Effects of marination processes on physicochemical traits of breast meat following thermal treatment

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Keywords: breast muscles, marination, thermal processing, quality

SUMMARY:

The objective of the study was to evaluate the impact of marination processes additions on the quality traits of raw breast meat subjected to baking and boiling. The raw material for the study were breast meats obtained from 36-day old Ross 308 broiler chickens, that were subjected to Protostal® TP phosphate marination processes. Tests to measure the physicochemical traits of both pickled and non-pickled meat subjected to thermal treatments were carried out, regarding such parameters as pH (Hanna HI99163 pH meter), meat colouration using the CIE L*a*b* system (Konica Minolta, Japan), the cutting force (resistance testing machine Zwick/Roell, Germany), Kjeldahl overall protein method (Foss Tecator, Sweden), fat using Soxhlet method (Büchi Extraction System B-811, Switzerland), ash by drying (Carbolite AAF1100 oven, UK), and product yield. The influence of marination on the physicochemical properties of raw breast meat, subjected to thermal treatment was demonstrated. The raw breast meat subjected to marination processes was characterized by better tenderness (lower cutting force of 2.27 N), brighter colour (higher brightness colouration L* parameter and lower red a* parameter) as well as higher water absorption capacity (of 1.44%) when compared with non marinated breast meat. The influence of marination and thermal treatment methods on product yield and its tenderness was also demonstrated. The highest yield of 79.29% was characteristic of marinated breast meat subjected to boiling processes, while the least of 73.27% was observed in non marinated breast meat, subjected to baking processes. The best tenderness (the lowest cutting force of 17.68 N) was characteristic of marinated breast meat, subjected to boiling processes, while the highest (21.76 N) was with non marinated, baked meat. The impact of marination on the colour parameters of breast meat subjected to thermal treatment as well as the impact of thermal treatment on fat and protein content were also demonstrated.

Wpływ procesu marynowania na cechy fizykochemiczne mięśni piersiowych po obróbce termicznej

Słowa kluczowe: mięśnie piersiowe, marynowanie, obróbka termiczna, jakość

STRESZCZENIE:

Celem badań była ocena wpływu procesu marynowania na cechy jakościowe surowych mięśni piersiowych oraz poddanych pieczeniu i gotowaniu. Surowcem do badań były mięśnie piersiowe pozyskane od 36-dniowych kurcząt brojlerów Ross 308, które poddano procesowi marynowania z wykorzystaniem fosforanu Protostal®TP. W ocenie cech fizykochemicznych mięśni piersiowych surowych i poddanych obróbce termicznej (niemarynowanych i marynowanych) uwzględniono: pH (pehametr Hanna HI99163), barwę mięśni w systemie CIE L*a*b* (Konica Minolta, Japonia), siłę cięcia (maszyna wytrzymałościowa Zwick/Roell, Niemcy), białko ogólne metodą Kjeldahla (Foss Tecator, Szwecja), tłuszcz metodą Soxhleta (Büchi Extraction System B-811, Szwajcaria), popiół metodą suszenia (piec Carbolite AAF1100, Wielka Brytania) oraz wydajność produktu. Wykazano wpływ marynowania na cechy fizykochemiczne surowych mięśni piersiowych i poddanych obróbce termicznej. Surowe mięśnie piersiowe poddane procesowi marynowania charakteryzowały się lepszą kruchością (niższą siłą cięcia o 2,27 N), jaśniejszą barwą (wyższym parametrem jasności L* i niższym parametrem czerwieni a*) oraz wyższą wodochłonnością (o 1,44%) w porównaniu do mięśni piersiowych niemarynowanych. Wykazano wpływ marynowania i metod obróbki termicznej na wydajność produktu i jego kruchość. Największą wydajnością (79,29%) charakteryzowały się mięśnie piersiowe marynowane poddane procesowi gotowania, najmniejszą (73,27%) mięśnie piersiowe niemarynowane poddane procesowi pieczenia. Najlepszą kruchością (najniższą siłą cięcia 17,68 N) cechowały się mięśnie piersiowe marynowane i poddane procesowi gotowania, najwyższą niemarynowane pieczone (21,76 N). Wykazano wpływ marynowania na parametry barwy mięśni piersiowych po obróbce termicznej oraz wpływ metody obróbki termicznej na zawartość tłuszczu i białka.

