texture improvement. Treated batches showed increased values for parameters associated with mechanical resistance and a decrease in cohesion. CIELab colorimetric analysis indicated a significant increase in the treated samples` L (lightness) values, while the a* (redness) component decreased. Overall, the results demonstrated that injecting pork tenderloin with up to 3% soy protein isolate leads to qualitative changes, with sensory acceptability being more favorable for the 1% and 2% treated batches.*

***Key words**: brine injection, plant-based protein additives, pork tenderloin optimization.*

INTRODUCTION

Protein of animal origin plays an important role in human consumption, representing an indicator of the economic status of the population, and consumers are showing increasing interest in the health and functionality of the food they consume (Anchidin et al., 2023). Meat is the raw material that provides essential nutrients such as proteins, fats, vitamins, minerals and essential amino acids, providing an overall energy supply to the human body (Chiurciu et al., 2024).

Meat processing is associated with a health risk, an aspect that can be improved by reducing the components used in the meat meal, with studies highlighting that their reduction may lead to technological limitations (Ciobanu et al., 2024a).

From a consumption point of view, pork and pork preparations are the most consumed types of meat globally, and their improvement is important to ensure consumer health and satisfaction (Covaciu et al., 2024).

Modern meat processing technologies utilize the injection of brines into the meat material, followed by mechanical treatments such as tenderizing, thus the salting process has a diffusive-osmotic character and its acceleration is achieved by the combined application of physical and chemical methods (Dementieva et al., 2021; Ciobotaru et al., 2024). For obtaining meat preparations, the most optimal solutions are the injection of multicomponent brines, which in addition to the main additions include functional elements such as soy protein isolate (Anchidin et al., 2024).

The aim of the study was to evaluate the impact of brine injection with added soy protein isolate in pork tenderloin. The main objectives of the study were to make the product and to analyse qualitative parameters, with focus on the analysis of textural and colour parameters on heat treated products.

MATERIALS AND METHODS

In order to achieve the proposed objectives, it was proposed to develop three types of brine-injected pork tenderloin with the addition of 1, 2 and 3% soy protein isolate (SPI). The pork tenderloin was purchased from a local producer in Iasi County, SAGROD S.A, and the isolate was purchased from Redis Nutrition, without flavors and sweeteners.

For the realization of the experimental batches, the procedure described by Flocea et al. (2024) for the preparation of pork tenderloin (*Psoas major muscle*) was followed, these being carried out in the micro production workshop of USV Iași.

The preparation of the brine was carried out in four variants, the first one being used for the control batch, and the others, in which soy protein isolate was added in proportions of 1, 2 and 3% in the basic brine with a reduced salt concentration, according to Table 1. Each batch was injected in a proportion of 10% by mass of meat.

Tabel 1. Formulation of brine solution

Brine components	CB	B1	B2	B3
M.U.	%			
Water	97	96	95	94
Salt	2.5			
Soy protein isolate	0	1	2	3

CB – control brine, B1 – brine 1% addition, B2 – brine 2% addition, B3 – brine 3% addition.

The heat treatment stages were performed according to the protocol described in the previous study (Ciobotaru et al., 2024) applied for the smoked chop assortment, using the smoking cell. The process included the technological steps of lifting, smoking, cooking, maintaining the same time and temperature conditions (Table 2).

Tabel 2. Heat treatment parameters applied to the product

Heat treatment	Time (min)	Temperature (°C)
Air drying	30	65
Smoking	30	72
Hot air cooking	50	86

After obtaining the finished product, the experimental batches were subjected to physico-chemical analysis, carried out in the laboratory of meat and meat preparations technology of USV Iași. The determination of the parameters related to the chemical composition was carried out as described by (Ciobanu et al., 2024b), using the FoodCheck infrared spectrophotometer, determining the parameters moisture, fat, protein, collagen and salt content.

The colour was determined using Chroma Meter CR-410 colorimeter (Konica Minolta Inc., Japan) in the CIELAB scale according to the procedure performed by Manoliu et al. (2023).

The TA Plus Texturometer (AMETEK/Lloyd Instruments) with a maximum measuring capacity of 500 N was used to determine textural parameters.

