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EFFECT OF LACTIC ACID CONCENTRATION ON THE QUALITY OF MARINATED BROILER BREAST FILLETS®

Wpływ stężenia kwasu mlekowego na jakość marynowanych filetów drobiowych®

*The aim of the study presented in this paper was to evaluate the effect of lactic acid concentration in marinade on the quality of baked chicken breast fillets. Poultry fillets were marinated in 1, 2 and 4% lactic acid solution. The evaluation of physical characteristics of fillets included measuring pH, assessing color according to the L*a*b* scale, as well as water absorption and tenderness of meat. The organoleptic evaluation included the intensity and desirability of the aroma, the intensity and desirability of the flavor, as well as the juiciness and tenderness of meat. Lactic acid marinating was shown to affect the brightness (L*), as well as red a* and yellow b* color saturation of the fillets. Marinating in 1 and 2% lactic acid solution had beneficial effects on physicochemical and sensory characteristics of marinated poultry meat after baking, whereas marinating in 4% lactic acid solution caused deterioration of flavor and smell of baked meat.*

Key words: broiler chickens fillets, marinating, lactic acid, sensory properties.

*Celem badań przedstawionych w artykule była ocena wpływu stężenia kwasu mlekowego w marynacie na jakość pieczonych filetów z piersi kurcząt brojlerów. Filety drobiowe marynowano w 1, 2 i 4% roztworze kwasu mlekowego. W ocenie cech fizycznych filetów uwzględniono pomiar pH, ocenę barwy w skali L*a*b* oraz wodochłonność i kruchość mięsa. W ocenie organoleptycznej uwzględniono natężenie i pożądalność zapachu, natężenie i pożądalność smaku oraz soczystość i kruchość mięsa. Wykazano, że marynowanie kwasem mlekowym ma wpływ na jasność (L*) oraz wysycenie barwy czerwonej a* i żółtej b* barwy filetów. Marynowanie w 1 i 2% roztworze kwasu mlekowego miało korzystny wpływ na cechy fizykochemiczne i sensoryczne marynowanego mięsa drobiowego po pieczeniu, natomiast marynowanie w roztworze kwasu mlekowego o stężeniu 4% spowodowało pogorszenie smaku i zapachu mięsa pieczonego.*

Słowa kluczowe: filety drobiowe, marynowanie, kwas mlekowy, cechy sensoryczne.

INTRODUCTION

Marinating is increasingly used in the culinary processing of poultry meat to increase the attractiveness and variety of poultry products. During the marinating process, meat is treated with a marinade solution containing various acids [8, 20]. The marinating process can be performed with the dipping method or the injection method [1, 21]. The dipping method involves immersing the meat in a marinade solution. During this process, the marinade solution is absorbed by the meat through diffusion. Marinating meat with acidic marinades is a widespread method of improving the quality characteristics, taste, and smell of meat, as well as extending its shelf life [23]. The marinating process is particularly important in the case of broiler chicken meat, as it brings out its delicate flavor, aroma, and color [1, 16, 19, 23, 26]. Previous studies have shown that marinating also improves the quality and yield of the product [13, 18]. Marinating also affects the juiciness and tenderness

of the meat [1]. The effectiveness of the marinating process is affected by numerous factors, including the marinating method and time, as well as the type and pH of the marinade [1, 2, 3, 4]. The pH of the marinade affects, among other things, the water retention capacity, tenderness, juiciness, and color of the meat [15, 16, 23].

Lactic acid and its salts, as well as cultures of lactic acid bacteria may be ingredients of acidic marinades [25].

The aim of the study was to evaluate the effect of lactic acid concentration in marinade on the quality of baked poultry fillets.

MATERIALS AND METHOD

To evaluate the effect of lactic acid concentration on meat quality, 40 breast muscles (fillets) of broiler chickens purchased at retail were used and randomly assigned to four

groups. Group K consisted of unmarinated fillets, group KM-1 of fillets marinated with 1% lactic acid, group KM-2 of fillets marinated with 2% lactic acid and group KM-3 of fillets marinated with 4% lactic acid. The fillets were marinated using the immersion method for 2 hours.

pH measurements were achieved using a dagger electrode, fitted with a (HI 99163 from Hanna) pH meter.

Sample's water holding capacity (WHC) determined using the Grau and Hamm method was based on the amount of juice squeezed from it.

The reading of the measurement results was achieved in a CIE LAB colorimetric system, with L* (lightness), a* (redness) and b* (yellowness). Brittleness was measured based on the cutting force (Fmax), using a Zwick/Roell machine BT1-FR1.OTH.D14 (from Zwick CmbH& Co.KG. Ulm, Germany), applying a wide-width Warner-Bratzler (V-blade) with a head speed of 100 mm·min⁻¹ and a 0.2 N pre-cut force. The cutting was carried out on not marinated and marinated breast muscles with a cross section of 100 mm² and length of 50 mm). Weight loss (%) was calculated based on the weight difference before and after heat treatment.

