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EFFECT OF TYPES OF PHOSPHATE PREPARATIONS USED ON THE QUALITY OF EMULSION-TYPE SAUSAGES

S u m m a r y

The objective of the research study was to determine the effect of phosphate preparations added in the form of 1 % aqueous solutions of various pH values on the quality of emulsion-type sausages. Four variants of sausages were manufactured: control variant with no phosphate preparations added (V1) and three variants with the phosphate preparations added: V2: 7.3; V3: 8.3; and V4: 9.7. The pH values of the meat batter and finished product were determined and the yield of the finished product was estimated. In the sausages studied, the total heme pigments and nitrosylhemochroms were determined and the heme pigment conversion degree was calculated. The texture parameters were measured and the sensory analysis of the emulsion-type sausages was performed. It was found that the addition of phosphate preparations impacted the pH value of the finished product, its yield, the total heme pigments and nitrosylhemochroms, as well as the heme pigment conversion degree. Moreover, a positive effect was reported of the added phosphate preparations on the texture of finished products (their hardness and chewiness) compared to the sausages with no phosphate preparations added. It was confirmed that it was advantageous to add, during the production process, phosphate preparations in the form of 1 % aqueous solutions of higher pH values to the emulsion-type sausages made from mechanically separated poultry meat; a proof thereof was, among other things, the increased yield of the finished product (from 117.9 % as for V1 to 122.8 % as for V4). The best results were obtained when the pH value of 1 % aqueous solutions of phosphate preparations was 9.7.

Key words: emulsion-type sausages, phosphate preparations, quality, texture

Introduction

Phosphate preparations are additives widely applied during the processing of meat [1 3, 5, 10, 11]. It is supposed that main mechanisms associated with the activity of phosphates in meat are as follows: dissociation of actomyosin complex, formation of

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pH values of the product, reinforcing the strength of ions in the surrounding environment and promoting the complex formation of divalent cations. Those functions are readily utilized in meat industry because the phosphates-based solutions are proven to impact the quality of meat products in many ways both during the production and the distribution processes. This fact is attributed to beneficial effects of phosphate preparations on water holding capacity (WHC) as well as on the rheological and sensory features of finished products [7]. The application of appropriate amounts of phosphates help manufacture meat products the features of which, such as: juiciness, tenderness, cross-section colour stability, easy-to-slice characteristics, and long shelf-life, are better [8, 12, 13, 17, 18, 19, 21]. The maximization of water-holding capacity of meat batters and the manufacturing of finished product with high overall acceptability characteristics in terms of consistency, colour, and flavour, depend, among other factors, on the composition and pH value of phosphate solutions. Owing to a wide range of pH values and their diverse composition, the phosphate-based solutions impact the quality of finished products in various ways [1, 15, 16]. In the industrial practice, blends of several phosphate preparations are applied to ensure the best technological results and to prevent precipitation of orthophosphates and di-phosphates in brine solutions containing calcium ions. In the reference literature, there are many publications on the impact of the amount of phosphates on the quality of processed meat products [4, 14, 20, 22]. However, there are very few scientific papers dealing with the issue of the effect of phosphates with various pH values of their 1% aqueous solution on the quality of emulsion-type sausages.

The objective of the present research study was to determine the effect of phosphate solutions (2000 mg/kg of meat batter expressed as P₂O₅) of various pH values on the quality of emulsion-type sausages. The results obtained should be regarded as important, in particular for the industrial manufacture of emulsion-type sausages.

Materials and methods

Preparing samples

The samples were made from a mechanically separated poultry meat, pork jowl, beef meat (consisting of 80 % of lean meat and 20 % of fat) and emulsion from pork rinds, which were produced in a medium-size meat processing plant in Poland (20 tons/shift) during the carcass fabrication therein.

