COLOUR OF MINCED MEAT UNDER CARBON MONOXIDE

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Introduction
The stability of packaged fresh meat colour is a problem, especially in the case of minced meat. Due to oxidation the red myoglobin and/or oxymyoglobin convert to brownish metmyoglobin. This reaction is accelerated due to interaction with lipid radicals and hydro peroxides. Usually a modified atmosphere (MA) is used in packaging of retail meat. MA with a high level of oxygen increases the formation of oxymyoglobin that inhibits for some time the oxidation. However the lipid oxidisation is eased by this high oxygen concentration. The growth of aerobic micro organisms is facilitated also (Martinéz, *et al.*, 2005; John, *et al.*, 2005). Carbon monoxide produces very stable carboxy derivatives with heme pigments. Although carbon monoxide is a toxic gas, the amount in packages is regarded as safe. The objection against its use is that it can mask the spoilage of meat (Sørheim, *et al.*, 1997; Stenzel and Feldhusen, 2004). A question is if the only spoilage criterion is colour or if it is advantageous to add oxygen in MA and to risk oxidisation and microbial growth.

Materials and Methods
The use of carbon monoxide in MA for packaged minced meat was studied under industrial conditions. Minced beef and mixture of beef and pork meat were packed in three different modified atmospheres: 1: 80% O_2+20% CO_2; 2: 25% CO_2+74% N_2+1% CO and 3: 25% CO_2+25% O_2+49% N_2+1% CO. All samples were stored at 4°C for 24 days. The colour of meat on the surface, internally and on the bottom of the meat surface was measured by reflectance spectrophotometry and video image analysis.
Reflectance spectrophotometry. The reflectance spectra were measured using a Chroma Meter Minolta CM-2600d spectrophotometer. The light source D_{65} and the standard observer angle 10° were used. The measured data were calculated using software Spectra Magic Ver. 3.3 (Minolta 2001, Japan) and the results expressed in terms of lightness (L*), redness (a*), yellowness (b*), chromacity (C*) and hue (h).
Calculation of metmyoglobin ratio. In the case of beef samples the myoglobin form (met, oxy and deoxy) ratios were calculated from the reflectance spectra by the Izumimoto and Ozawa method (Izumimoto and Ozawa, 1993).
Video image analysis was performed using software LUCIA 3.52. The results were expressed in RGB system as mean red (R), mean green (G) and mean blue (B), and as brightness (MB) and saturation (MS). From these values the ratios for red (r), green (g) and blue (b) were calculated as following ratios: $r = R/(R+G+B)$; g; b.
Lipid oxidation was evaluated by TBA test (absorbance at 538 nm).

Results and Discussion
The use of carbon monoxide and the elimination of oxygen suppressed oxidation of heme pigments and lipids and stabilized the colour of minced meat. From the comparison of the three different mixtures of MA it was found that the samples of minced meat under atmospheres containing CO and no oxygen are more stable then these ones under common oxygen containing MA. Results were similar for both beef and for a mixture of pork/beef.
The red colour ratio measured using VIA (Figure 1) on the beginning of the storage period was nearly identical for both MA. But although the oxygen atmosphere stabilized the colour forming oxymyoglobin, during the storage this value decreased due to the heme pigment oxidation. The oxidation of heme pigment was confirmed using calculations after [5] (see Figure 4). In the deeper layers these changes were slower.
Very similar results were achieved also by reflectance spectrophotometry; most apparent are changes of redness a* (see Figure 2, 3). Although the red colour seems to be stable at the samples packaged under oxygen atmosphere (80% O_2) on the beginning of the storage, the reflectance spectrophotometry uncovered that the redness a* and r ratio decreased since the beginning and that conversion of oxymyoglobin to metmyo-globin starts immediately. The change at this point, while detectable instrumentally, was not apparent visually, i.e. these objectively measured differences were below the detection level visually. Similar observation is described also by [Nicolade, *et al.*, 2005). Opposite to this, at the samples, where the modified atmosphere contained carbon monoxide and was free of oxygen, the colour remained stable for all storage times as documented by both methods used (Figure 1-3). Under MA3 (1% CO and 25% oxygen) the measured values were inconsistent; next measurement are necessary using different oxygen content. In the literature a positive effect of this is reported (Luňo, *et al.*, 1998).
The oxidation of lipids in the same samples was measured. It is evident that whereas under anaerobic atmosphere with CO almost no oxidation was obvious in the oxygen atmosphere a steep increase of TBA number occurred (Figure5 and 6). It can be assumed that this oxidation is delayed under CO atmosphere not only by the absence of oxygen, but also by the direct effect of the formation of carboxymyoglobin that is not oxidised and thus less Fe^{III+} is available as catalyst for lipid oxidation.

Conclusions

Carbon monoxide can stabilize the red colour of minced meat. In comparison with oxygen atmosphere, the lipid oxidation is lowered. Video image analysis proved to be a suitable simple method to enable monitoring of colour changes during storage.

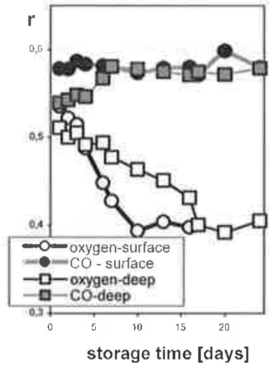

Figure 1: r-ratio changes during storage.

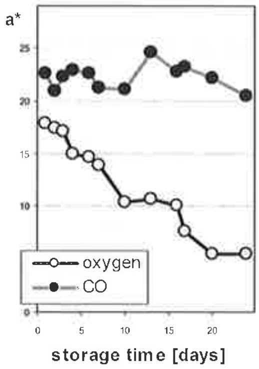

Figure 2: redness a* during storage of beef.

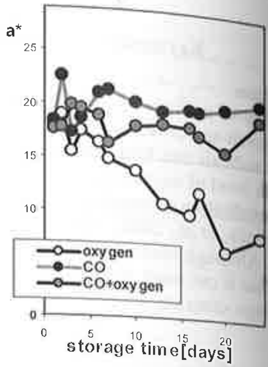

Figure 3: redness a* during storage of mixture of beef and pork.

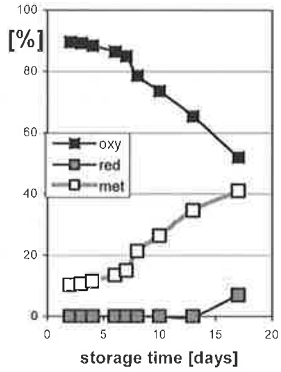

Figure 4: Oxidation of heme pigments during storage.

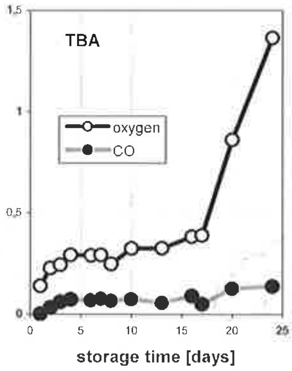

Figure 5: TBA during storage of beef.

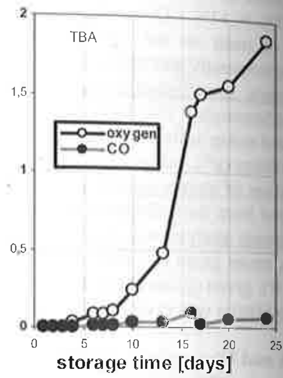

Figure 6: TBA during storage of mixture of pork and beef.

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