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APPLICATION OF NATURAL SUBSTANCES TO REDUCE pH VALUE OF EGG-BASED MAYONNAISE PRODUCTS

S u m m a r y

The objective of the research study is driven by the need to reduce the pH value of gourmet foods containing eggs with regard to their quality and safety. The analyses were focused on the production of mayonnaise and mayonnaise-containing salads and egg spread. To decrease the pH value of gourmet products, a pH-reducing ('pH minus') ingredient was applied, which was added at a concentration of 2 % (w/w) to the aqueous phase during the production of the two types of mayonnaise. The 'pH minus' preparation was a clear, yellowish solution with a sour taste and aroma; it was made from lemon juice and onion essential oil. The traditional or pH-reduced mayonnaise was mixed with the egg salad and egg spread. The products manufactured were analyzed in terms of microbiological and sensory quality; then they were compared with the control samples of the original products. Those two gourmet products (egg salads and egg spreads) differed in the acidity compared to the control samples. After adding the 'pH minus' preparation, the acidity of egg salad and egg spread samples was, on average, 0.2 % higher compared to the control samples. On the other hand, the pH value of the samples was by 0.2 to 0.5 lower than that of the control samples of those two types of gourmet products analysed. The adding of the 'pH minus' solution caused the number of the units forming filamentous fungal colonies in the samples to be reduced by 3×10^1 $CFU\times g^{-1}$ on average. The remaining microbiological parameters were comparable with those of the control samples.

Key words: eggs, gourmet products, pH reduction, natural substances, lemon juice, onion essential oils

Introduction

Gourmet products belong to the category of cold food that is suitable for immediate consumption. Those products usually consist of two main ingredients, namely mayonnaise or mayonnaise dressing, and of other various food components. The pH value of mayonnaise plays an important role in its structure and stability [8]. Food safety has become an increasingly discussed issue due to the outbreak of food-borne

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diseases worldwide. Food is an excellent medium, in which many pathogens can multiply and form suitable colonies [21]. Pathogenic microorganisms, commonly found in the gourmet salads and causing food-borne diseases, include *Listeria monocytogenes, Salmonella* spp., *Escherichia coli, Staphylococcus aureus, Campylobacter jejuni* and *Aeromonas* spp. [15].

The microbiological quality of ready-to-eat salads is very closely related to the quality of raw materials used to produce them as there is no treatment step during the production process, where the microorganisms in raw materials and additives could be eliminated. Therefore it poses a possible health risk to the consumer [10].

Egg products include cooked, peeled and canned eggs, which are produced through cooking, peeling and loading into the preservative brine. Their shelf life is about 1 month and those products are mainly used as semi-finished products in the food industry [23]. Heat-treated egg products are safer, cheaper, easier to be stored, and, owing to the heat treatment, they are in some cases less allergenic than the fresh eggs [20]. While analysing samples of the gourmet salads obtained from various manufacturers, Fowler and Clark [11] reported that the total numbers of microorganisms contained in the surimi and egg salads amounted to 6.1 log CFU×g^{-1} and 4.1 to 6.8 log CFU×g^{-1}, respectively. Bergdoll and Wong [4] detected *S. aureus* in tuna, chicken, egg and potato salads. The Centers for Disease Control and Prevention [6] published that the serotype *Salmonella* spp. was responsible for 18 occurrences of food poisoning caused by the consumption of salad with hard-boiled eggs. According to the Food Safety Guidelines published by the Australian Government, the pH value of 4.2 and below has proved to be effective in controlling *Salmonella* spp. in the products made from raw eggs. There are many factors to affect bactericidal properties of the products, such as the type of acid used [36], temperature [34], water activity [19] and essential oils of plant origin. The acidification of food to a pH value below 4.5 inhibits the growth of *Clostridium botulinum* and thus the formation of botulinum toxin [24]. Perales and Garcia [22] demonstrated that the mayonnaise produced from vinegar had a stronger bactericidal effect on *Salmonella* spp. compared to that of the mayonnaise of the same pH level and made from lemon juice. Jung and Beuchat [16] showed that citric acid was more effective in controlling *Salmonella* spp. than acetic, lactic and malic acids. When analysing *Salmonella* spp. in the mayonnaise contaminated with it, Zhu et al. [36] reported that lemon juice was more effective than wine vinegar. Smittle [25] summarized the results of the research studies on the survival of pathogenic microorganisms in mayonnaise and dressings. Those results proved that the pathogens causing food-borne diseases varied depending on the type and adaptability of the microorganisms (for example *E. coli* survived in the most unfavourable environment), type and concentration of acidic substance used to make mayonnaise, storage temperature, temperature chain and pH.

