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Original scientific paper

The influence of different gas mixtures on the shelf life of fresh beef

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ABSTRACT

The paper presents the results of testing the influence of different gas mixtures on the shelf life of different beef round primal cuts. A total of five gas mixtures were used, and the change in microbiological status (total number of bacteria, *Escherichia coli*, *Salmonella* spp., *Listeria monocytogenes*, *Proteus* spp., sulphite-reducing clostridia), change in pH and sensory characteristics of the meat were monitored. The results of this study showed that beef packaged in a gas mixture consisting of 70% O_2 and 30% CO_2 was the most acceptable in terms of sensory characteristics and microbiological status.

1. Introduction

Nowadays, food must be healthy, minimally processed and attractively packaged, as consumer expectations are constantly growing (*Martinez et al.*, 2006). As a consequence, the demands to be met by manufacturers of food and packaging materials have also increased (*McMillin et al.*, 1999; *Brody*, 2003). Today's consumers are also very sensitive when it comes to the use of additives in the food industry. Public demands to be able to get fresh food at any time are increasing, and food safety and easy availability of all kinds of foods are very important. That is why it is becoming increasingly difficult to meet consumer expectations. It is clear that time, as a factor in food production, plays an important role. From the moment when the fruit is harvested, the cattle are slaughtered, or the fish is caught, the race against time begins. From that moment on, natural degradation and deterioration threaten the quality and sustainability of the product. However, external factors such as the hygiene of the production process, temperature, etc., also pose dangers to the usability of the product. Therefore, the ways in which the food will be handled during the production, packaging, or cold chain processes are very important. Special emphasis should be placed on the packaging stage, because the packaging method can enable greater sustainability of the product (*Phillips et al.*, 2001).

Over the past two decades, modified atmosphere packaging (MAP) has become the dominant form of packaging in the meat industry (*Robertson*, 1993). The main reasons that stimulated the development of this technology are the constant increase in the consumption of fresh meat, the increase in the population in cities and the reduction of natural food sources. MAP can be defined as the removal of air from the package and its replacement with a specific gas or mixture of gases. The purpose of this technology is to extend the sustainability of food by preventing or slowing biochemical processes (oxidation of fats, formation of metmyoglobin), the growth of spoilage bacteria and the degree of product respiration. Numerous literature data indicate that several gases, such as carbon dioxide (CO_2), nitro-

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gen (N_2), oxygen (O_2) and carbon monoxide (CO), are used individually or in different combinations in MAP technology (*Xiong*, 1999). CO_2 shows antimicrobial activity, mostly against Gram-negative bacteria and psychrotrophic pathogens such as *Yersinia enterocolitica* and *Aeromonas hydrophila* (*Brody*, 1989), but this gas does not significantly inhibit the growth of *Listeria monocytogenes*. CO_2 also does not affect the growth of *Clostridium botulinum* (*Sinell*, 1988). $O_2$is used to preserve the bright red color of the meat and prevent the growth of anaerobic bacteria (*Martinez et al.*, 2006). $N_2$is an inert gas that replaces O_2 in the mixture and prolongs the product's shelf life, and also prevents rancidity and the growth of ae robic bacteria *(Blakistone*, 1998). N_2, due to its low solubility, has a role to prevent the collapse of the package. CO is very effective in preserving the red color of fresh meat, as it has a 20-fold greater affinity for binding to myoglobin, compared to O_2 (*Boeckman*, 2006).

The aim of this experiment was to investigate the effect of different gas mixtures on the color, pH value and microbiological status of beef packaged in a modified atmosphere.

2. Materials and methods

The study was carried out in a medium-sized meat processing plant. Beef round parts were used as the matrix. The average temperature of the pieces of meat during packaging was 3.1°C, and the pH was 5.75. Twenty-four hours after packaging, the pieces of meat were cut into smaller pieces, where the average temperature of the meat was 4.2°C, and the pH was 5.54. Temperature and pH values were measured every three days using a Testo 205 apparatus (Testo AG, Germany). Pieces of meat, 1–2 cm thick, were placed in Cryovac LidSys polystyrene containers with a depth of 50 mm (Sealed Air, USA), in which there were papers for absorbing meat juice (Sealed Air, USA). The pieces of meat were then packed in a modified protective atmospheres and stored for 28 days at 4°C. A total of five different gas mixtures (Messer AG, Germany) were used in the study (Table 1).