The raw meat was a one-time purchase product divided into 4 batches that were vacuum packaged and stored at -20 ± °C for further analysis (the maximum storage time of refrigerated meat was 14 days). 18 h before the production of emulsion-type sausages started, relevant batches of pork jowl, beef meat, and emulsion from pork rinds were thawed at 4 ÷ °C. The following proportions of different meat types were

used to produce four various meat batters: mechanically separated poultry meat: 50%; pork jowl: 25 % beef meat: 15 % (consisting of 80 % of lean meat and 20 % of fat); emulsion from pork rinds: 10 %; and ice: 30 %. To make meat batters, non-meat ingredients, such as spices and functional additives, were also used, including: curing salts: 2 % (99.4 % of NaCl and 0.6 % of NaNO₂); phosphate solution: 0.35 %; curing enhancer: 0.2 %; smoke powder: 0.15 %; and flavouring agents: 0.4 %. The meat batters were enhanced with phosphates of varying pH values of their 1 % aqueous solution; they served as a differentiating factor for the analyzed variants of meat batters: V2: 7.3 (di- and triphosphates); V3: 8.3 (di-, tri-, and polyphosphates); V4: 9.7 (triphosphates). All the phosphate compounds contained 57 % of P₂O₅.

In the analysis performed under this study, the formulation of the product was based on a production practice of one meat processor specialized in this kind of product. The content and composition of phosphate preparations added were as declared in the declaration of their manufacturer (BK Giulini, Germany).

Manufacturing emulsion-type sausages

The formulations of all the subsequent meat batter preparations were made according to good manufacturing practice (GMP) in meat processing plants. The thawed pork jowl and beef meat were processed using a Mesko WN60 mincing machine (manufactured by Mesko, Skarżysko-Kamienna, Poland) that was equipped with a 3 mm plate. The meat was minced in a heavy-duty bowl cutter with rapidly moving blades of 3000 rpm (manufactured by GmbH & Co., Ulm, Germany) in a vacuum environment. The meat batter was prepared in three stages. In the first stage, the ingredients: beef meat, mechanically separated poultry meat, 1/3 of all the crushed ice, curing salts blend, and phosphate solution (appropriate for the sausages manufactured acc. to the formulation of V2-V4 variants) were emulsified for 1 minute. In the second stage, the emulsion of pork rinds and 1/3 of all the crushed ice were added; next, the whole homogenate was minced for 1.5 min. In the third stage, the pork jowl, the rest of the crushed ice, spices, and other functional additives were added. The meat batters were ground for another two minutes until their temperature reached the level of max 12°C. Then, using a hand sausage stuffer (manufactured by Friedr. Dick GmbH & Co. KG, Deizisau, Germany), 22 mm cellulose casings were filled with the ready meat batters; next, 15 cm long batons of stable weight were formed so as to guarantee a uniform fill in each casing. The encased sausages were held at 30 °C for 30 min and, afterwards, heated in a smoking-scalding chamber (manufactured by Jugema, Środa Wielkopolska, Poland) until their internal temperature became 72° C. The sausages were heated for 40 min. Subsequently, the sausages were cold showered for 10 min and, then, stored at 4 ÷ 6 °C for 24 h. In every production batch, approx. 2 kg of sausages of every variant were produced (approx. 40 batons of each product variant).

Ca. 24 h after the production was finished, physicochemical and sensory analyses were performed. Sausages designed for the physicochemical analysis were minced twice using a Zelmer Diana 886.8 mincing machine (manufactured by Zelmer, Rzeszów, Poland) equipped with a 3 mm plate.

Measuring pH values

Both the pH value of the meat batter and the finished product were evaluated using a CP-411 pH-meter calibrated with pH 4 and pH 7 buffers (manufactured by Elmetron, Zabrze, Poland). The pH level of the meat batter was measured by inserting a glass-calomel electrode and temperature compensation sensor directly into the analyzed meat batter. The pH level of the finished product was measured upon the completion of 24 h cooling (at 4 \div 6 °C). Prior to taking the pH values, 10 g of previously minced finished sausage and 30 cm³ of distilled water were placed in a 50 cm³ glass beaker; next, all the ingredients were thoroughly mixed and, then, left for 10 min.

Yield of finished product

Upon the completion of the planned 24 hr refrigeration of the sausages at 4 \div 6 °C, the yield of the finished product was assessed. The assessments were based on the weight differences between the pre- and post-cooking samples and they were expressed as %.