Essential oils are known to be antibacterial agents that may be used to control food-borne diseases [3]. Those secondary metabolites of the plants are hydrophobic in nature and can be added to mayonnaise, where their effect is advantageous since they may interact with the cell membranes of bacteria and, consequently, cause the cellular components to leak from the cell [18]. According to Wendakoon and Sakaguchi [33], some essential oils inhibit enzymatic reactions by inhibiting bacterial proteins. Valgimigli et al. [31] as well as Viuda-Martos et al. [32] reported that citric essential oils acted as a potent antibacterial agent against *Bacillus cereus*, *L. monocytogenes*, *E. coli*, *Staphylococcus* spp. Applied at concentrations of 0.01, 0.02, 0.05 and 0.11 $\mu g \cdot ml^{-1}$, onion oil reduced the growth of *Aspergillus* and when applied at an elevated concentration level of 0.05 $\mu g \cdot ml^{-1}$, it completely inhibited the growth of *A. versicolor* growth and the biosynthesis over a 21 day period [17]. The application of onion oil caused the production of *A. flavus* and *A. parasiticus* aflatoxins to decrease 50.6 ÷ 94.9 % and 38.3 ÷ 76.2 %, respectively [37]. Hayes et Markovic [13] investigated the antimicrobial properties of lemon and found that lemon exhibited antimicrobial activity against *S. aureus, Klebsiella, E. coli, Pseudomonas aeruginosa* and *Candida albicans*. In their study, Al-Ani et al. [2] confirmed the inhibitory effects of lemons, in particular against *S. aureus, P. aeruginosa* and *Proteus vulgaris*.

The study results presented by Bornemeier et al. [5], who tested mayonnaise salads for their potential contamination with *S. aureus* and *L. monocytogenes*, demonstrated that the higher pH values and deviations from the recommended storage temperature conditions promoted the growth of pathogenic microorganisms. In their study, Alali et al. [1] reported that decreasing the pH level of the mayonnaise-based salad reduced the survival rate of *Salmonella* spp. regardless of the temperature.

The objective of the research study was to decrease the pH level of gourmet salads made with eggs using a 'pH minus' ingredient and to improve the health safety of those products.

Material and methods

Samples

The analysed samples of the products tested were derived from a 'Ryba Žilina s.r.o.' production plant (the Slovak Republic), a manufacturer of gourmet products (Tab. 1). The products for analyses were taken directly from the production line after being packed; they were stored at 1 to 6 ºC until the moment of analyses. There were used hard-boiled eggs in brine with a pH-reducing or 'pH minus' ingredient added. There were 96 samples analysed.

Table 1. Profile of samples of gourmet products included in the experiment
Tabela 1. Charakterystyka próbek produktów delikatesowych objętych eksperymentem

Name of product Nazwa produktu	Composition of product Skład produktu	Shelf life Okres trwałości
Egg salad, 140 g Sałatka jajeczna, 140g	mayonnaise, boiled eggs, potatoes, cucumbers, marinated onion, mustard, sugar, salt, potassium sorbate majonez, jaja na twardo, ziemniaki, ogórki, marynowana cebula, musztarda, cukier, sól, sorbinian potasu	21 days 21 dni
Egg spread, 100 g Pasta jajeczna, 100 g	eggs, mayonnaise, butter, marinated onion, mustard, chives, potassium sorbate jaja, majonez, masło, marynowana cebula, musztarda, szczypiorek, sorbinian potasu	14 days 14 dni

Determination of pH

The pH value was determined using the electrode of a TitroLine TL 6000/7000 automatic titrator (Schott GmbH, Germany) [9].

