DEVELOPMENT AND DISTRIBUTION OF THIOBARBITURIC-ACID-REACTIVE SUBSTANCES IN COOKED, CHILL STORED BEEF

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INTRODUCTION

Cooked meat stored at chill temperatures for a few days develops a characteristic off-flavour known as warmed-over flavour (WOF). This off-flavour is characterized by a rapid decrease in the characteristic meaty flavour and a simultaneous development of a stale flavour described as 'cardboard'. The cardboard flavour is gradually transformed into an oxidized/rancid/painty flavour [1]. The development of cardboard and rancid flavours is highly correlated to meat phospholipid oxidation as measured by thiobarbituric-acid-reactive substances (TBARS).

It seems reasonable to believe that the oxidative processes mainly take place at the meat surface, since the oxygen concentration is very low in interior parts of meat [2]. A few researchers have studied differences in lipid oxidation in interior and superficial parts of cooked meats. Wu & Sheldon [3,4] cooked turkey rolls in a water bath to an internal temperature of 79°C. During four days of chill storage, TBARS of the interior part increased by approx. 50%, while TBARS of the exterior part almost tripled. Similar results were found in oven roasted beef by Spanier *et al.* [5], who also observed comparable rates of lipid oxidation in interior and exterior parts separated prior to storage.

Cooking method affects the development of WOF. Cooking methods such as roasting and frying, which induce high surface temperatures in the meat, reduce the development of WOF due to the production of antioxidative intermediates in the Maillard reaction [6]. These antioxidants are particularly important, since they are located at the surface where the rate of lipid oxidation is highest.

The aim of this work was to investigate the distribution of lipid oxidation in cooked, chill stored meat in further details. Lipid oxidation was measured by the development of TBARS during four days of chill storage. Two heating methods were compared, and the samples were sliced either before or after chill storage.

MATERIALS AND METHODS

Sample preparation: 36 samples (10.0×10.0×2.0 cm) were cut from four bovine *M. biceps femoris* 2-4 days post-mortem with the muscle fibres parallel to one of the longer sides. The samples were vacuum packed and stored at -18°C for 4 or 11 days. Then they were thawed for 24h at 3°C and either heated in the vacuum bag for 30 min in a water bath at 70°C or wrapped in aluminium foil and heated for 50 min in a conventional oven at 175°C. The core temperature was approx. 70°C after both heat treatments. The samples were divided in exterior and interior slices either before or after chill storage. The slices or intact samples were placed without overlap in oxygen permeable polyethylene bags and stored for 0-4 days at 3°C. The outer 1 cm of the smaller sides was discarded and the rest of the samples were sliced parallel to the larger sides into 2 mm thick slices, as shown in Fig. 1. The number of slices varied between 6 and 10 due to dimensional changes caused by the heat treatments.

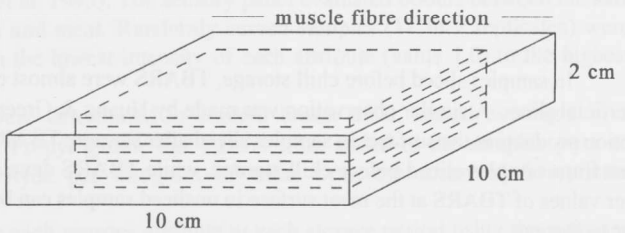

Fig. 1 Dimensions of meat samples (—) and slices (- - -).

Thiobarbituric-acid-reactive substances (TBARS): Lipid oxidation was measured by the TBARS extraction method developed by Vyncke [7]. The dry matter content of all slices was measured by drying 2g at 105°C for two days. TBARS are expressed in µmol malonaldehyde equivalents per kg dry matter to correct for differences in water losses after the two heating methods.

Computational methods: The design of this experiment was intended as a factorial block design with heating method (water bath or oven), slicing time (before or after chill storage), chill storage time (0-4 days) and slice location (slice 1-10) as main effects and with frozen storage time (4 or 11 days) as a block effect. This was not possible because the number of slices varied and treatments with slicing before and after chill storage are identical at 0 days chill storage time. These problems were overcome by normalizing the distance from the slices to the centre of the meat blocks (giving the outer slices the distance's -1 and 1), approximating the TBARS profiles by 2nd order polynomials (see Fig. 2) and using the squared distance as a regressor in a mixed model and by eliminating the effect of slicing time from the model in unstored samples.

RESULTS AND DISCUSSION

The observed values of TBARS are shown in Fig. 2. TBARS development was significantly affected by slice location, all main effects except heating method and most of their interactions. Though heating method significantly interacted with chill storage time and slice location, the absolute differences in TBARS produced by the two heating methods were small. TBARS increased during the chill storage of all samples with the largest increase during the first day.