Not marinated and marinated breast muscles were weighed with an accuracy of 0.1 g and processed using an electric oven at 180°C to achieve a temperature of 80°C±2°C inside the muscle sample. The temperature inside the muscles was measured with a digital thermometer with an external K-type thermocouple probe (Therma plus, England), then cooling at room temperature. The colour assessment of the cross-sectional surface of not marinated and marinated breast muscles was determined, based on the reflection method, using the Chrome Meter colorimeter (Konica Minolta Osaka, Japan), fitted with a CR 400 head (ø=11mm).

In the organoleptic evaluation of baked unmarinated and marinated fillets, the following were considered: intensity and desirability of smell, intensity, and desirability of taste, as well as juiciness and tenderness. The organoleptic evaluation was

carried out by a team of 7 people on a 5-point scale, where 1 point meant the least desirable evaluation and 5 points the most desirable.

The obtained data were collated and submitted for statistical analysis using Statistica 13.3 (StatSoft, Visual Basic, TIBCO Software Inc., PL) Significant differences between the means in groups were estimated with Duncan's test. The differences were considered to be statistically significant when P<0.05. The results on the effect of marinating on sensory properties of roast products were verified with the use of non-parametric Kruskal-Wallis tests. Differences were considered as significant if P<0.05.

RESULTS AND DISCUSSION

The results of studies conducted to determine the effect of lactic acid concentration in the marinade on the quality of raw and heat-treated broiler chicken meat are presented in Tables 1–3.

In our study, the pH value of raw non-marinated poultry meat was 5.74, which indicates that meat intended for marinating, due to its pH, was normal meat, not affected by DFD or PSE type defects. This result is close to the one obtained by [12]. The acidity of poultry meat marinated with marinade containing 1, 2 and 4% lactic acid was lower than that of unmarinated meat (p<0.05) (Table 1). The study showed that as the concentration of lactic acid in the marinade increased, the pH of meat decreased. In addition, the results of studies by other authors have shown that the pH of breast muscle after marinating with acidic marinades depends on the marinade pH [21,22]. Acidity of poultry meat (pH) is an important factor determining its usefulness not only for technological purposes, but also for consumption. pH plays an important role in shaping the physical characteristics of poultry meat, such as color, water absorption and tenderness of meat.

Table 1. Effect of lactic acid concentration in marinade on physicochemical properties of raw poultry fillets

Tabela 1. Wpływ stężenia kwasu mlekowego w marynacie na cechy fizykochemiczne surowych filetów drobiowych

Parameter	Group			
	K	MK-1	MK-2	MK-3
pH	5,74 ±0,08 ^a	5,68 ±0,02 ^b	5,41 ±0,03 ^c	5,27 ±0,05 ^d
WHC (%)	10,50 ±0,71 ^a	12,00 ±1,41 ^b	12,50 ±0,71 ^b	10,50 ±1,12 ^a
Colour:				
L* - lightness	66,08 ±0,24 ^a	65,19 ±0,54 ^a ^b	66,55 ±0,47 ^a ^b	68,52 ±0,07 ^b
a* - redness	1,61 ±0,16 ^a	1,00 ±0,09 ^b	-0,21 ±0,13 ^c	0,56 ±0,11 ^d
b* - yellowness	6,01 ±0,11 ^a	6,70 ±0,11 ^b	6,69 ±0,16 ^b	7,46 ±0,13 ^c
Shear force (N)	8,92 ±0,54 ^a	7,26 ±0,34 ^b	7,63 ±0,06 ^c	9,16 ±0,59 ^a

K-control group – non-marinated, MK-1 – marinated with 1% lactic acid, MK-2 marinated with 2% lactic acid, MK-3 marinated with 4% lactic acid

Explanations: ($\bar{x} \pm s$) arithmetic mean±standard deviation, the mean values in rows with different letters differ significantly p < 0.05

Objaśnienia: ($\bar{x} \pm s$) średnia arytmetyczna ± odchylenie standardowe, wartości średnie oznaczone różnymi literami w wierszach różnią się statystycznie istotnie przy p ≤ 0.05