Microbial analysis

To microbiologically analyse the samples, Petrifilm 3M™ and Petrifilm™ were utilized. The petrifilm plates were inoculated with 1 ml of the diluted solution of a pre-homogenized sample and incubated under the thermostatic control at 22 ºC for 5 days in order to determine fibrous fungi and yeast. To determine the coliform bacteria and *E. coli*, the petrifilm plates were incubated at 37 ºC for 48 h. Subsequently, the colonies were grown based on the indicators that stained the colonies [30].

Physicochemical analyses

A TitroLine TL 6000/7000 (Schott GmbH, Germany) automatic titrator and a Kern DBS 60-3 (KERN GmbH, Germany) moisture analyser were utilized to determine the analytical parameters.

Determination of the dry matter in samples using Kern DBS 60-3 moisture analyser

The dry matter content was determined by removing water from the sample at 105 ºC and next by measuring the weight loss [27].

Determination of the acidity using TitroLine TL 6000/7000 automatic titrator

The titration is based on the gradual addition of a solution of the NaOH titrating reagent, which selectively reacts with the constituent until the equivalent point is reached. Based on the known concentration of the titrating reagent and the volume of titration reagent used, the amount (quantity) of the component to be determined is calculated. The result of the titration (measurement) is expressed as the relative percentage of the constituent [28].

Determination of the salt content in samples using TitroLine TL 6000/7000 automatic titrator

The content of chloride was determined argentometrically according to Fajans [7]. The method is based on the reaction of silver cations with halide anions to produce poorly soluble white clots (AgCl) [26].

The analyses were carried out in two replications.

Sensory evaluation

The sensory evaluation was conducted under the laboratory conditions pursuant to the requirements reference to the assessment room environment as pointed out in STN ISO 6658:2010 [29]. The sensory analysis was conducted by a panel of five evaluators, two laboratory staff and three assessors certified on the basis of their valid certificates of competence for sensory assessment of food and agricultural products issued by the Veterinary and Food Institute in Bratislava. The sensory evaluation was based on the experience of the group of evaluators and the knowledge of the sensory properties of the control samples that were compared with the samples of the products manufactured. A descriptive qualitative method was used to sensory evaluate attributes, i.e. appearance, colour, smell, taste and consistency. The samples were evaluated using a sensory profile method; the description of perception was broken down into descriptors.

It was important that the sensory properties of the samples were comparable to those of the control samples. Also, it was focused on preventing the consumer from recognizing the difference in the sensory properties.

Results and discussion

Adding 'pH minus' preparation directly to the product

In the authors' own study the initial attempt to decrease the pH level of the gourmet products made from eggs was to add a 'pH minus' preparation to the product being manufactured. Then the 'pH minus' preparation (3 %) was added directly to the mixing device while stirring the egg salad and egg spread. The finished product samples were placed on polypropylene trays and stored at 6 ºC. Subsequently, the samples were analysed analytically, microbiologically and sensory. It was found that the adding of the 'pH minus' preparation significantly decreased the pH level of the products tested and this was very desirable, however during the sensory evaluation of those products after 24, 48 and 72 h it was found that their taste properties were markedly acidic. On the basis of the microbiological parameters evaluated, it was reported that the samples of the products with the 'pH minus' preparation added were more stable during the whole consumption period than the control samples.

Adding 'pH minus preparation' directly to the mayonnaise

The 'pH minus' preparation added to the products analysed proved to be effective in terms of pH, but not in terms of the sensory evaluation. Therefore in the successive experiment the 'pH minus' preparation was not applied directly to the product; instead it was added to the mayonnaise during the production thereof. The amount of the preparation used was 2 % by weight and the volume of water added to the mayonnaise in the aqueous phase was reduced by 2 %. The parameters of the mayonnaise sample are listed in Tab. 2 and 3.