For the determination of textural parameters, the samples were prepared in cylindrical form of 2 x 2 cm hexagonal dimensions using a standard device. The determinations were performed using the Warner-Bratzler test for shear force evaluation (shear force - N and mechanical shear work - mJ) and compression test for texture profile analysis (TPA), for the analysis of hardness, elasticity, cohesivity and adhesion parameters. The samples were analyzed within 24 hours after processing and maintained at 0-4°C.

The instrument was operated and data were recorded using NEXYGENPlus software, which allows precise control of the test parameters. The software also facilitates the extraction of textural parameters based on predefined formulas and integration zones.

The sensory evaluation of the experimental batches was carried out in the sensory analysis laboratory under controlled lighting and isolation conditions and was performed with the help of 50 semi-trained evaluators. The sex ratio of assessors was 15 males and 45 females, aged between 20-22 years and consumers of pork products. To understand the product, the evaluators went through a training process which consisted of presentation of the finished product, explanation of the specific attributes of the meat products as well as the attributes targeted in the session.

For the actual conduct of the evaluation session, the samples were uniformly portioned and randomly coded with a 3-digit code and served at optimal temperature. The online Google forms platform was used to create the questionnaire, which was structured by each attribute (appearance, odour, taste, aroma and texture) using the intensity scale from 1 to 9 where 1 represents extremely unpleasant and 9 extremely pleasant.

To analyse consumer preferences for pork samples injected with soy protein isolate (SPI), an affective sensory evaluation was performed, followed by a multivariate analysis using the Preference Mapping (PrefMap) method. The aim of this method was to correlate the preference scores given by consumers with the sensory positioning of the samples in principal component space.

Four pork tenderloin samples were analysed, coded as follows:

243 - control lot, no addition of SPI (pork tenderloin injected with basic brine only);

141 - pork tenderloin injected with 1% soy protein isolate;

351 - pork tenderloin injected with 2% soy protein isolate;

611 - pork tenderloin injected with 3% soy protein isolate.

All these analyses were performed using XLSTAT, an add-in software for Microsoft Office Excel (Trial Version 2025, Addinsoft, Paris, France. The results are expressed as mean ± standard deviation.

RESULTS AND DISCUSSIONS

The results obtained for the chemical composition of the batches with soy protein isolate and the control batches are shown in Table 3. Following the addition of soy protein isolate it can be observed that the moisture content increased progressively, being directly proportional to the amount of isolate added. Astfe, the values ranged from the control batch (76.96%) to 74.96% for the 3% injected batch. The differences for this parameter are significant (p = 0.030), which indicates that the addition of soy protein isolate increases the moisturizing capacity of the meat, as it retains water better. Similar studies indicate a similar trend, such as that of Ha et al. (2019), who observed moisture increases in meat preparations injected with vegetable protein.

The values obtained for dry matter ranged from 20.88% for the control batch to 25.05% for the 3% batch with a significant difference between the results (p = 0.030). The results obtained indicate an indirect relationship with moisture, as higher water content dilutes the solid components. The injection of soy protein isolate in the experimental batches increased the value of crude protein content, obtaining values ranging from 21.24% (1% injection) - 21.74 (3% injection) compared to the control batch (20.88%), an increase due to a better retention capcaity of the protein fractions in meat Zhang X. et al. (2024).

Collagen recorded values ranged from 19.08% for the control group, and the highest value was recorded for the 3% injected group of 19.72%. Analyzing the results, these can be correlated with a lipid dilution resulting from higher water retention and increased total mass by injection. In the study by Do Santos Junior et al. (2020), they demonstrate that the addition of soy protein isolate to pork results in improved protein networks and textural properties.

Table 3. Mean (± standard deviation) of physico-chemical parameters for the samples of injected pork tenderloins

Samples	Statistical estimators	Physico-chemical parameters (%)						
		Humidity	Dry Matter	Protein	Colagen*	Fat	Salt	pH
LC0%	X̄±sx	72.96 ± 0.07	27.04 ± 0.07	20.88 ± 0.10	19.08 ± 0.10	4.46 ± 0.05	1.54 ± 0.05	6.13 ± 0.01
LISP1%		73.22 ± 0.06	26.78 ± 0.06	21.24 ± 0.07	19.26 ± 0.05	4.18 ± 0.05	1.32 ± 0.04	6.08 ± 0.02
LISP2%		73.98 ± 0.06	26.02 ± 0.06	21.48 ± 0.04	19.46 ± 0.05	3.18 ± 0.12	1.24 ± 0.05	5.95 ± 0.02
LISP3%		74.96 ± 0.09	25.04 ± 0.09	21.74 ± 0.04	19.72 ± 0.06	2.04 ± 0.11	1.18 ± 0.04	5.72 ± 0.04
	p value	0.030	0.030	0.029	0.030	0.017	0.051	0.030

Values are given as means ± Standard deviation from five repeated determinations. Means with different superscripts in a row orientation indicate significant differences (p < 0.05) between samples determined by the Tukey test. *Collagen content is expressed as % from the total protein content.