1. INTRODUCTION

The marination of chicken breast has been known for ages. The choice of the marinade ingredients and marination techniques has continued to undergo improvements to make sure the final product meets consumers' expectations [21].
Marination processes as well as thermal treatment methods do impact on the chemical composition as well as the quality features of chicken meat [1, 2, 10]. The heightened consumer interest in pickled meat products is not only due to their beneficial impacts on sensory and physicochemical traits. This is also due to the high degree of comfort when preparing meals, including time savings in cooking [3]. Phosphates (phosphates of phosphoric V acid) are common additives in marination processes in meat processing industry. The additives should, irrespective of the marination technique, be added in accordance with Good Manufacturing Practices (GMP) as well as with the provisions of the Regulation of the European Commission (UE) No 1129/2011 of 11 November 2011 [8].

The objective of the study was to evaluate the influence of the results of marination with phosphate Protostal®TP additives on the physicochemical traits of breast meat subjected to baking and boiling.

2. MATERIAL AND METHODS

The raw material for the study were breast meat pieces obtained from 36-day old ROSS 308 broiler chickens. The slaughtering took place in required production conditions in a local slaughter house. The broiler chicken carcasses (of 2000 ±50 g average weight) were transported in secured chilled to the laboratory of the department of animal production and evaluation of poultry products, where they were dissected to obtain 40 pairs of prepared breast meat portions. The meat portions were weighed, labelled and divided into two groups, consisting of 40 individual pieces of breast meat not subjected to marination processes (group A) and the second also consisting of 40 pieces subjected to marination processes

(group B). Breast meat samples from both groups A and B were further sub-divided for the assessment of physicochemical properties of raw material (n=10), boiling treatment (n=15) and baking treatment (n=15). The physicochemical evaluation of the raw breast meat was carried out within 24 hours after slaughtering, accompanied with the marination process.

The marinade was prepared 24 hours prior to its application for testing and stored at 4°C. The marinade consisted of water (20%), salt (1.5%), sugar (1.5%), lemon juice (1.2%), Protostal®TP phosphate (0.5%) and dried herbs (1.2%). The marinade was formulated based on the proportion of meat. The marination process involved immersing the breast meat (group B) in the prepared marinade. The pickled samples were then sealed in air-tight plastic containers, stored in a refrigerator over a 24-hour period at 4°C, and occasionally being shaken.

The assessment of the physicochemical traits of raw breast meat subjected to thermal treatment (groups A and B) involved the pH measured with a dagger electrode using the Hanna HI 99163 pH meter; water absorption using the Grau and Hamm methodology; color assessment using Chroma Meter colorimeter (Konica Minolta Osaka, Japan) with a CR 400 head, according to the CIE LAB system, L*a*b* scale (standard observer 2o, light source D65); tenderness based on the cutting force (Fmax) of the Zwick/Roell BT1-FR1. OTH.D14 resistance machine (Zwick GmbH & Co. KG, Ulm Germany), a Warner-Bratzler knife with a head speed of 100 mm··min^{-1} and initial force of 0.2 N (a meat of 100 mm^2 thickness and 50 mm in length was cut); the chemical composition involving nitrogen content measured using the Kjeldahl method (Foss Tecator set, Höganäs, Sweden), which was converted into protein using a factor of 6.25 [15]; fat using the Soxhlet method (Büchi Extraction System B-811 apparatus, Flawil, Switzerland) [16] and as well as the total ash through the total mineralization of the sample (Carbolite AAF1100 muffle furnace, Hope Valley, UK) [17]. The thermal treatment for non-pickled and pickled breast meat included baking (electric oven, temperature of 180°C) and boiling. The treatment methods tested in this study involved using the thermal treatment to achieve breast meat internal temperature of 80 ±2°C. The test samples were weighed to the nearest 1 g prior to and after the cooking process. The quality assessment of breast meat subjected to thermal treatment followed the same pattern as for the raw breast meat. Moreover, the post cooking quality assessment of the meat involved the yield of the finished product, calculated by determining the weight difference before and after the thermal treatment.