The microbiological status and pH were examined 2, 6, 13, 17 and 28 days after setting up the study. The color of the meat was evaluated organoleptically, at the beginning and at the end of the study, without instrumental measurement. Microbiological tests were performed according to validated ISO methods. These tests were the total number of viable aerobic bacteria (TVA*), Escherichia coli, Salmonella* spp., *Listeria monocytogenes*, *Proteus* spp. and sulphite-reducing clostridia.

The change in the total number of bacteria is presented in Figure 1.

In cuts of meat packed in a gas mixture consisting of 30% CO_2 and 70% N_2, and in 100% CO_2,

Table 1. Composition of gas mixtures used in the modified atmosphere packaging for beef.

	Mix 1	Mix 2	Mix 3	Mix 4	Mix 5
CO_2	30%	100%	50%	30%	20%
O_2	-	-	-	70%	20%
N_2	70%	-	50%	-	60%

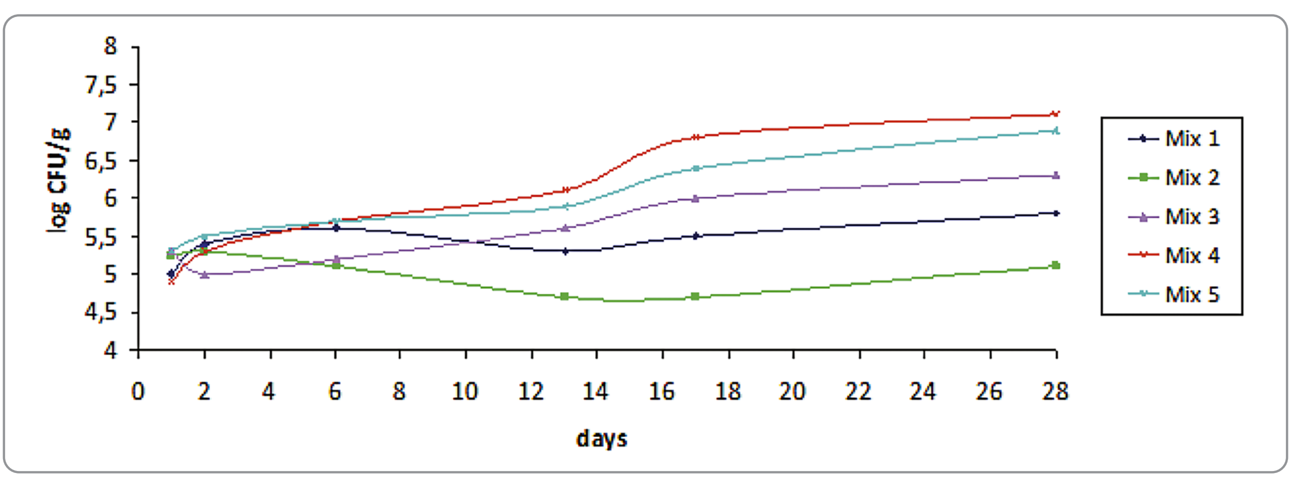

Figure 1. Total viable aerobic counts measured in beef packed in different gas mixtures (see Table 1) during the study.