The addition of soy protein isolate decreased the fat content in the treated batches, with significant differences (p = 0.017). The control batch recorded values of 4.46% while the experimental batches recorded values ranging from 4.18% (1% batch), 3.18% (2% batch) and 2.04% (3% batch). The decrease can be explained by the dilution of lipids but also by the injection process which contributed to the partial dispersion of lipids during processing. A constant decrease in the salt content is observed, being the highest in the control batch (1.54%) reaching the minimum average value (1.18%-3% batch). This indicates that this type of addition influences the salt content by increasing the moisture content of the samples, leading to a significant reduction in the salt content and is in line with current consumer requirements. The pH values followed a decreasing trend registering 6.13 for the control batch, while the experimental batches recorded values ranging from 6.08 to 5.72. The decrease in pH may be attributed to the slightly acidic character of the soy protein isolate as well as the injection process. The color parameters (L*, a*, b*, C*, h°) are represented in Table 4.

Chromatic analysis performed on the injected experimental batches (LC0%, LISP1%, LISP2%, LISP3%) shows significant changes in color parameters depending on the treatment applied, reflecting the compositional and structural impact of soy protein isolate on the optical characteristics of the product.

Table 4. Mean (± standard deviation) of colour parameters for the samples of injected pork tenderloins

Parameters	Batches				p-value
	LC0%	LISP1%	LISP2%	LISP3%	
L*(D65)	69.322±1.352	71.912±0.519	72.352±0.582	71.02±0.687	0.034
a*(D65)	12.81±0.244	8.394±0.318	9.606±0.299	7.900±0.470	0.003
b*(D65)	8.394±0.395	9.200±0.501	8.310±0.676	8.448±0.281	0.032
C*	15.319±0.196	12.138±0.333	11.817±0.612	12.797±0.079	0.010
h°	33.230±1.567	49.337±2.829	44.655±2.037	41.334±1.800	0.072

L*(D65) – lightness (ranging from 0 = black to 100 = white); a*(D65) – red-green component (positive values = red tones, negative values = green); b*(D65) – yellow-blue component (positive values = yellow tones, negative values = blue); C* – chroma (reepresents the color saturation or intensity, higher values indicate more vivid colors); h* – hue angle (expresses the dominant color tone); Values are given as means ± Standard deviation from five repeted determinations. Means with different superscripts in a row orientation indicate significant differences (p < 0.05) between samples determined by the Tukey test.

The values of the lightness parameter (L*) were significantly higher for the batches injected with soy protein isolate (p = 0.034), indicating a tendency for the meat color to open up after the treatments. As regards the intensity of the a* (red-green) coordinate, a significant reduction (p = 0.003) was observed for the experimental batches, with the most marked decrease being recorded by batch LISP3 (7.900±0.470). For coordinate b* (blue-yellow), the LISP1 sample showed a slight enhancement of yellow nutation compared to the control batch.
The C* parameter was significantly lower in the treated batches, especially in LISP2% (11.817) and LISP1% (12.138) compared to LC0% (15.319). This indicates a decrease in color saturation, i.e. a duller, less vivid color. The result is consistent with the decreases observed in a* and suggests that SPI treatments may induce a 'masking' effect on the natural pigmentation of the meat.
Although the nunaune angle (h°) showed an increase for injected batches, the differences were not significant (p = 0.072).
The analysis of the textural parameters of the injected muscle, presented in Table 5, shows significant differences between the samples treated with soy protein isolate at various concentrations (LISP1%, LISP2%, LISP3%) compared to the control (LC0%), highlighting the direct influence of this component on the mechanical properties of muscle tissue.