Source: Own study

Źródło: Opracowanie własne

Water holding capacity (WHC), defined as water absorption of poultry meat, is a decisive factor in terms of its processing and technological usefulness. In our study, marinated broiler chicken meat was characterized by higher water absorption than meat marinated in lactic acid solution (Table 1). Similar results were obtained by [21]. Poultry meat color is one of the most important characteristics for consumers when choosing the meat to buy. Color is also one of the most important quality characteristics of meat, determining its suitability for processing [20, 21, 26]. The color of poultry meat depends on muscle pigments, including deoxymyoglobin responsible for dark red color, light red color is provided by oxymyoglobin, and grey-brown color is determined by metmyoglobin. Light red is the most desirable color for consumers, while the grey-brown is the least desirable color [6, 10, 24]. When analyzing the results obtained in the original study in terms of color measurement (Table 1), it was found that marinating chicken breast muscle fillets in marinade with 1% and 2% lactic acid had no significant effect on the color lightness (L^*) of meat, while marinating in marinade with 4% lactic acid solution resulted in meat color brightening ($p < 0.05$). The study also confirmed the effect of marinating on the color saturation parameter towards red a^* and yellow b^* (Table 1). A similar direction of changes in red color's brightness and saturation was found by [21] in studies on the color of chicken breast muscles marinated in acidic marinade.

Tenderness and juiciness are the two main textural characteristics of poultry meat. Myofibrillar proteins and muscle fiber cytoskeleton proteins play the most important role in forming meat tenderness [9]. Heat treatment also plays an important role in the texture development of broiler chicken meat, as heating denatures proteins, making the meat firmer [17]. In our study, meat marinated in 4% lactic acid solution (MK-3) was characterized by the highest cutting force (9.16 N), whereas meat marinated in 1% lactic acid solution (MK-1) was characterized by the lowest one, matching the results of the studies by Marcinkowska-Lesiak et al. [14]. The obtained results indicate good tenderness of the meat, as according to Corzo et al. [7], the cutting force value of broiler chicken meat suitable for the impression of tenderness should not exceed 30 N.

The results of pH and meat color measurement after roasting showed that, similarly to raw meat, the pH value of marinated poultry fillets decreased with the increase of lactic acid concentration in the marinade (table 2.). The meat marinated in 4% marinade (MK-3) had the lowest pH value after baking, whereas the meat marinated in 1% lactic acid (MK-1) had the highest pH value. The results showed that higher concentrations of lactic acid (4%) in the marinade not only caused acidification of raw marinated meat, but this acidification also persisted after heat treatment. The results obtained are similar to those obtained by [2, 3, 4] who achieved similar pH measurement results in studies on breast muscles of organically raised hens with buttermilk and whey.

In the conducted study, marinated meat after heat treatment did not differ from unmarinated meat ($p < 0.05$) in terms of the L^* parameter, yet there was an increase in the a^* red color saturation in the marinated meat. The saturation of yellow color (b^*) in the meat marinated with marinade containing 1 and 2% lactic acid concentration was higher than in unmarinated meat ($p < 0.05$). The obtained results correspond to the results of the study [3] and to the results obtained by [5], who stated that during marinating, there are no significant changes in the meat brightness parameter L^* , while there is an increase in the saturation of red a^* and yellow b^* colors.

Measurements of the cutting force of heat-treated fillets showed a decrease in the value of this parameter compared to raw meat, in case of meat marinated with 2% and 4% lactic acid, while the greatest increase in the cutting force was observed in case of meat marinated with 1% lactic acid. The obtained results prove that higher concentration of lactic acid in marinade decreases the value of force needed to cut the roasted poultry meat, indicating increased tenderness of fillets after marinating.

Consumers most often associate marinated poultry meat with activities aimed at enhancing the sensory qualities of a product [11]. The conducted study (Table 3) indicates that marinating fillets using a marinade with a certain lactic acid concentration can have a beneficial effect on the sensory characteristics of the product, also after heat treatment.

Table 2. Effect of lactic acid concentration in marinade on physicochemical characteristics of baked poultry fillets

Tabela 2. Wpływ stężenia kwasu mlekowego w marynacie na cechy fizykochemiczne pieczonych filetów drobiowych

Parameter	Group			
	K	MK-1	MK-2	MK-3
pH	5,90 ±0,03 ^a	5,70 ±0,01 ^b	5,10 ±0,30 ^c	4,50 ±0,10 ^d
Colour:				
L^* - lightness	80,33 ±1,45	78,69 ±1,81	80,28 ±0,16	80,99 ±1,12
a^* - redness	1,30 ±0,07 ^a	1,88 ±0,31 ^b	2,15 ±0,28 ^b	1,95 ±0,07 ^c
b^* - yellowness	10,50 ±0,29	12,35 ±0,37	11,41 ±0,16	10,99 ±0,10
Shear force (N)	24,95 ±2,31 ^a	26,05 ±2,63 ^a	20,85 ±3,53	21,85 ±4,86

K-control group control group – non-marinated, MK-1 – marinated with 1% lactic acid, MK-2 marinated with 2% lactic acid, MK-3 marinated with 4% lactic acid

Explanations: ($\bar{x} \pm s$) arithmetic mean ± standard deviation, the mean values in rows with different letters differ significantly $p \leq 0.05$