The mayonnaise sample with 50 % of the oil was used to produce the egg salad and the sample containing 35 % of the oil was applied to the egg spread. The two mayonnaise samples were prepared in a homogenizer. The mayonnaise sample with 35 % of oil contained rapeseed oil, egg yolk, vinegar, E1442 modified starch, sugar, salt, E412 and E415 stabilizers; acidity regulators: sodium lactate, lactic acid; and potassium sorbate as a preservative. The mayonnaise sample with 50 % of oil contained rapeseed oil, egg yolk, vinegar, mustard, E1442 modified starch, sugar, salt, E412 and E415 stabilizers; acidity regulators: sodium lactate, lactic acid; and potassium sorbate as a preservative.

Based on the results of the sensory evaluation, it was concluded that the taste of mayonnaise with 2 % of the 'pH minus' preparation added was a little bit, but not significantly, more acidic compared to the control samples made according to the original recipe. The mayonnaise tested after 24 h had a significantly acidic taste, however 72 h after their production, the samples and the control samples were characterised by an almost indistinguishable taste profile.

Mixing gourmet products with mayonnaise produced with 'pH minus' preparation

There was no need to decrease the pH value while producing mayonnaise as it fulfilled the relevant legal requirement; the priority was to decrease the pH level of the mayonnaise that was a component of the finished products – spreads and salads. Two types of mayonnaise were tested: mayonnaise I with 35 % of oil and mayonnaise II with 50 % of oil. Mayonnaise I was used to produce the egg spread; it was somewhat thinner and tasted more acidic than mayonnaise II, which contained mustard as an additive and a higher percentage of oil and, for that reason, it had a fuller taste. Mayonnaise II was used to produce the egg salad. The 'pH minus' preparation added caused the pH level of the two mayonnaises tested to decrease; when comparing the mayonnaise samples with the control samples, it was found that the results of their microbiological assessment did not change significantly. The analytical assessment did not

Table 2. Microbiological and analytical parameters of mayonnaise with 35 % of oil and produced according to standard recipe (control sample) and of mayonnaise produced with 'pH minus' preparation added (sample)

Tabela 2. Mikrobiologiczne i analityczne parametry majonezu z 35-procentową zawartością oleju wyprodukowanego według standardowej receptury (próbka kontrolna) i majonezu wyprodukowanego z dodatkiem preparatu „pH minus" (próbka)

Mayonnaise 35 % (control sample) Majonez 35 % (próbka kontrolna)	Total count of microorganisms Całkowita liczba drobnoustrojów		Coliform bacteria Bakterie coli		*E. coli*		Yeast Drożdże		Filamentous fungi Włókniste grzyby	
	$[CFU \times g^{-1}]$ / $[jtk \times g^{-1}]$									
Microbiological parameters Parametry mikrobiologiczne	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka
At the beginning of shelf life period Na początku okresu przydatności do spożycia	30 ± 2	30 ± 2	0	0	0	0	10	10	10	0
During shelf life period / W trakcie okresu przydatności do spożycia	30	40	15	0	0	0	30	45	0	0
	Dry matter Sucha masa		Acidity Kwasowość		Salinity Słoność		Fat in dry matter Tłuszcz w suchej masie		pH	
	[%]									
Analytical parameters Parametry analityczne	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka
At the beginning of shelf life period Na początku okresu przydatności do spożycia	43.2	41.5	0.5	0.6	1.3	0.6	40.0	39	3.9	3.4
After 24 h / Po 24 h	41.4	40.8	0.4	0.4	1.3	1.4	36.9	38.9	4.1	3.4
After 48 h / Po 48 h	42.5	42.6	0.5	0.4	1.3	1.3	38.4	36.9	3.9	3.4
After 72 h / Po 72 h	43.2	40.9	0.4	0.5	1.5	1.4	38.8	37.6	4.1	3.3