Content of total heme pigments, nitrosylhemochroms, and the heme pigment conversion degree

The content of total heme pigments and the heme pigment conversion degree were measured according to a method as described by Hornsey [9]. The absorbance was evaluated using a HITACHI-U-1100 reflectance spectrophotometer (Hitachi Corporation, Ltd., Tokyo, Japan). The heme pigment conversion degree was calculated using the following formula:

$$x = Nc/Nt \times 100 \%$$

where: Nc – content of nitrosylhemochrom,

Nt – content of total hem pigments.

Texture analysis

Double compression

A texture analysis of emulsion-type sausages was performed 24 h after the production. The texture readings were taken using a Zwicki 1120 texture analyzer (Zwick GmbH & Co., Ulm, Germany). Prior to the evaluation, the samples of 22 mm in diameter and 30 mm in height were stored at 20 \div 22 °C for 2 h. Those samples were com-

pressed twice between two parallel sheets of the apparatus. The head speed was set at 30 mm/min until the load cell sensed a 0.2 N force and 50 mm/min during the relevant analysis.

During the first cycle of compression, the sample was 50 % deformed. Once initiated, the second cycle continued until this value decreased upon the sample deformation. A testExpert software (v.12.0, 2006, Zwick GmbH & Co., Ulm, Germany) was used to calculate, based on the parameter descriptors, the values of the following parameters: springiness, cohesiveness, hardness, and chewiness. The analysis was replicated four times and an average was calculated from all four replicates.

The parameters were determined as follows: – hardness: maximum force value [N] at a first sample compression; – cohesiveness: ratio between the work performed during the second compression and the work performed during the first compression; – springiness: ratio between the second peak base and the first peak base; and – chewiness: product of firmness, cohesiveness, and springiness.

Warner-Bratzler shear force

A shear test was performed using a Zwicki 1120 texture analyzer. The samples were taken by cutting the emulsion-type sausages with a special Warner-Bratzler attachment equipped with an inverted V-cut. The crosshead speed was set at 30 mm/min until it reached 0.2 N pre-stress and, then, at 50 mm/min during the main analysis. The analysis was conducted until the sample was wholly cut.

Sensory evaluation

A sensory evaluation was carried out 24 h after the emulsion-type sausages were produced. A six-member sensory panel was selected to evaluate the product. The sensory analysis was performed using an unstructured intensity scale with anchors. The parameters: colour, odour, flavour, hardness, springiness, and overall acceptability of the sausages were evaluated. The sensory evaluation was replicated six times [2].

Statistical analysis

The results obtained were statistically analyzed using a Statgraphics 4.1. Plus software (Statistical Graphics Corp., Rockville, MD). All the data were analysed using an analysis of variance (One-Way ANOVA). Significant differences appearing among the features tested were verified by a Tukey's HSD test at a significance level of $p = 0.05$.

Results and discussion

The effect of phosphate compounds on the pH value of meat batter and emulsion-type sausages

One of the most important indicators of technological quality characteristics of meat and meat batters is their pH value. Based on the One-Way ANOVA analysis, it was proved that, although many phosphates of various pH values of their 1% aqueous solutions were applied, the addition of phosphate compounds did not have any significant ($p > 0.05$) effect on the pH value of meat batter (Tab. 1).

Table 1. pH values and yield of analyzed emulsion-type sausages

Tabela 1. Wartość pH oraz wydajność badanych kiełbas homogenizowanych

Characteristic Wyróżnik	Variant 1 Wariant 1 ($\bar{x} \pm SD / s$)	Variant 2 Wariant 2 ($\bar{x} \pm SD / s$)	Variant 3 Wariant 3 ($\bar{x} \pm SD / s$)	Variant 4 Wariant 4 ($\bar{x} \pm SD / s$)
pH of meat batter pH farszu	5.9 ± 0.1	6.1 ± 0.1	6.1 ± 0.1	6.1 ± 0.1
pH of finished product pH wyrobu gotowego	6.1 ^a ± 0.2	6.2 ^{ab} ± 0.1	6.3 ^b ± 0.1	6.3 ^b ± 0.2
Yield of finished product [%] Wydajność wyrobu gotowego	117.9 ^a ± 2.3	121.6 ^b ± 0.6	121.4 ^b ± 1.4	122.8 ^c ± 1.0

