PE4.62 Effect of animal diet and muscle type on the evolution of the colour of cooked beef meat. 227.00

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Abstract: Color was studied on slices of cooked meat issued from 3 muscles (Longissimus thoraci, Semi tendinosus, Semimembranosus) of Norman heifers fed with 3 rations associated with different PUFA (Poly Unsaturated Fatty Acid) and antioxidant levels. Meat was cooked for different times at 3 temperature levels (66, 98 and 205°C) using a superheated steam jet. The principal component analysis of the results show no effect of the animal diet on the raw or cooked meat colour while colour parameters (L*a*b*) are very sensitive to the treatment time. The L* and a* kinetic were model using a simple first order reaction model. These kinetic seemed to be affected by the previous marinating of the raw meat.

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I. INTRODUCTION

Colour of raw and of cooked meat affects directly consumer attitude. Consumer is also more and more aware of the putative link between lipid consumption and some human diseases. A French governmental project (ANR, led by D. Bauchart INRA-URH) aims at studying the effects of various lipid and antioxidant enriched diets (pig, bovine) in fat or lean breeds (bovine) to determine the optimal feeding conditions to obtain the best sensorial and nutritional qualities. Lipid fusion, migration and oxidation during heating and cooking are key factors which affect final product quality. In practice, cooking is always heterogeneous and heating conditions are highly dependent on the type of installation used ([5], [7]). Variation of final product quality comes both from the composition of raw product and from its further processing (marinating, cooking…). L*a*b* measurement were performed on slices of raw and cooked muscles issued from heifers fed with three types of rations to analyse the respective effect of animal diet and of cooking conditions on the evolution of meat colour. These results were used in the prosafebeef project to choose a model to predict the evolution of colour parameters in relation to the heating treatment. A few heating treatment were performed on slices of marinating Biceps femoris muscles.

II. MATERIALS AND METHODS

A. Animals and muscles

Norman heifers (3 to 5 years old) were killed in the experimental slaugtherhouse of INRA Theix Research Centre. For this study, 4 muscles: Longissimus thoraci (LT), Semi tendinosus (ST), and Semimembranosus (SM), and Biceps femoris (BF) were taken from the carcasses twenty four hours after animal slaughter. Muscles were cut into big pieces, aged for 12 days under vacuum-packed conditions, then frozen and stored at -20°C. The LT, ST and SM muscles were directly used for the cooking experiments while the BF was marinating before being cooked.

B. Animal diets

Groups of Normand heifers were fed for a 100 days with three types of rations which were made either of: (1) concentrate (70%) and straw (30%) which was the control diet without any lipid supplements, or of (2) the same as the control but with and addition of extruded linseed (n-3 PUFA source), or of (3) the same as (2) but with a mixture of vitamin E (250 U/kg and vegetal antioxidant extracts (provided by Phytosynthèse society).

C. Marination

Only BF muscles coming from the animal fed with the control diet were used. After thawing muscles were trimmed and injected at 10% (in mass) with the following brine: NaCl 58.5%, acetate 20.7%, calcium lactate 16.9%, ascorbic acid 3%. Meat pieces were tumbled at 7 rpm during three hours and further used for cooking treatment.

D. Cooking treatment

Samples were cut in slices 1mm thick to ensure a uniform heating and were treated during 10s to 300s using superheated steam jets [3]. Meat sample was located in a hollow cylindrical support made of Teflon®. Distance d, between the surface of the sample and the outlet of the pipe was fixed accurately using a manual traversing system. The temperature at the surface of the sample was measured by and Infra-Red thermometer in a spot of 2 cm in diameter located at the centre of sample. The measuring part of the Infra-Red system was attached to the sliding device to be able to measure the surface temperature of sample all along the cooking treatment. Temperature of the impinging jet was measured every second using a 0.5 mm thick thermocouple (of type K) located 3.0 mm above the middle of sample surface. Thermocouple and IR thermometer were calibrated using procedures already described elsewhere [3]. At the end of the heat treatment the surface of the sample was rapidly cooled by sliding the sample under a 45-55 m.s-1 jet flow of cold air (temperature 3°C-5°C), produced by a Ranque-Hilsch tube ("vortex cooler"). The three positions of the sliding system: sample away from the steam jet, subjected to jet and subjected to cold air were perfectly fixed using blocking ball bearings. Apparatus was kept under the same heating conditions for at least two hours to reach steady-state conditions before experiments began.

E. Color measurement

Color was recorded using a spectrocolorimeter Konica Minolta CM 2500d (Japan) in CIELAB system (D65-10°-L*a*b*-d/8 SCE). The instrument was calibrated at 0 (in the air) and with white standard (n°7009694). Color was measured on the top of meat slices. For raw meat, slices were slightly transparent and thus put on another 4 mm thick meat piece of the same type to avoid the measure being affected by the bottom support. During the treatment, the measurement area can be heterogeneous in color due to heat transfer differences in the steam jet. The color data represented in this paper are the average of 5 local measurements performed on the slices.