The results obtained were statistically verified using the Statistica 12 software. The arithmetic mean ($\bar{x}$), standard deviation (SD), and the standard mean error (SEM) were considered in the study. The significance of differences ($p \leq 0.05$) between mean values of the physicochemical properties of raw breast meat for groups A and B were verified using the T-student test. The major effect (a – marination effect; b – thermal treatment effect) and effects of interactions between the factors (a × b) were determined using the two-factor analysis of ANOVA variance. The significance of differences between the mean values in the groups was estimated by means of the Tukey's test. The differences were assumed to be statistically significant ($p \leq 0.05$), while cases of insignificant differences were denoted as „ns" (statistically insignificant).

3. RESULTS AND DISCUSSION

The influence of marination on the physicochemical traits of raw breast meat of broiler chickens is illustrated in Table 1. The capacity of meat to absorb water is an important technological indicator of its suitability for processing purposes. While this depends on the meat's pH, that of the pickled meat depends on the constituents of the marinade [10]. The current study has indicated a significant ($p \leq 0.05$) impact of the marination process on the increased water absorption capacity of raw breast meat. The results obtained correspond to those of Komoltri and Pakdeechanuan [9] as well as Sokołowicz and Augustyńska-Prejsnar [20]. Marinated raw breast meat was characterized by brighter coloration, as evidenced by the significant ($p \leq 0.05$) increase in the brightness (L*) parameter and a decline in redness colour saturation (a*). The results obtained for the brightness indicator (L*) were similar to those achieved by Bianchi et al. [4], Casco et al. [5] as well as Sokołowicz and Augustyńska-Prejsnar [20]. These were, however different from those obtained by Qiao et al. [14]. A less redness coloration (a*) in meat immersed in

Table 1 Influence of marination process on the physicochemical factors of raw chicken breast muscles ($\bar{x}$ ± SD)

Specification	Breast muscles		
	A	B	SEM
pH	5.94 ±0.14	5.96 ±0.12	0.06
water holding capacity (%)	24.68 [a] ±5.37	26.12 [b] ±5.73	0.80
colour			
L*	50.18[a] ±5.65	54.89 [b] ±5.05	0.70
a*	1.30 [a] ±0.23	0.98 [b] ±0.70	0.08
b*	5.10 ±2.03	4.92 ±1.58	0.22
shear force (N)	14.82[a] ±1.07	12.06[b] ±0.97	0.32
crude protein (%)	24.11 ±0.91	23.52 ±1.17	0.12
fat (%)	1.52 ±0.13	1.43 ±0.25	0.04
ash (%)	0.92 ±0.33	0.78 ±0.85	0.18

A – non marinated breast muscles; B – marinated breast muscles; a, b – means with different letters in lines differ significantly (p≤0.05)

a base marination solution was observed by Gorsuch and Alvarado [7]. The current study has indicated significant differences (p≤0.05) in the cutting force of raw breast meat. Raw breast meat that had been pickled showed characteristically less cutting force. Pickled meat, according to Komoltri and Pakdeechanuan [8] is characterized by less cutting force due to the weakening of the myofibreli structures because of the higher water content. The influence of marination on the chemical composition of breast meat was not demonstrated.