Explanatory notes: / Objaśnienia:

$\bar{x} \pm s / SD$ – mean value ± standard deviation / wartość średnia ± odchylenie standardowe; a, b – mean values in individual rows and denoted by different lower case letters differ statistically significantly ($p \leq 0.05$) / wartości średnie w poszczególnych wierszach oznaczone różnymi literami różnią się statystycznie istotnie ($p \leq 0.05$).

However, because of the salts of phosphoric acid used in the experiment an alkaline reaction occurred. Thus, their addition caused a slight shift in the pH value of meat batter manufactured according to a V2-V4 recipe towards the acidic region compared to the control meat batter (V1). The tendency observed in this study agrees with the results reported by other authors [4, 6].

The pH level of the finished product was significantly different ($p \leq 0.05$) depending on the variety of phosphate addition used (Tab. 1). The sausages containing phosphate compounds (V2-V4) had a higher pH compared to phosphate-free sausages (V1). Compared to the sausages manufactured without phosphate preparations (V1), the most significant increase in the pH value of sausages was reported in the products enhanced with phosphates the 1 % aqueous solutions of which had a pH value of 8.3 (V3) and 9.7 (V4; Tab. 1). Those results were also consistent with the findings by other researchers [13, 16] who confirmed that the alkaline phosphates produced an increase in the pH value of the finished product.

Yield of finished product

The sausages produced according to the recipe of control variant, i.e. they were not enhanced with the phosphate preparations (V1), were found to have the lowest ($p \leq 0.05$) yield (Tab. 1). The phosphate preparations added (V2-V4) caused the yield of the analyzed sausages to increase by 2.9 units to a level of 4.9 % compared to the sausages without any phosphates added (V1, Tab. 1). This was attributed to the fact that the phosphate anions had a meat protein activating capacity, and, consequently, contributed to the improvement of water binding and retention capacity in the finished products and to the reduction in the cooking loss. The results of the studies by many authors [12, 13, 18, 19] indicate that the addition of phosphates inhibits a drip loss across all processing stages of meat products including emulsion-type sausages. Moreover, the application of the phosphate compounds in combination with NaCl causes the WHC of the finished product to considerably increase and, also, the yield of that product to be raised. The phosphates used in the present study exhibited a reaction from neutral (7.3 for V2) to alkaline (9.7 for V4), which caused the pH to shift away from the isoelectric point (IEP) of myofibrillar proteins and this, in turn, resulted in a higher water retention in the product. The results are in a ‘broad agreement’ with earlier works on this matter [16, 17].

Content of total hem pigments, nitrosylhemochroms, and heme pigment conversion degree

Including phosphates in the emulsion-type sausage production caused no impact ($p > 0.05$) on the content of the total hem pigments; however, they affected the content of nitrosylhemochroms ($p \leq 0.05$) as well as the heme pigment conversion degree (Tab. 2).

Regardless of the addition of phosphates, the heme pigment conversion degree calculated amounted to more than 50 %, thus, producing a desirable colour of the finished product [9]. The highest heme pigment conversion degree was determined in the non-treated sausages. In addition, it was concluded that the heme pigment conversion degree decreased with the increasing pH of 1 % aqueous solution of the enhanced phosphate (Tab. 2). With regard to the content of nitrosylhemochroms and the heme pigment conversion degree, the differentiation of sausages can be attributed to the fact that while the pH values decreased, the rate of curing process, i.e. of the reaction of heme pigments with nitric oxide (NO), rose.