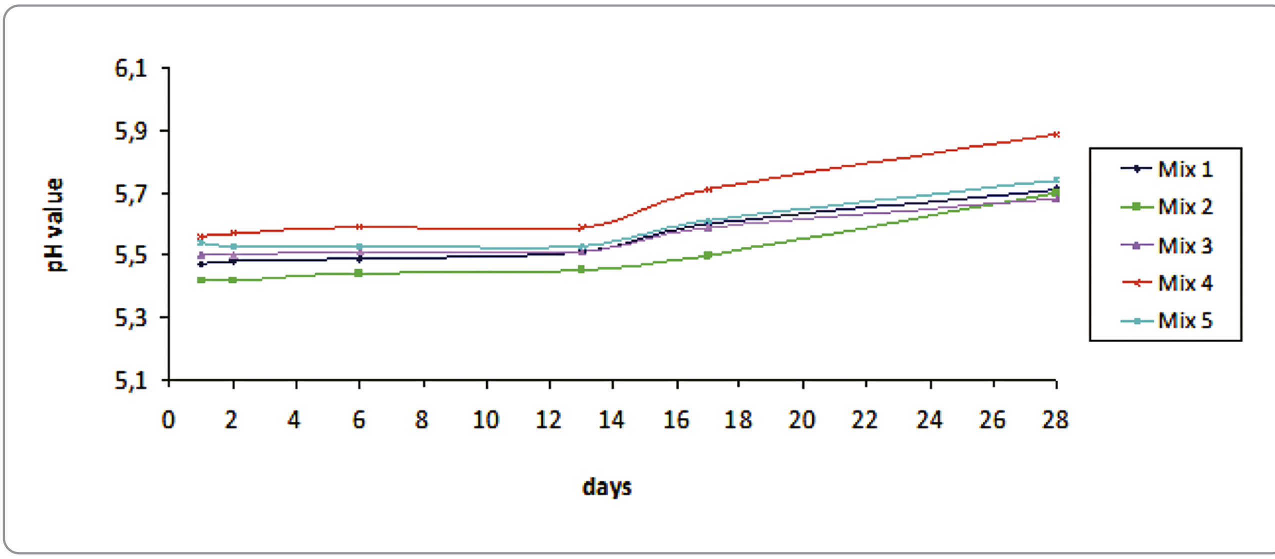

Figure 2. pH measured in beef packed in different gas mixtures (see Table 1) during the study.

the total number of bacteria remained low almost throughout the study. In beef pieces packed in gas mixture containing 20% and 70% O_2, during the entire study, there was a gradual increase in TVA, with a sudden increase between days 13 and 17.

The presence of pathogenic bacteria during the entire experiment (*E. coli*, *Salmonella* spp., *L. monocytogenes*, sulphite-reducing clostridia) was not recorded in any sample of beef packed in MAP.

The results of monitoring the pH change are shown in Figure 2. A significant increase in the pH value occurred in beef packaged in a gas mixture containing 70% O_2. Other mixtures showed a slow but steady increase in pH. A significant increase in pH value was noted around day 15, for all gas mixtures.

Pieces of beef packaged in gas mixtures containing a high percentage of CO_2 acquired a dark green color, and meat packaged in a mixture consisting of 30% CO_2 and 70% O_2 retained the most acceptable red color.

3. Discussion and results

Increasing the concentration of oxygen from 20% to 70% in the packaging has a positive effect on the color stability of the micro-fabricated parts of the beef leg. These results were also confirmed in research by other authors (*Seyfert et al.*, 2007; *Djenane et al.*, 2001; *Brody*, 1989; *Martinez et al.*, 2006). This is probably due to the formation of a larger amount of oxymyoglobin in the meat in proportion to the higher concentration of oxygen in the gas mixture. Pieces of beef packed in mixtures containing a high percentage of CO_2 acquired an unacceptable dark green color due to the formation of metmyoglobin.

Beef that was packed in gas mixtures with a higher percentage of CO_2 showed lower pH values. This is explained by the dissolution of CO_2 in the aqueous phase of the meat, whereby carbonic acid is formed, which leads to a decrease in pH. These statements were made by other authors in their works (*Phillips*, 1996; *Antoniewski et al.*, 2007; *Arnold et al.*, 1993; *Bendall et al.*, 1972; *Klettner*, 2004; *Hess et al.*, 1980).

The TVA was higher in beef packed in the gas mixture with a higher (70%) O_2 than in the 20% O_2 mixture. This was due to the aerobic conditions that prevailed in the packaging and the slightly higher pH of the beef in the high-O_2 mixture that favoured the development of microorganisms.

4. Conclusion

The TVA was higher in beef packed in a mixture with a higher percentage of O_2, due to the aerobic conditions that prevailed in the packaging and slightly higher pH values that favoured the development of microorganisms.

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