Since colour is one of the sensory attributes of food, it greatly influences the choice, acceptance and consumption of food [12, 13]. The current study has revealed that marination significantly (p≤0.05) reduces the brightness colour after thermal treatments (Tab. 2). The results obtained are similar to those by Zhuang and Bowker [21]. Smith and Young [19] demonstrated that the saturation of the redness colour of post thermally treated meat increases with phosphate additions. Higher saturation of yellow colour (b*) in pickled meat was also demonstrated by Qiao et al. [14]. However, results obtained by Sokołowicz and Augustyńska-Prejsnar [20] differed. The current study also demonstrated the effects of thermal treatment methods on the variation of the brightness parameter (L*) (Tab. 2). Changes to the colour of thermally treated meat depends on the degree of denaturation of the myoglobin part of protein relative to the duration and temperature of heating, while the colour of pickled meat depends on the pH and composition of the marinade as well as the meat colour prior to its marination [6, 9-11]. The heating process alters the durability of the intracellular connective tissues as well as the meat's tenderness [13]. The influence of marination, thermal treatment methods and the interaction of these factors on the meat's tenderness was demonstrated in the current study. Less cutting force (Fmax) which translates to mean greater tenderness was characteristic of baked meat that had been previously pickled (Tab. 2). The results thus obtained correspond to those in studies by Komoltri and Pakdeechanuan [9], where the benefitting impact of high temperatures as well as the constituent of the marinade on the meat's tenderness was demonstrated. Studies by Augustyńska-Prejsnar and Sokołowicz [3] as well as Sokołowicz and Augustyńska-Prejsnar [20] also indicated benefitting influences of marination on the tenderness of thermally treated broiler chicken meat. The current study has also shown that both the marination process and thermal method had significant (p≤0.05) influence on the product yield. Higher thermal (cooking) losses were observed as a result of boiling (Tab. 2). The results achieved in this study are consistent with those of Bianchi et al. [4], where lower loss was observed when pickled breast meat was boiled. The efficiency of pickled products depends on the constituents of the marinade and salt concentration. Weight loss increases with the temperature of the thermal process, its duration, humidity and fat con-

Table 2 Influence of marination process and thermal methods on the physicochemical factors of chicken breast muscles ($\bar{x}$ ± SD)

Specification	Breast muscles				SEM	Impact		
	A		B					
	I	II	I	II		a	b	a × b
pH	5.97 ±0.10	6.09 ±0.12	5.80 ±0.08	6.11 ±0.10	0.01	ns	ns	ns
colour: L*	82.99 ±2.11	86.98 ±3.63	80.62 ±2.91	82.10 ±3.34	0.21	*	*	ns
a*	2.32 ±0.31	1.85 ±0.19	2.93 ±0.75	2.15 ±0.39	0.06	*	ns	ns
b*	11.85 ±1.46	10.63 ±0.79	11.75 ±1.10	13.38 ± 0.99	0.12	*	ns	ns
shear force (N)	21.01 ±2.43	21.76 ±2.43	17.68 ±3.80	18.51 ±2.81	0.45	*	*	*
product yield (%)	77.00 ±1.93	73.27 ±3.29	79.29 ±2.98	75.31 ±1.41	0.29	*	*	*
crude protein (%)	32.90 ±1.52	33.85 ±1.22	30.34 ±1.12	29.12 ±1.64	0.40	ns	*	ns
fat (%)	1.69 ±0.30	2.29 ±0.47	2.04 ±0.23	2.62 ±0.35	0.15	ns	*	ns
ash (%)	0.99 ±0.14	0.87 ±0.25	1.10 ±0.20	0.88 ±0.12	0.28	ns	ns	ns

A – non marinated breast muscles; B – marinated breast muscles; I – baking method; II – boiling method; a – impact of marination; b – impact of thermal methods; a × b – impact of marination and thermal methods; * – statistically significant differences p≤0.05; ns – differences statistically insignificant

tent [19]. The current studies have shown the significant (p≤0.05) influence of thermal treatment on the nutritive value of breast meat (Tab. 2). Boiled breast meat was characterized with higher fat content but lower protein content. No impact of the marination process on the chemical composition of the breast meat was observed (Tab. 2). This is, however, contrary to results obtained by Mudalal et al. [12] and Latif [10].

4. CONCLUSION

The influence of marination on the physicochemical properties of raw breast meat, subjected to thermal treatment was demonstrated. The raw breast meat subjected to marination processes was characterized by better tenderness (lower cutting force of 2.27 N), brighter colour (higher brightness colouration L* parameter and lower red a* parameter) as well as higher water absorption capacity (of 1.44%) when compared with unmarinated breast meat.

The influence of marination and thermal treatment methods on product yield and its tenderness was also demonstrated. The highest yield of 79.29% was characteristic of marinated breast meat subjected to boiling processes, while the least of 73.27% was observed in non marinated breast meat, subjected to baking processes. The best tenderness (the lowest cutting force of 17.68 N) was characteristic of marinated breast meat, subjected to boiling processes, while the highest (21.76 N) was with non marinated, baked meat. The impact of marination on the colour parameters of breast meat subjected to thermal treatment as well as the impact of thermal treatment on fat and protein content were also demonstrated.

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