Table 3. Microbiological and analytical parameters of mayonnaise with 50 % of oil and produced according to the standard recipe (control sample) and of mayonnaise produced with ‘pH minus’ preparation added (sample)

Tabela 3. Mikrobiologiczne i analityczne parametry majonezu z 50-procentową zawartością oleju wyprodukowanego według standardowej receptury (próbka kontrolna) i majonezu wyprodukowanego z dodatkiem preparatu „pH minus” (próbka)

Mayonnaise 50 % (control sample) Majonez 50 % (próbka kontrolna)	Total count of micro-organisms Całkowita liczba drobnoustrojów		Coliform bacteria Bakterie coli		*E. coli*		Yeast Drożdże		Filamentous fungi Włókniste grzyby	
	[CFU×g^{-1}] / [jtk×g^{-1}]									
Microbiological parameters Parametry mikrobiologiczne	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka
At the beginning of shelf life period Na początku okresu przydatności do spożycia	115 ± 2	50 ± 2	0	0	0	0	65	15	0	0
During shelf life period / W trakcie okresu przydatności do spożycia	85	30	60	0	0	0	40	35	5	0
	Dry matter Sucha masa		Acidity Kwasowość		Salinity Słoność		Fat in dry matter Tłuszcz w suchej masie		pH	
	[%]									
Analytical parameters Parametry analityczne	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka
At the beginning of shelf life period Na początku okresu przydatności do spożycia	56.4	54.6	0.5	0.5	0.9	0.8	47.9	51.3	4.2	3.5
After 24 h / Po 24 h	53.3	54.2	0.5	0.6	0.8	0.8	49.5	50.2	4.2	3.3
After 48 h / Po 48 h	55.7	55.5	0.6	0.7	0.7	0.5	52.1	47.5	4.1	3.3
After 72 h / Po 72 h	57.0	52.4	0.5	0.5	0.6	0.7	49.4	48.2	4.1	3.3

reveal any significant differences between the tested samples and the control samples. The sensory evaluation after 72 h showed that the mayonnaise samples with the 'pH minus' preparation added tasted almost the same as the control samples made according to the original recipe. Based on those results, it was decided to apply the mayonnaise with the 'pH minus' preparation added to the original recipe for the purpose of producing the salad and spread. The microbiological and analytical parameters of the control samples of the products and samples with 'pH minus' preparation added are shown in Tab. 4 and 5.

The comparison of the salad samples with the control samples showed no significant deviations in their taste and odour. While sensory evaluating the samples and control samples of the egg spread, a slight difference was reported in their tastes. The sample of the egg spread produced had a more delicate taste profile compared to the control sample, however this deviation was considered to be negligible for the average consumer.

Compared to the control samples, the samples of the two gourmet products, i.e. egg salads and egg spreads, had different analytical parameters only in the case of the acidity parameters, which were affected by the 'pH minus' preparation. The acidity of the egg salad samples was higher than that of the control samples. The pH of the samples was lower than the pH of the control samples for both types of the product. The results of the study by Bornemeier et al. [5], who analysed mayonnaise salads for their potential contamination with *S. aureus* and *L. monocytogenes*, confirmed that the higher pH values and undesirable storage conditions promoted the growth of pathogenic microorganisms. In the authors' own study, the values of microbiological parameters as given in Tab. 4 and 5 evidently proved that the 'pH minus' preparation added to the recipe caused the number of colony-forming filamentous fungi units in the samples to decrease. Also Alali et al. [1] confirmed in their study that, regardless of the temperature, the decreasing of the pH value of mayonnaise salad reduced the survival rate of *Salmonella* spp. Giuseppe et al. [12] reported the occurrence of limonoids in citrus species that exhibited a inhibitory activity against many clinically isolated bacterial strains. Limonoids derived from the limon citrus showed a good antibacterial and antifungal activity. The *E. coli* microorganism, whose drug resistance is well known, was also tested and exhibited the susceptibility to limon juice. A similar result was found in the case of *Staphylococcus epidermidis, Streptococcus agalactiae* and *Candida albicans* [14]. In their study, Hayes and Markovic [13] proved the antimicrobial activity of lemon juice. In the present research study, the authors achieved the pH reduction and the inhibition of the number of CFU by adding lemon juice extract and onion oil, thus those results confirmed the results of Hayes and Markovic. It was assumed that the 'pH minus' solution had an inhibitory effect on *E. Coli*, however this assumption could not

