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EFFECT OF RETAIL-PACKAGING METHODS ON PREMATURE BROWNING OF COOKED BEEF PATTIES

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Abstract

Consumers are advised to use the color of internal meat or of meat juice to determine whether cooked beef patties are well done. However, several experiments have shown that meat packed in a high concentration of oxygen develops premature browning (PMB), which means that the meat appears well done at lower temperatures than expected. This implies that the color of the cooked meat is no longer a reliable indicator for when the meat is well done and when the pathogens, if any, are killed. In this study the effect of the oxygen level in retail packaging systems of ground beef on the development of premature browning of internal meat and meat juice during cooking of beef patties was examined.

Loosely ground beef (8-10% fat) was portioned into 250 g packs with three different headspace oxygen concentrations: 1) high oxygen packaging (80% O_2/20% CO_2), 2) in oxygen permeable wrap film (20% O_2/80% N_2) or 3) in anaerobic MA-packaging using 100% nitrogen. The meat packages were subsequently stored at 2°C for 24 hours (20% O_2), 2 days (0% O_2) and 3 days (80% O_2). Following four 125 g patties were cooked to an internal temperature of 55°C, 65°C, 71°C and 75°C, respectively. After cooking the internal color and meat juice color was evaluated using color gamuts.

Because of PMB, ground beef packed in a high oxygen concentration obtains a well-done appearance already at 55°C. Beef patties produced from traditional wrap-packed ground beef (20% oxygen) obtains the same well-done appearance around 71°C. Hence, from a safety point of view present recommendations - to cook ground beef until the meat juice clears, or the meat is no longer pink - are insufficient if microbiological food safety is to be considered. However, from an eating quality point of view cooking to 75°C (Danish recommendations) or 71.1°C (US recommendations) seems unnecessary since cooking to 65°C center temperature ensures a sufficient killing effect to eliminate pathogenic bacteria. At the same time cooking to 65°C will result in a more juicy beef patty.

New public recommendations must be applied for safe cooking of ground beef with emphasis on cooking time and/or centre temperature. The thickness of the patty and the temperature of the frying pan should also be considered.

Introduction

Consumers are advised to use the color of internal meat or of meat juice to determine when cooked beef patties are well done. However, several experiments have shown that meat packed in a high concentration of oxygen develops premature browning (PMB), which means that the meat appears well done at lower temperatures than expected. The proportion of ground beef being packed centrally in modified atmosphere with a high concentration of oxygen is increasing, which causes a risk of PMB. This implies that the color of the cooked meat is no longer a reliable indicator for when the meat is well done and when the pathogens, if any, are killed. Furthermore, some Danish consumers have a preference for 1.5-2.5 cm thick patties with a pink internal color where the meat juiciness is high. Persuing only to achieve a pink cooked color irrespective of the achieved centre temperature can mislead the consumers.

Objective

To examine the effect of the oxygen level in retail packaging systems of ground beef on the development of premature browning of meat and meat juice during cooking of beef patties.

Methodology

Loosely ground beef (8-10% fat) was portioned into 250 g retail packages and packed with three different headspace oxygen concentrations (0%, 20% and 80%). The meat was modified atmosphere (MA) packed (tray-sealed) in high oxygen packaging (80% O_2/20% CO_2) at a Danish commercial meat packaging plant. Furthermore, trays were packed in oxygen permeable wrap film (20% O_2/80% N_2) and anaerobic MA-packaging using low oxygen permeable bags (OTR:40-45cm^2/m^2/24h/23°C/85% RH,300x400PA/PE20/70, Walten-hofen, Germany) filled with 100% nitrogen (N_2) and sealed using a Multivac A300/16 packing machine (100 mbar vacuum, 750 mbar filling).

The meat packages were subsequently stored at 2°C for 24 hours (20% O_2), 2 days (0% O_2) and 3 days (80% O_2). Beef patties weighing 125g were formed in a template (diameter = 9.7 cm, height = 1.5-1.7 cm) and equilibrated after storage at room temperature to approx. 15°C. Four patties were cooked in a pre-heated frying pan (180°C) and were turned every 3 minutes until internal temperatures of 55°C, 65°C, 71°C and 75°C, respectively, was reached. Time and temperature data were registered (logging every 15 sec.) during and after heating using a Grant-1205 time and temperature logger.

Two color charts were developed from standardized pictures of the internal color of beef patties and meat juice. The charts represent the variation within different packaging methods and the centre temperature. On the basis of the color charts, two 5-point color gamuts were designed: one for meat juice color (figure 1) and one for meat color (figure 2). They represent the development in color from raw meat to cooked meat, which is well done. After cooking the internal color of one cross-sectioned patty were evaluated by a trained expert using the gamut. Meat juice was obtained from three patties by a pipette after a conic section in the centre of the patty. The juice was then centrifuged at 1300 rpm for 2 min. and chilled in a water bath. Five drops on a white filter paper were used for immediate evaluation of meat juice color by the expert using the gamut in figure 2.