Objaśnienia: ($\bar{x} \pm s$) średnia arytmetyczna ± odchylenie standardowe, wartości średnie oznaczone różnymi literami w wierszach różnią się statystycznie istotnie przy $p \leq 0.05$

Source: Own study

Źródło: Opracowanie własne

Table 3. Effect of lactic acid concentration in marinade on sensory attributes of baked poultry fillets**Tabela 3. Wpływ stężenia kwasu mlekowego na cechy sensoryczne pieczonych fileatów drobiowych**

Traits	Group			
	K	MK-1	MK-2	MK-3
Odour intensity	4,36±0,28 ^a	4,18±0,31 ^a	4,96±0,21 ^b	4,82±0,31 ^b
Flavour intensity	3,85±0,22 ^a	3,54±0,20 ^a	4,48±0,28 ^b	4,96±0,27 ^b
Odour desirability	4,36a ±0,20	4,56 ^a ±0,32	3,56 ^b ±0,27	3,20 ^b ±0,32
Odour desirability	4,18±0,31 ^a	4,62±0,34 ^a	3,62±0,21 ^b	3,00±0,34 ^b
Juiciness	4,27±0,31 ^a	4,94±0,27 ^b	5,00±0,22 ^b	4,18±0,18 ^a
Tenderness	3,85±0,22 ^a	4,18±0,31	4,94±0,18 ^b	4,92 ±0,31 ^b

K-control group control group – non-marinated, MK-1- marinated with 1% lactic acid, MK-2 marinated with 2% lactic acid, MK-3 marinated with 4% lactic acid

Explanations: ($\bar{x} \pm s$) arithmetic mean±standard deviation, the mean values in rows with different letters differ significantly $p < 0.05$

Objaśnienia: ($\bar{x} \pm s$) średnia arytmetyczna ± odchylenie standardowe, wartości średnie oznaczone różnymi literami w wierszach różnią się statystycznie istotnie przy $p \leq 0.05$

Source: Own study

Źródło: Opracowanie własne

The results of organoleptic evaluation of baked marinated fillets showed that poultry meat marinated in 2% and 4% marinade (MK-2 and MK-3) was characterized by the highest intensity of smell and flavor, whereas meat marinated in 1% marinade was characterized by the lowest intensity of these features. Meat marinated in 1% solution (MK-1) and unmarinated meat had the highest smell desirability, while meat marinated in 4% marinade had the lowest one. In terms of assessing the taste desirability, meat marinated in 1% lactic acid marinade received the highest marks, while meat marinated in 4% lactic acid received the lowest marks, as the sour taste of the marinade was perceptible during its evaluation. According to consumer assessment, juiciness is an important quality parameter of heat-treated meat. In our study, meat marinated in 1% and 2% marinade (MK-1 and MK-2) was characterized by the highest juiciness, whereas meat marinated in 4% marinade (MK-3) and unmarinated meat were characterized by the lowest juiciness. In our study, broiler chicken meat marinated in 2% lactic acid (MK-2) was characterized by the best tenderness, whereas meat not marinated received the lowest scores for this property.

The obtained results correspond to those obtained by [3,4] who, in a study of breast muscles marinated in buttermilk and whey, demonstrated that marinating has a beneficial effect on sensory characteristics of poultry meat.

SUMMARY

The study showed that the pH value of both raw and baked broiler chicken breast fillets decreased with the increasing lactic acid concentration in marinade. Marinating with lactic acid did not affect the brightness of color (L^*) but influenced the saturation of yellow b^* and red a^* colors of poultry fillets. Marinated muscles were characterized by lower cutting force, i.e., greater tenderness. Marinating in 1 and 2% lactic acid solution had beneficial effect on sensory attributes of baked poultry fillets, whereas marinating fillets with 4% lactic acid was less beneficial, because acidic marinade taste was perceptible in meat after baking.

PODSUMOWANIE

Przeprowadzone badania wykazały, że wraz ze wzrostem stężenia kwasu mlekowego w marynacie zmniejsza się wartość pH zarówno surowych jak i pieczonych fileatów z piersi kurcząt brojlerów. Marynowanie kwasem mlekowym nie miało wpływu na jasność barwy (L^*) ale miało wpływ na wysycenie barwy żółtej b^* i czerwonej a^* fileatów drobiowych. Mniejszą siłą cięcia, czyli większą kruchością charakteryzowały się mięśnie marynowane. Marynowanie w 1 i 2% roztworze kwasu mlekowego miało korzystny wpływ na cechy sensoryczne pieczonych fileatów drobiowych, natomiast marynowanie fileatów 4% kwasem mlekowym było mniej korzystne, gdyż po pieczeniu był wyczuwalny kwaśny posmak marynaty w mięsie.

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