Table 4. Microbiological and analytical parameters of egg salad made from mayonnaise with 50 % of oil and produced according to standard recipe (control sample) and from mayonnaise with 50 % of oil and produced with ‘pH minus’ preparation added (sample)

Tabela 4. Mikrobiologiczne i analityczne parametry sałatki jajecznej na bazie majonezu z 50-procentową zawartością oleju wyprodukowanego według standardowej receptury (próbka kontrolna) oraz na bazie majonezu z 50-procentową zawartością oleju wyprodukowanego z dodatkiem preparatu „pH minus” (próbka)

Egg salad (control sample) Sałatka jajeczna (próbka kontrolna)	Coliform bacteria Bakterie coli		*E. coli*		Yeast Drożdże		Filamentous fungi Włókniste grzyby	
Microbiological parameters Parametry mikrobiologiczne	[CFU× g^{-1}] / [jtk× g^{-1}]							
	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka
At the beginning of shelf life period Na początku okresu przydatności do spożycia	10 ± 2	30 ± 2	0	0	40	100	5	0
During shelf life period W trakcie okresu przydatności do spożycia	10	0	0	0	10	110	0	0
At the end of shelf life period Na końcu okresu przydatności do spożycia	70	10	0	0	130	90	20	0
Analytical parameters Parametry analityczne	Dry matter Sucha masa		Acidity Kwasowość		Salinity Słoność		pH	
	[%]							
	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka
At the beginning of shelf life period Na początku okresu przydatności do spożycia	33.2	31.3	0.6	0.7	1.1	1.7	4.7	4.4
After 24 h / Po 24 h	34.6	48.4	0.4	0.7	1.1	1.1	4.8	4.4
After 48 h / Po 48 h	33.7	33.2	0.4	0.9	1.4	1.7	4.8	4.3
After 72 h / Po 72 h	32.2	31.3	0.5	0.9	1.3	1.6	4.5	4.3

Table 5. Microbiological and analytical parameters of egg spread made from mayonnaise with 35 % of oil and produced according to standard recipe (control sample) and from mayonnaise with 35 % of oil and produced with 'pH minus' preparation added (sample)

Tabela 5. Mikrobiologiczne i analityczne parametry pasty jajecznej na bazie majonezu z 35-procentową zawartością oleju wyprodukowanego według standardowej receptury (próbka kontrolna) oraz na bazie majonezu z 35-procentową zawartością oleju wyprodukowanego z dodatkiem preparatu „pH minus" (próbka)

Egg spread (sample) Sałatka jajeczna (próbka)	Coliform bacteria Bakterie coli		*E. coli*		Yeast Drożdże		Filamentous fungi Włókniste grzyby	
	[CFU×g^{-1}] / [jtk×g^{-1}]							
Microbiological parameters Parametry mikrobiologiczne	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka Kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka
At the beginning of shelf life period Na początku okresu przydatności do spożycia	110 ± 2	10 ± 2	0	0	270	60	10	0
During shelf life period W trakcie okresu przydatności do spożycia	140	30	0	0	100	50	10	10
At the end of shelf life period Na końcu okresu przydatności do spożycia	1100	10	0	0	300	120	20	0
Analytical parameters Parametry analityczne	Dry matter Sucha masa		Acidity Kwasowość		Salinity Słoność		pH	
	[%]							
	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka Kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka	Control sample Próbka kontrolna	Sample Próbka
At the beginning of shelf life period Na początku okresu przydatności do spożycia	32.2	35.7	0.3	0.7	0.7	1.4	5.2	4.5
After 24 h / Po 24 h	33.8	32.6	0.4	0.7	1.2	1.1	4.9	4.4
After 48 h / Po 48 h	40.3	36.5	0.6	0.6	1.6	1.5	4.8	4.6
After 72 h / Po 72 h	38.8	35.1	0.6	0.6	1.8	1.2	4.7	4.5