Table 5. Mean (± standard deviation) of texture parameters for the samples of injected pork tenderloins

Analyzed parameter	Sample				*p-value*
	LC0%	LISP1%	LISP2%	LISP3%	
Shear force (N/cm^2)	12.700 ± 2.209	15.593 ± 3.184	10.870 ± 2.248	11.386 ± 3.061	0.018
Work of shear (mJ)	488.516 ± 192.215	436.063 ± 62.696	318.379 ± 67.726	439.969 ± 115.028	0.017
Hardness (N)	31.953 ± 8.941	31.691 ± 6.187	21.534 ± 3.454	26.609 ± 6.991	0.079
Cohesiveness (N)	0.186 ± 0.082	0.273 ± 0.214	0.349 ± 0.235	0.241 ± 0.140	0.553
Elasticity	0.127 ± 0.022	0.156 ± 0.032	0.109 ± 0.022	0.114 ± 0.031	0.059
Gumminess (N)	6.040 ± 3.136	9.262 ± 8.542	6.962 ± 3.489	6.898 ± 4.930	0.811
Chewiness (N)	0.795 ± 0.456	1.424 ± 1.295	0.736 ± 0.348	0.880 ± 0.769	0.529
Adhesiveness	1.615 ± 0.481	0.961 ± 0.072	0.693 ± 0.044	0.660 ± 0.0318	<0.0001

Values are given as means ± Standard deviation from five repeated determinations. Means with different superscripts in a row orientation indicate significant differences (p < 0.05) between samples determined by the Tukey test.

The force required to shear the samples varied significantly between batches (p = 0.018). LISP1% batch showed the highest value (15.593 ± 3.184 N/cm²), significantly higher than LISP2% and LISP3% batches. This result indicates an increase in cutting resistance when a low percentage of protein isolate is added, an effect possibly due to protein networks formed as a result of the interaction between the meat proteins and the soy isolate proteins. However, higher concentrations appear to decrease this resistance, possibly due to protein dilution or a more gel-like texture.

Shear-associated mechanical work values follow the same trend as the shear force ($p = 0.017$), with a maximum value in the control batch (488.516 ± 192.215 mJ), followed by a decrease in LISP1% and LISP2%. This reduction in required energy may reflect a decrease in internal structural cohesion as a result of the applied treatment.

The hardness, defined as the maximum force registered at first compression, did not show significant differences between batches ($p = 0.079$), although a clear tendency of reduction was observed in the treated batches, especially in LISP2% and LISP3%. This result is in agreement with the literature, which highlights the ability of soy protein isolate to interact with myofibrillar proteins, modifying the protein network and conferring a softer texture.

The parameters cohesiveness ($p = 0.553$) and elasticity ($p = 0.059$) did not show statistically significant differences between batches, although a slight increase in cohesiveness in the treated batches and a slight decrease in elasticity in the LISP2% batch were observed. These variations could be attributed to the reorganization of the protein networks in the presence of the isolate, but without significantly affecting the viscoelastic behavior of the product.

Gumminess was higher in the LISP1% batch, consistent with the increased values of hardness and cohesion. However, these differences were not statistically significant ($p = 0.811$). Similarly, chewiness, resulting from the product of gumminess and elasticity, followed the same pattern ($p = 0.529$). These parameters suggest that, at low concentrations, soy protein isolate contributes to a more consistent texture, while at higher concentrations, the structure becomes more brittle and chewable.

Of all parameters analyzed, adhesivity ($p < 0.0001$) was the most affected by treatment, decreasing significantly in the injected batches. The maximum value was recorded in the control batch (1.615 ± 0.481 N-s), while the values in the treated batches decreased progressively, reaching the minimum in LISP3% (0.660 ± 0.031 N-s). This decrease indicates better homogeneity and a less sticky surface, traits favored by the modified protein network and potentially of technological interest for packaging and handling.

Similar to the observations in the present study, Lin and Barbut (2025) reported that the addition of soy protein isolate influences meat textural properties and water-holding capacity, these effects being dependent on the level of substitution and initial moisture composition.

The PrefMap plot, shown in Figure 1, illustrates consumer preferences for meat samples injected with soy protein isolate (SPI) at different concentrations. By applying the external preference mapping method, the hedonic preference data are projected into the sensory space defined by the first two principal components (F1 and F2), providing a clear picture of the relationship between the sensory profile of the products and the degree of liking expressed by different consumer clusters.