Results & Discussion

When the temperature increases, the color of the meat juice changes from dark red, through to pink ending up in a yellow/clear color (figure 3), irrespective of the oxygen concentration in the packages. The difference between the packages is the temperature at which the color change (from reddish shades to a clear shade) occurs. The temperature-point is very much dependent on the headspace oxygen concentration in the packaged. For packages with 0% oxygen (N_2), the meat juice remained faint pink all the way to 75°C and never cleared. When the meat was packed in atmospheric air (wrap - 20% oxygen), the meat juice was still red at 65°C and the denaturation of the pigment including clearing of the meat juice took place at around 71°C. In headspace containing even higher oxygen concentrations (80% oxygen) the meat juice cleared already between 55-65°C.

For meat color, the same tendency is seen in the development of well-done appearance. Increasing centre temperature scores are related to well-done appearance. When packing in 0% oxygen (N_2), the color remained faint rose-pink all the way to 75°C. Whereas packing in wrap resulted in a faint rose-pink at 65°C and had a well-done appearance at 71°C. If the meat was packed in 80% oxygen, a well-done appearance was obtained already at 55°C, whereas the meat juice cleared at 65°C. Overall, the higher the oxygen concentration in the headspace of the pack, the greater the tendency for the ground meat to develop a well-done appearance at lower temperatures. The early color changes can be explained by the phenomenon of PMB. PMB is defined as *meat having a well-done appearance at lower temperatures than expected* (Hauge *et al.*, 1994).

Premature browning occurs as the pigment heat-denaturates, which is related to the oxidative state of the pigment (Warren et al., 1996). In anaerobic environments the pigment (myoglobin) is present as deoxymyoglobin and in oxygen containing environments as oxymyoglobin, the oxidized form metmyoglobin is present at very low oxygen concentrations at 0,5-1% (Ledward, 1970). Deoxymyoglobin is the most heat stable form of the pigment, and blooms when heated to approx. 68-69°C. Both oxymyoglobin and metmyoglobin are relatively more heat labile and obtain a brown and well-done appearance at a centre temperature of around 55°C, and even more distinct at around 65°C (Hunt et al., 1999).

If ground beef is cooked on a grill, in a frying pan or in an oven, calculations by Jacobsen (2004) shows that a heat treatment to reach 65°C in the centre is sufficient to obtain microbiologically safe cooked ground beefs These calculations are based on time/temperature studies, and z-values for *Salmonella*, *L. monocytogenes* and *E. coli*.

Conclusions

Because of premature browning, ground beef packed in a high oxygen concentration obtains a well-done appearance already at 55°C. Beef patties produced from traditional wrap-packed ground beef (20% oxygen) obtains the same well-done appearance around 71°C.

Hence, from a safety point of view present recommendations - to cook ground beef until the meat juice clears, or the meat is no longer pink - are insufficient if microbiological food safety is to be considered. However, from an eating quality point of view cooking to 75°C (Danish recommendations) or 71.1°C (US recommendations) seems unnecessary since cooking to 65°C centre temperature ensures a sufficient killing effect to eliminate pathogenic bacteria. At the same time cooking to 65°C will result in a more juicy beef patty.

Perspective

New public recommendations must be applied for safe cooking of ground beef with emphasis on cooking time and/or centre temperature. The thickness of the patty and the temperature of the frying pan should also be considered.

To ensure that a beef patty is both safe and tasty, the recommendation could be as follows: Ground beef should be cooked to a centre temperature of 65°C at a high temperature (180°C-200°C). For normal sized patties (125g/1.5-1.7 cm thick) the estimated cooking time is 13-15 minutes and for thick patties (175g/2.3-2.5 cm) the estimated cooking time is 17-20 minutes.

It may be possible to develop a mathematical model for calculating the cooking time dependent on specific conditions like beef thickness, meat temperature and temperature of frying pans, fats, and the required final centre temperature. The developed model should be customized for consumer use and available on the Internet for easy consumer access.