be confirmed by the results obtained by the authors in their own study. The reason thereof was that no *E. coli* was detected in any of the control samples evaluated. In their study, Ye et al. [35] reported the sensitivity of *Rhodotorula glutinis, Saccharomyces cerevisiae, Candida tropicalis, Aspergillus niger, Monascus purpureus* and *Aspergillus terreus* to onion oil. However the results obtained by them could not definetely confirm the inhibitory effects of the 'pH minus' solution on yeasts. On the other hand, under this research study, the authors conducted a microbiological evaluation of CFU of yeasts in the salad and their results confirmed the significant inhibitory effect of the 'pH minus' solution on yeasts; those results are shown in Tab. 4 and 5. Furthermore, while microbiologically evaluating CFU of yeasts in the egg spread, it was determined that CFU of yeasts in the samples and in the control samples were comparable. This could be caused by the following factors: different microbiological stability of the raw materials, different composition of the products or the failure of the human factor in terms of hygiene.

Conclusions

1. The adding of the 'pH minus' preparation to the standard recipe caused the number of the colony-forming units of fibrous fungi in the samples to decrease.
2. The adding of the 'pH minus' preparation to the mayonnaise proved to be a method to decrease the pH level of food products with the use of natural substances and at the same time to increase the microbiological stability of the evaluated products. Consequently, the research goal was achieved and the effects of the 'pH minus' preparation were confirmed.
3. Based on the confirmed positive effect of the 'pH minus' preparation added, an appropriate process was implemented in the manufacturing facility in 2016.

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WYKORZYSTANIE NATURALNYCH SUBSTANCJI DO REDUKCJI pH MAJONEZOWYCH PRODUKTÓW NA BAZIE JAJ

S t r e s z c z e n i e

Cel podjętych badań wynika z potrzeby obniżenia pH produktów delikatesowych zawierających jaja w aspekcie ich jakości i bezpieczeństwa. Analizy skupiono na produkcji majonezu oraz sałatki i pasty jajecznej z majonezem. Aby obniżyć pH produktów delikatesowych, zastosowano składnik redukujący pH („pH minus”), który dodawano w stężeniu 2 % (m/m) do fazy wodnej podczas produkcji dwóch rodzajów majonezu. Preparat „pH minus” to klarowny żółtawy roztwór o kwaśnym smaku i aromacie, otrzymany z soku z cytryny i olejku z cebuli. Majonez tradycyjny lub o obniżonym pH mieszano z sałatką lub pastą jajeczną. Otrzymane produkty analizowano pod względem jakości mikrobiologicznej oraz sensorycznej i porównywano z próbkami kontrolnymi oryginalnych produktów. Obydwa produkty delikatesowe (sałatki i pasty jajeczne) różniły się pod względem kwasowości w porównaniu z próbkami kontrolnymi. Kwasowość sałatki jajecznej i pasty jajecznej po dodaniu preparatu „pH minus” była średnio o 0,2 % wyższa w porównaniu z próbkami kontrolnymi. Natomiast pH próbek było o 0,2 ÷ 0,5 wartości niższe niż pH próbek kontrolnych obydwu rodzajów badanych produktów delikatesowych. Dodanie roztworu „pH minus” spowodowało redukcję liczby jednostek tworzących kolonie grzybów nitkowatych w próbkach średnio o 3×10^{1} jtk·g^{-1}. Pozostałe parametry mikrobiologiczne były porównywalne z próbkami kontrolnymi.

Słowa kluczowe: jaja, produkty delikatesowe, redukcja pH, substancje naturalne, sok cytrynowy, olejki eteryczne cebuli