The external preference mapping method was used to correlate consumers' hedonic data with the sensory profiles of the products, projected in the space formed by the first two main components (F1 and F2). The initial interpretation of the graph focuses on the positioning of the four analyzed samples (243 - control, 141 - 1% SPI, 351 - 2% SPI, 611 - 3% SPI) in distinctly colored areas of the map. These colors correspond to consumers' preference levels, where red indicates the area with the highest liking (above 80%) and blue represents the area with the lowest preference level (between 20% and 40%).

Sample 141 (1% SPI) is located in the upper-left quadrant, in the orange area (60-80% preference), close to the preference direction of Cluster 2. This suggests that the sample is moderately liked, especially by consumers with expectations oriented towards sensory characteristics such as uniform color, characteristic odor and balanced taste.

Sample 243 (control batch) is located close to the origin, but still in the orange zone. This reflects an average preference, supported in particular by consumers in Cluster 3, who appear to have a more conservative preference orientation, perhaps valuing the traditional characteristics of colour, smell and taste.

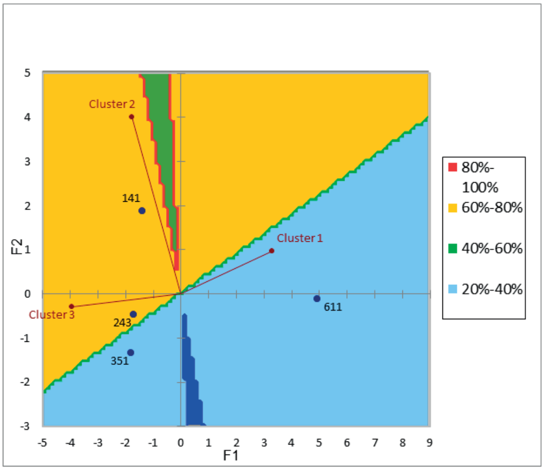

Figure 1. Positioning of the four pork chop samples injected with soy protein isolate (SPI) according to the preferences expressed by consumers in the sensory evaluation. The following samples were analyzed: 243 - control (without SPI), 141 - 1% SPI, 351 - 2% SPI and 611 - 3% SPI.

Sample 141 (1% SPI) is located in the upper-left quadrant, in the orange area (60-80% preference), close to the preference direction of Cluster 2. This suggests that the sample is moderately liked, especially by consumers with expectations oriented towards sensory characteristics such as uniform color, characteristic odor and balanced taste.

Sample 351 (2% SPI) is positioned in the blue zone, close to Cluster 3, indicating that only a small proportion of the evaluators showed appreciation. It is possible that this sample suffered in terms of taste or texture, or had an unconvincing combination of attributes.

Sample 611 (3% SPI) lies in a region marked in blue (20-40% preference), positioned on the positive F1 axis, but at a significant distance from all three preference clusters. This positioning indicates a low appreciation from all consumer segments and a possible lack of sensory alignment with their general expectations. It may be perceived as having an excessively firm texture, modified taste or exaggerated elasticity.

CONCLUSIONS

Our results suggest that injecting pork tenderloin with soy protein isolate significantly influences certain textural properties, in particular shear strength, mechanical shear work and adhesiveness. While low isolate concentrations (1%) appear to improve consistency and shear strength, higher doses lead to a decrease in these characteristics. The significant decrease in adhesiveness may be a functional advantage in the context of further product handling and processing. From a technological point of view, the adaptation of soy protein isolate concentration needs to be carefully calibrated to achieve the desired balance between consistency, palatability and manipulability.

The data obtained indicate that the addition of soy protein isolate causes significant changes in the color of the injected meat, reflected in increased brightness and decreased red intensity and color saturation. These changes may have both technological and sensory implications, as color is a critical factor in consumer acceptability. From an industrial perspective, these effects should be taken into account in recipe optimization, especially if the final product aims at a visual appearance close to that of untreated meat.

REFERENCES

Anchidin, B. G., Lipsa, F. D., Manoliu, D. R., Ciobanu, M. M., Ciobotaru, M. C., Gucianu, I., & Boisteanu, P. C. (2024). Enhancing antioxidant capacity in functional meat products through infusion with sea buckthorn oil to combat inherent antioxidant deficiency. *Scientific Papers. Series D. Animal Science*, *67*(1), 366–380.