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Tables and Figures

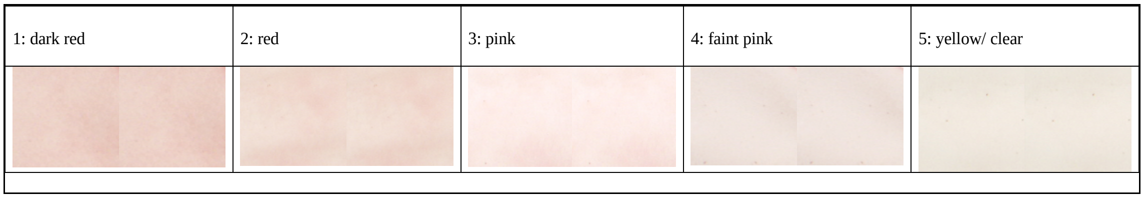

Figure 1. Five-point gamut for evaluation of meat juice color

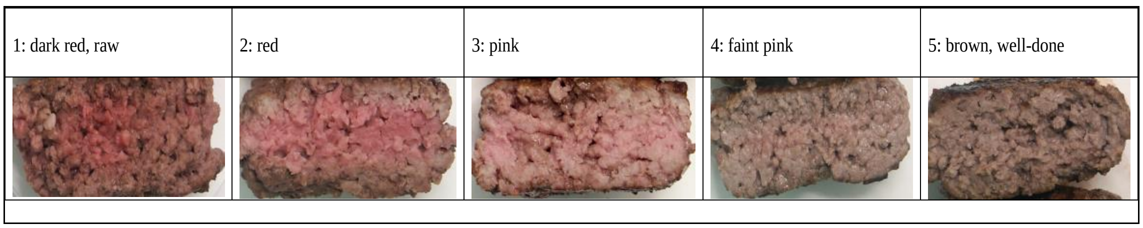

Figure 2. Five-point gamut for evaluation of internal meat color

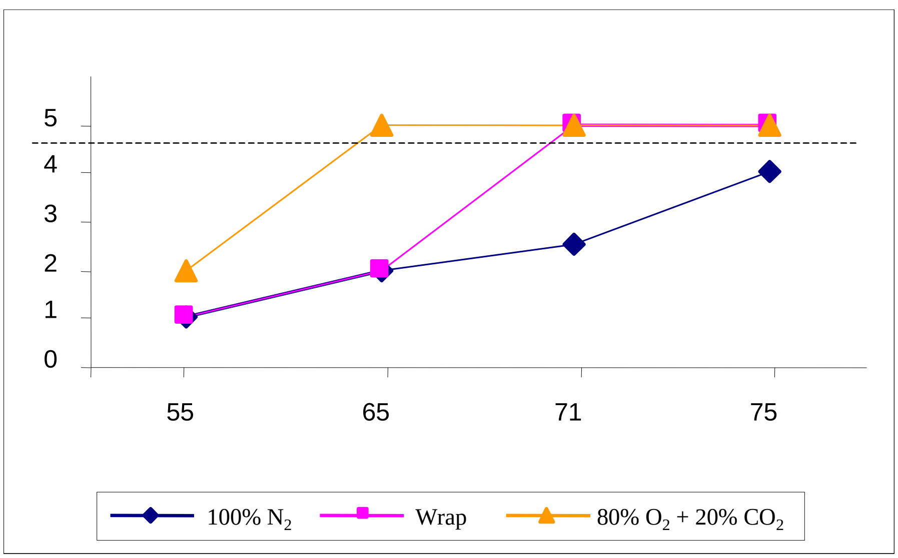

Figure 3. Meat juice color of beef patties for different packaging methods and end point cooking temperatures evaluated using a 5-point color gamut; 1= dark red, 2= red, 3= pink, 4 = faint pink, 5 = yellow/clear. The broken line indicates the point of change when the meat juice clears (n=4).

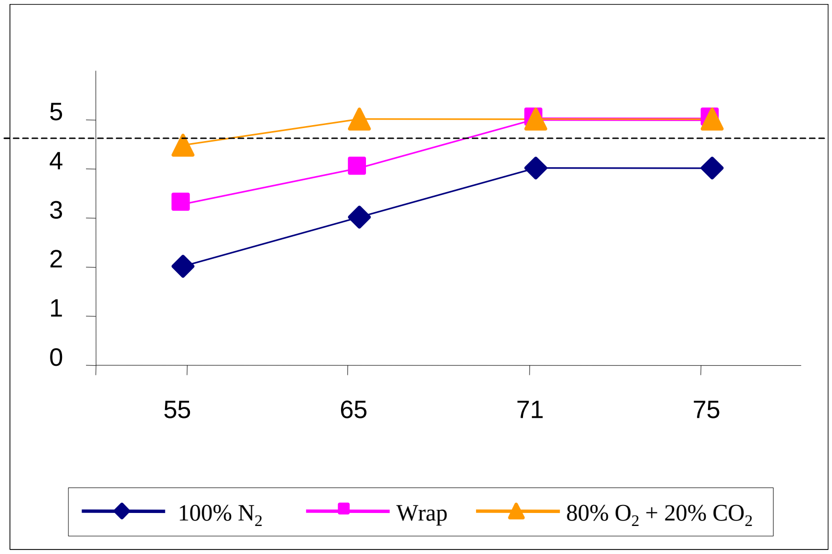

Figure 4. Meat color of beef patties for different packaging methods and end point cooking temperatures evaluated using a 5-point color gamut; 1= dark red, 2= red, 3= pink, 4 = faint pink, 5 = brown. The broken line indicates the point of change when the meat reaches a well-done appearance (n=4).