Table 2. Content of total heme pigments, nitrosoylhemochromes, and heme pigment conversion degree of emulsion-type sausages analyzed

Tabela 2. Zawartość barwników hemowych ogółem, nitrozylobarwników i stopień przereagowania barwników badanych kiełbas homogenizowanych

Characteristic Wyróżnik	Variant 1 Wariant 1 ($\bar{x} \pm SD / s$)	Variant 2 Wariant 2 ($\bar{x} \pm SD / s$)	Variant 3 Wariant 3 ($\bar{x} \pm SD / s$)	Variant 4 Wariant 4 ($\bar{x} \pm SD / s$)
Content of total heme pigments Zawartość barwników hemowych ogółem [ppm hemin]	118.2 \pm 2.4	117.5 \pm 3.3	117.5 \pm 3.1	117.1 \pm 3.1
Content of nitrosoyl-hemochromes Zawartość nitrozylobarwników [ppm hemin]	74.5 ^a \pm 1.5	67.9 ^b \pm 1.5	66.9 ^b \pm 2.0	66.0 ^b \pm 2.0
Heme pigment conversion degree Stopień przereagowania barwników [%]	63.0 ^a \pm 1.0	57.8 ^b \pm 1.9	56.9 ^b \pm 3.8	56.4 ^b \pm 3.8

Explanatory notes as in Tab. 1: / Objasnienia jak w Tab. 1.

Texture analysis

Double compression and Warner-Bratzler shear force

The phosphate treatments used in the study significantly ($p \leq 0.05$) impact the hardness and chewiness of the analyzed sausages (Tab. 3). The lowest values of the parameters were determined in the untreated samples (V1) and there were no differences among the sausages with added phosphates of different pH of their 1 % aqueous

Table 3. Texture parameters of emulsion-type sausages analyzed

Tabela 3. Parametry tekstuury badanych kiełbas homogenizowanych

Characteristic Wyróżnik	Variant 1 Wariant 1 ($\bar{x} \pm SD / s$)	Variant 2 Wariant 2 ($\bar{x} \pm SD / s$)	Variant 3 Wariant 3 ($\bar{x} \pm SD / s$)	Variant 4 Wariant 4 ($\bar{x} \pm SD / s$)
Cohesiveness Spoistość	0.4 \pm 0.04	0.4 \pm 0.04	0.4 \pm 0.03	0.4 \pm 0.02
Springiness Sprężystość	0.7 \pm 0.03	0.7 \pm 0.01	0.7 \pm 0.01	0.7 \pm 0.03
Hardness Twardość [N]	35.4 ^a \pm 0.5	39.9 ^b \pm 1.2	40.9 ^b \pm 1.5	41.3 ^b \pm 2.3
Chewiness Żujność [N]	9.9 ^a \pm 1.3	11.2 ^b \pm 1.1	11.5 ^b \pm 0.9	11.5 ^b \pm 1.5
Shear force Sila cięcia [N/cm ²]	3.6 \pm 0.2	3.9 \pm 0.2	3.9 \pm 0.2	3.9 \pm 0.2

Explanatory notes as in Tab. 1: / Objasnienia jak w Tab. 1.

solutions. The findings made in this study were in agreement with the results reported by other authors [16]. Similarly, the addition of the phosphate compounds for the purpose of producing restructured scalded hams from PSE meat resulted in their greater hardness and chewiness [14].

The statistical analysis did not show significant differences ($p > 0.05$) in shear force on the day after production (Tab. 3). There were no significant differences in shear force among the phosphate-stimulated products (V2-V4). Only a tendency to higher shear force values for sausages with phosphates were observed (Tab. 3).

Sensory analysis

The statistical analysis did not show any effect from adding the phosphates on the colour, odour, and flavour of the emulsion-type sausages that underwent the sensory evaluation (Table 4). However, the sausages were rated higher as regards their overall acceptability for they showed an increasing pattern in pH of their 1% aqueous solution.

