SUMMARY

Influence of selected methods of thermal processing and packaging on quality and nutritional value of ready-to-cook red pepper products

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The aim of the study was to determine the effect of applying different heat treatments and packaging methods to the preparation of ready-to-cook red pepper products on the physicochemical characteristics, including the content of bioactive compounds and microbiological safety.

Roberta variety peppers were used in the study. The cut peppers were packaged using VAC and MAP technology (30% CO_2, 70% N). Vegetables packaged in an unaltered atmosphere (ATM) and not subjected to heat treatment constituted the control sample. After packaging, the material was subjected to thermal treatment by boiling (100°C/ 4 minutes), sous vide thermal treatment (60°C/ 30 minutes; 70°C/ 15 minutes and 80°C/ 8 minutes) and microwaving (180W/ 40 seconds,, 360W/ 30 seconds and 600W/ 15 seconds). The microbiological quality of vegetables stored at 4°C was evaluated for 24 days at 3-day intervals from the day of heat treatment to day 24, based on the total aerobic microbial count, the Enterobacteriaceae count, and the mold and yeast. The microbial profile present in the tested products was analysed using MALDI-TOF mass spectrometry. Physicochemical properties were evaluated, including color by CIE Lab space spectrophotometry, texture profile by TPA test, Kramer chamber test and Volodkevich tooth test, dry matter content, spectrum of selected saccharides (glucose, fructose and sucrose content), antioxidant potential and profile and content of selected biologically active compounds (total polyphenols, β-carotene, lycopene, L-ascorbic acid, profile of phenolic compounds). For each parameter described in the study, a one-way ANOVA analysis of variance was performed, and the significance of the differences between the averages was determined using a post hoc test (Fisher's NIR) at $p \leq 0.05$. On the basis of the microbiological results obtained, the periods in which the products were subjected to the remaining analyzes were selected, i.e., on the first day after receipt of the products, on the ninth day of storage, which was clocked as the optimum storage time for the products, and on the last day of storage, which varied according to the cooking treatment applied and the packaging method.

Microbiological analysis showed a statistically significant effect of heat treatment, packaging method, and storage time on the total number of microorganisms in raw fruiting

bodies and culinary products. The type of thermal treatment was found to have a significant effect on the shelf life of the products, as the sous vide-treated culinary products had the longest storage time and the microwave-treated ones the shortest. The VAC (average storage time 19 days) and MAP (21 days) packaging methods increased the maximum storage time of raw pepper fruiting bodies and culinary products compared to ATM objects (16 days). Several rhizobacteria were identified in raw peppers and culinary objects, but pathogenic bacteria were found. The microbial contamination limit (< 4 log CFU/g) for ready-to-eat foods was adopted based on the recommendations of the Department of Food and Environmental Hygiene of the Chief Sanitary Inspectorate.

The heat treatment methods and packaging methods used in this study had a statistically significant effect on the quality and nutritional value of ready-to-cook red pepper culinary products. The culinary treatment of the culinary products caused a noticeable color change in most of the culinary products tested ($\Delta E>5$). The most negligible color differences were found in ATM-packed products and the largest in VAC-packed products. The culinary treatment of microwave-irradiated products had a minor effect on colour differences. The evaluation of texture parameters showed that culinary peppers after sous vide heat treatment had the most similar texture compared to raw fruitcakes, while the least favorable in this respect was the treatment with 30s/360W microwave radiation. Treatment with microwave radiation resulted in the highest increase, 17-33%, in dry matter content compared to raw fruiting bodies. Culinary products packaged with VAC had the lowest loss of polyphenol content of all packaging methods tested. The total polyphenol content of the raw pepper fruiting bodies ranged from 1004 to 1068 mg of GAE /100 g of the product (average 1042 mg GAE/100 g dm of pepper), while after cooking, the content of the described parameter decreased and ranged from 707 to 1186 mg GAE/100 g dm (average 910 mg GAE/100 g dm). The trends in changes in the antioxidant properties of the products tested by the $ABTS^{+\bullet}$, $DPPH^{+\bullet}$, and FRAP methods were similar in all of these methods. Depending on the analysis method, the lowest antioxidant potential was found in ATM products, while those packaged in VAC and MAC showed a higher antioxidant potential. Twenty-five phenolic compounds, including 10 phenolic acids and 15 flavonoids, were identified in raw pepper fruiting bodies and culinary products. The results obtained for the content of phenolic compounds in raw pepper fruiting bodies and culinary products are reflected in the potential antioxidant values obtained in this study. Heat treatment caused a significant decrease in β-carotene content in all culinary products. However, the lowest losses, which amounted to a maximum of 4%, were found in culinary products after sous vide heat treatment (8min/80°C).

Based on the analysis of the test results obtained, it can be concluded that the sub vide heat treatment of 15min/70°C 8min/80°C and the VAC vacuum packaging of the peppers guaranteed the production of ready-to-eat culinary products of adequate quality and health safety at the tested storage time. Sous vide heat treatment of the red pepper fruiting bodies with the appropriate parameters allows functional culinary products of satisfactory nutritional value and microbiological safety to be produced when stored for the specified time.