Anchidin, B. G., Manoliu, D. R., Ciobotaru, M. C., Ciobanu, M. M., Gucianu, I., Sandu, G. A., & Boisteanu, P. C. (2023). Development of a functional meat product with sea buckthorn oil and analysis of its sensory and physicochemical quality. *Scientific Papers. Series D. Animal Science*, *66*(1), 370–376.

Chiurciu, I.-A., Vlad, I. M., Stoicea, P., Zaharia, I., David, L., Soare, E., Fîntîneru, G., Micu, M. M., Dinu, T. A., Tudor, V. C., & Smedescu, D. I. (2024). Romanian meat consumers' choices favour sustainability? *Sustainability*, *16(*24), 11193.

Ciobanu, M. M., Mădescu, B.-M., Flocea, E.-I., Ciobotaru, M. C., Manoliu, D. R., Anchidin, B. G., Gucianu, I., & Boișteanu, P. C. (2024a). Impact of disodium diphosphate on the colorimetric profile in a meat product with heterogeneous structure: An analysis in actual technology. *Scientific Papers. Series D. Animal Science*, *67*(1), 389–394.

Ciobanu, M. M., Ciobotaru, M. C., Gucianu, I., Boișteanu, P. C., & Manoliu, D. R. (2024b). Impact of bone broth on protein content, color, and consumer preferences in emulsified chicken and turkey frankfurters. *Scientific Papers. Series D. Animal Science*, *67*(1), 395–403.

Ciobotaru, M. C., Manoliu, D.-R., Ciobanu, M. M., & Boișteanu, P. C. (2024). Influence of salting method on quality parameters of sheep pastrami produced at U.S.V. Iași through traditional and extensive methods. *Animal & Food Sciences Journal Iasi*, 150–157.

Covaciu, F.D., Feher, I., Cristea, G., & Dehelean, A. (2024). Nutritional quality and safety assessment of pork meat cuts from Romania: Fatty acids and elemental profile. *Foods*, *13*(5), 804.

Dementieva, N. V., Sakharova, O. V., Fedoseeva, E. V., Bogdanov, V. D., & Botsova, T. M. (2021). The substantiation of technological regimes of production of refrigerated semi-finished products from Japanese mackerel with prolonged storage time. *IOP Conference Series: Earth and Environmental Science*, *640*(3), 032010.

Do Santos Junior, A. C., Oliveira, R. F. D., Henry, F. D. C., Maia Junior, J. D. A., Moulin, M. M., Della Lucia, S. M., Quirino, C. R., Martins, M. L. L., & Rampe, M. C. C. (2020). Physicochemical composition, lipid oxidation, and microbiological quality of ram mortadella supplemented with *Smallanthus sonchifolius* meal. *Food Science & Nutrition*, *8*(11), 5953–5961.

Flocea, E.-I., Ciobanu, M. M., Anchidin, B. G., Ciobotaru, M. C., Manoliu, D.-R., Gucianu, I., Matei, M., & Boișteanu, P. C. (2024). Evaluation of the impact of artificial additive on physicochemical quality parameters in a functional meat product with heterogeneous structure. *Scientific Papers. Series D. Animal Science*, *67*(1), 443–450.

Ha, J.-H., Lee, J.-H., Lee, J.-J., Choi, Y.-I., & Lee, H.-J. (2019). Effects of whey protein injection as a curing solution on chicken breast meat. *Food Science of Animal Resources*, 39(3), 494–502.

Lin, W., & Barbut, S. (2025). Impact of five soy proteins on lean chicken breast systems with varying moisture contents: Cooking loss, texture, microstructure, and T2 NMR. *Foods*, *14*(3), 427.

Manoliu, D.R., Ciobanu, M.M., Ciobotaru, M.C., Postolache, A.N., Anchidin, B.G., & Boișteanu, P.C. (2023). Physico-chemical and sensory evaluation of three types of pork mortadella manufactured in the IULS meat processing microsection. *Scientific Papers. Series D. Animal Science*, *66*(2), 527–531.

Zhang, X., Wu, Y., Li, Y., Zhang, M., & Li, B. (2024). Soy protein isolate with higher solubility and improved gel properties via pH-shifting treatment. *International Journal of Food Science*, *59*(4), e17242.

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