Table 4. Characteristics of sensory quality of analyzed emulsion-type sausages

Tabela 4. Wyróżniki jakości sensorycznej badanych kiełbas homogenizowanych

Characteristic / Wyróżnik (0 p. not acceptable - 10 p. acceptable) (0 pkt. niepożądana - 10 pkt. pożądana)	Variant 1 Wariant 1 ($\bar{x} \pm s /SD$)	Variant 2 Wariant 2 ($\bar{x} \pm s /SD$)	Variant 3 Wariant 3 ($\bar{x} \pm s /SD$)	Variant 4 Wariant 4 ($\bar{x} \pm s /SD$)
Colour / Barwa	8.2± 0.3	7.9± 0.5	7.7± 1.0	7.8± 0.8
Odour / Zapach	8.2± 0.5	8.0± 0.9	8.1± 0.9	8.3± 0.5
Flavour / Smak	8.0± 0.3	8.0± 0.6	7.7± 0.5	8.0± 1.0
Hardness / Twardeść	7.5± 0.7	7.1± 0.7	7.4± 0.6	7.8± 0.4
Springiness / Żejność	7.8± 0.5	7.4± 1.5	7.5± 0.6	7.8± 1.0
Overall acceptability Akceptowalność ogólna	7.7± 0.3	7.4± 0.3	7.7± 0.6	8.1± 0.2

Explanatory notes as in Tab. 1: / Objasnienia jak w Tab. 1.

In the reference literature, there are publications on the sensory quality of products with and without phosphate preparations added. The scalded sausages produced with the addition of phosphates did not exhibit differences with regard to the aforementioned descriptors [15].

Conclusions

1. The addition of phosphate compounds of varying pH values of their 1 % aqueous solutions did not impact the pH value of meat batters, but it significantly influenced the pH of the finished product.
2. The concentration of phosphates of higher pH values of their 1 % aqueous solutions represents the most suitable method to increase the yield of the finished prod-

- uct. The best results were obtained using phosphates the 1% aqueous solutions of which had a pH 9.7 (V4).
3. The sensory analysis showed that the addition of phosphates of pH values of their 1 % aqueous solutions improved the overall acceptability of emulsion-type sausages. There were slight differences in the characteristics evaluated as regards the different pH values of 1% aqueous solution of phosphates.
 4. It is suggested to apply phosphates of higher pH values of their 1 % aqueous solutions to produce the emulsion-type sausages from mechanically separated poultry meat because it makes it possible to increase the yield of the finished product. The different pH of 1 % aqueous solutions of phosphates did not significantly influence other examined quality factors, such as texture parameters and sensory characteristics of the emulsion-type sausages.

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WPŁYW RODZAJU ZASTOSOWANYCH PREPARATÓW FOSFORANOWYCH NA JAKOŚĆ KIEŁBAS HOMOGENIZOWANYCH

Streszczenie

Celem pracy było określenie wpływu dodatku preparatów fosforanowych w postaci 1-procentowych wodnych roztworów o różnym pH na jakość kiełbas homogenizowanych. Produkowano 4 warianty kiełbas: kontrolny (W1) bez dodatku preparatów fosforanowych oraz 3 warianty z ich dodatkiem o pH: W2 – 7,3, W3 – 8,3 i W4 – 9,7. Dokonano oznaczeń pH farszu oraz wyrobu gotowego, a także obliczono wydajność wyrobu gotowego. W badanych kiełbasach oznaczono zawartość barwników hemowych ogółem i nitrozylobarwników, a także obliczono stopień przereagowania barwników. Dokonano pomiaru parametrów tekstury i przeprowadzono analizę sensoryczną badanych kiełbas homogenizowanych. Stwierdzono, że dodatek preparatów fosforanowych wpłynął na pH gotowego wyrobu, jego wydajność, a także zawartość barwników hemowych ogółem, nitrozylobarwników oraz stopień przereagowania barwników. Stwierdzono także pozytywny wpływ preparatów fosforanowych na teksturę wyrobów (twardość i żujość) w porównaniu z kiełbasami bez ich dodatku. Dowiedziono celowości użycia w produkcji kiełbas homogenizowanych z odcięgnionego mięsa drobiowego 1-procentowych roztworów preparatów fosforanowych o wyższym pH, na co wskazuje m.in. wzrost wydajności gotowego wyrobu (ze 117,9 % – W1 do 122,8 % – W4). Najlepsze wyniki uzyskano przy użyciu 1-procentowych roztworów preparatów fosforanowych o pH 9,7.

Słowa kluczowe: kiełbasy homogenizowane, preparaty fosforanowe, jakość, tekstura 