F. Statistical analysis and kinetic modelling

Statistical treatment of data was performed by principal component analysis (PCA) using « R » statistical software [6]. During kinetic modelling colour parameters which have been measured on cooked meat were normalized by their initial value measured on raw meat. The evolution of theses parameters values was assumed to be that of an intermediate compound B involved in two successive first order chemical reactions which reaction rates were k1 and k2 respectively: k1 k2 A B C

The initial parameter value (concentration of B at t = 0) was supposed to be 1. Different mathematical relations can be drawn from this situation depending on the sign of the rate of A and on its initial and final value. Two cases were used. In the first one, the amount of B coming from A was decreasing with time and the initial concentration of A was 1. In the second case the amount of B coming from A was increasing with time and the final concentration of A at infinite time was 1. The two cases lead to the following relation with  = 1 and -1 respectively:

Equation (1) Values of k1, k2 and B were obtained by minimization (Nelder-Mead method) of the sum of squared differences (SSD) between calculated and experimental values. The "fminsearch" function in Matlab 7.0 was used to find the minimum of the SSD. The minimization process was stopped when SSD variation during the last 50 calculation steps was less than 1% of the SSD value.

III. RESULTS AND DISCUSSION

The temperature of treatment evolves throughout the cooking of the sample, this is why we will speak here in average temperature about surface measured with the infra-red pyrometer: 66, 98 (stage of boiling water at 800m of altitude) and 205°C. The average temperature of treatment is calculated between the points A and B1, B2, B3 (fig. 1). The 3 temperatures used for this study are representative of conditions usually used during the domestic cooking of meat product. A biological matrix is heterogeneous by definition.

The presence of lipidic masses is to be taken into account during the measurement of color (hence the interest of a measurement at 5 points). For the marinated meat, the external part of the sample was much darker than the core and measurements were taken on the latter. The variation of the colour parameter b* (colour variation from yellow to blue) does not depend on L* and a* and is small and irregular on cooked product. The most significant but limited variations are observed on the raw meat but they are not correlated to animal diet or muscle type

(fig. 2). This parameter will not be use in the following data analysis. PC analysis of the data of L* and a* measured on non-marinated meat is given in figure 3. During this statistical treatment temperatures were not considered as variables. Thus all the heating information was transferred to the treatment time which appears to be the most important factor to explain the variation of the colour parameter. L* (meat lightness) and a* (colour variation from red to green) are correlated in an opposite way. When L* increases a* is subjected to a simultaneous decrease whatever the type of treatment, diet or muscle. PC analysis also leads to non significant differences in the colour of cooked meat between the 3 types of animal diet and of muscles. Kinetics of L*/ L*0 and a*/a*0 are given at the different temperature levels in figures 4 and 5 respectively.

Data are the average of all the results obtained on the different animal diets and muscles for each time-temperature condition. Standard deviation is calculated from all these experimental values. For the 66°C and the 98°C heat treatment L*/ L*0 increases to a maximum during the first 30s-60s and stabilizes until the end of the experiment. The increase is more rapid for the 98°C than for the 66°C treatment. For the 205°C treatment L*/ L*0 increases during the first 10s of treatment and then decreases sharply toward a minimum value. The variations of a*/a*0 are opposite to those of L*/ L*0 and can be described in similar but opposite way. Variations of L*/ L*0 and a*/a*0 obtained on non-marinated meat were described from relation (1) using = 1 and -1 for L* and a* respectively. The values of model parameters: k1, k2 and B obtained by minimizing the SSD between the calculated and experimental non-marinated results are given in table 1.

Difference between the calculated and experimental results is less than the standard deviation interval excepted after 120s of the 205°C treatment. L*/ L*0 and a*/a*0 values obtained on cooked marinated meat are generally significantly different from those obtained on non-marinated meat. They cannot be described by the set of model parameters given in Table 1. Change in colour parameters leads visually to the whitening, the browning and the darkening of the sample in the course of the cooking treatment. For the 66°C and the 98°C temperatures sample whitened and then does not change colour until the end of the treatment where small browning was noticed. On the contrary for the 205°C treatment the whitening was limited to the first 10s of treatment while afterwards sample browned and darkened very quickly. These colour changes are known to be associated with biochemical reactions. Whitening is mostly associated with myoglobin denaturing [4] while browning and darkening are associated with the first stage (protein-sugar complexes) and the last stage (melanoids) of Maillard reactions. Changes in colour and reactions rate are also affected by cooking losses [1]. This effect of dehydration was much more pronounced for the 205°C treatment which led to “crumbly” samples. Under this condition the time-temperature modelling is probably not enough to describe the evolution of colour parameters. In the future, water activity will be introduced in the model for a better description of experimental results.

IV. CONCLUSION

The two different diets enriched in PUFA only and in PUFA plus antioxidants do not change the colour of the cooked meat compared to the control. This result can be considered as positive as consumer can benefit of an added nutritional value without the drawback of having different aspect on the cooked product. Processes conditions have a preponderant effect on cooked beef meat colour. Marinating affects both raw and cooked meat colour often in a heterogeneous way. The b* value does not vary much during cooking while variations of L* and a* can be described by the same model parameters whatever the type of animal diet and muscle. Colour model is in good agreement with measurements except for the 205°C treatment where variations of water activity shall be included in the model to take into account sample dehydration. Addition of water activity is very important to predict the variation of colour in the crust which formed during roasting and grilling at the surface of meat where heterocyclic amines can be generated [2].

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