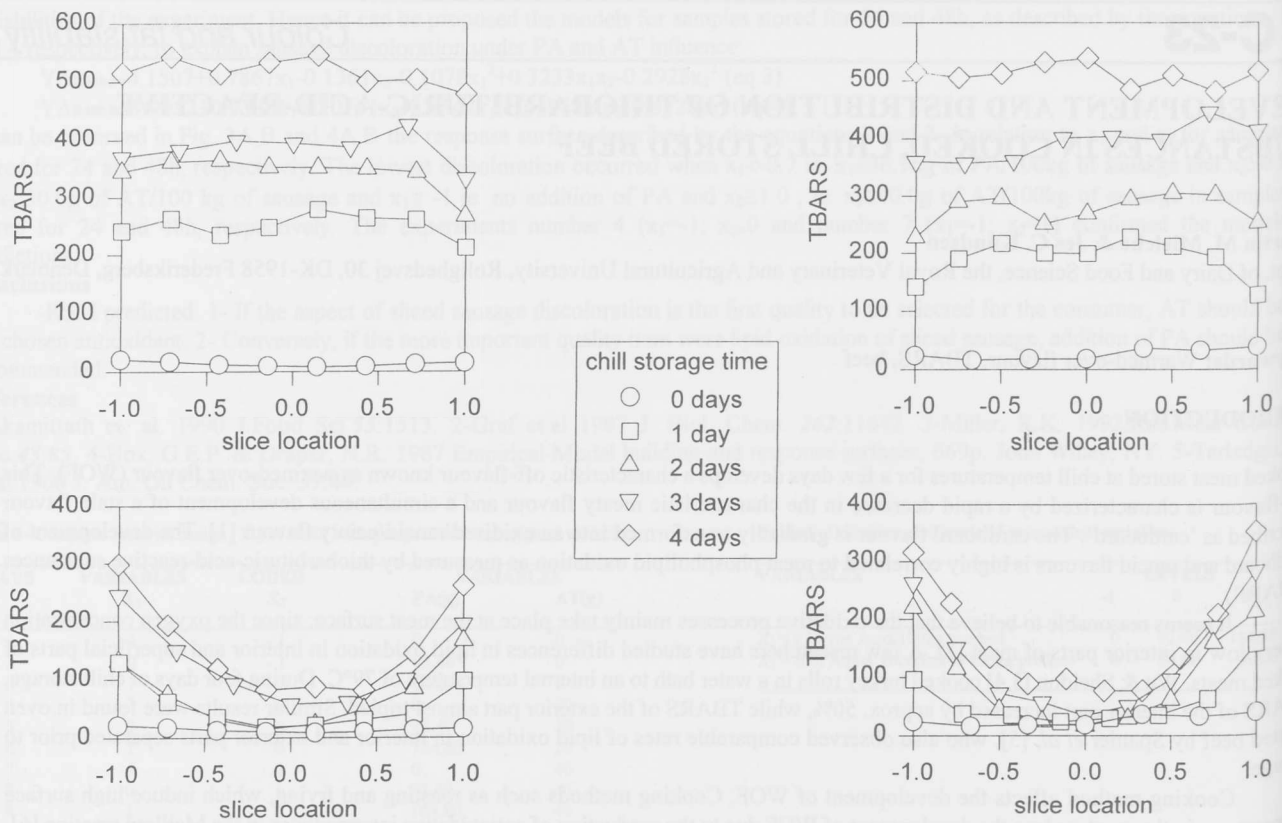

Fig. 2 TBARS of slices of beef cooked 30 min in a 70°C water bath (left) or 50 min in a 175°C oven (right) and stored at 3°C for 0-4 days. The samples were sliced before (top) or after (bottom) chill storage. Slice location was measured by normalized distance as described in 'Materials and Methods'.

In samples sliced before chill storage, TBARS were almost constant at a given chill storage time with slightly lower values in the superficial slices. A similar observation was made by Huang & Greene [8] and is probably due to the formation of antioxidative Maillard reaction products at the surface. In samples sliced after storage, TBARS in the outer slices were approx. 60% of the values observed in outer slices from samples sliced before chill storage, while TBARS developed increasingly slower towards the centre of the meat blocks. The lower values of TBARS at the meat surface in unsliced samples can be explained by the larger surface exposed to oxygen in samples sliced prior to storage.

Meat products are normally sliced perpendicular to the fibre direction to improve tenderness, while samples were sliced with the muscle fibres parallel to the slice surfaces in this experiment. A sample orientation with the muscle fibres perpendicular to the slice surfaces could increase lipid oxidation in internal slices, because oxygen possibly diffuses more rapidly parallel than perpendicular to the fibre direction due to cracks along the fibres. Consequently, the TBARS profiles shown in Fig. 2 could be more flat in commercial products.

Cooked, sliced meat products are usually sliced shortly after the heat treatment and before packaging and chill storage. The results of this experiment clearly shows that slicing prior to chill storage increases the lipid oxidation in this type of meat products. It dramatically increases the oxidation of the interior parts of the meat, and even in the exterior parts a more rapid oxidation can be expected.

LITERATURE

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