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THE TENSIPRESSER CAN DETECT THE DIFFERENCES IN THE PHYSICAL PROPERTIES BETWEEN GRILLED AND BOILED BEEF

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Please refer to Folio 32.

INTRODUCTION

Numerous methods have been developed to objectively evaluate the physical properties of marketplace meat (Deatherage *et al.*, 1952; Paul and Bratzler, 1955a; 1955b; MacFarlane and Marer, 1966; Bouton *et al.*, 1971; Bouton and Harris, 1972a; 1972b; 1972c), but up to now, they have all had the problems of inconsistent values. Likewise, when comparing samples, in order to minimize errors in measurement, many samples are required, using a large amount of meat. At the 38th ICMST we made a presentation of a new method of meat quality evaluation using a Tensipresser (Nakai *et al.*, 1992). We showed how we were able to accurately measure the physical properties (such as severing point threshold and pliability) of pork as a function of cooking time, cooking is, then, to present our findings using the same methodology for beef that is either grilled or boiled, the two most common ways of cooking beef.

MATERIALS AND METHODS

The samples of meat used were chosen from beef semimembranosus (n=6) sold in the market. They were cut along the meat grain in elongated cubes of 2x2x5cm and divided into samples to be grilled on a hot plate at 200°C or boiled in water. The grilled samples were heated 2 1/2 minutes on each side for totals of 5, 10, 15, 20, 25, and 30 minutes respectively. The boiled samples were divided into samples boiled 5, 10, 15, 30, 60, 90, and 120 minutes respectively. The outer portions of these samples were cut away to leave samples that were 1x1x4cm in size. These were tested with a Tensipresser using an up and down motion to imitate chewing action in order to measure pliability, severing point threshold (amount of sheering force necessary to sever the meat sample) and toughness. A round, hollow 5.5mm diameter plunger (inner diameter 5mm) was used. Figure 1 shows the graph of the stress placed upon the plunger of the Tensipresser. The severing point threshold is the point at which the back pressure or resistance on the plunger is at its maximum value, and the pliability value is determined by dividing the area of the ABC triangle by that of the area delineated by the points AEBC (see Figure 1). The toughness of the meat sample is approximated as the area of AEBC, which is the integral value of the stress on the plunger up to the severing point threshold.

RESULTS AND DISCUSSION

The transmission of heat into the boiled and grilled samples is different. Figure 2 shows the upper surface temperature and core temperature of the samples grilled on a hot plate at 200°C. Because the sample was flipped over once every two and a half minutes, the graph of the upper surface temperature has a zigzag appearance. The surface temperature of the side that was exposed after the first turn over had risen to 65°C, but after that the rise in temperature was only minor, going up and down in a zigzag pattern. Upon reaching around 70°C, the degree of change in temperature became smaller, and the temperature just before turning over was lower than the core temperature. On the other hand, the core temperature increased along a curve with slower rates of increase as the temperature increased. After five minutes, the core temperature was 60°C, at 10 minutes it had risen to 70°C and after 15 minutes, it showed only small increases. On the other hand, as is shown in Figure 3, the core temperature for the boiled samples was already at 70°C after only three minutes, and at five minutes it had risen to 85°C, showing that the transfer of heat into the core was faster for the boiled meat when compared to grilled. This agrees with Illing and Swan (1992) findings that the core temperature had risen faster when beef steaks were boiled. Next, we compared the color change that took place in the cores of the grilled and boiled samples as a function of time. At five minutes, the core of the grilled samples was still red (corresponding to "rare"), at 10 minutes it was pink (corresponding to "medium") and after 15 minutes it was grayish brown (corresponding to "well done"). However, for the boiled samples, at five minutes the color had already changed to that of well-done, being equivalent to that of 15 minutes of frying. The American Meat Science Association (AMSA, 1978) has set a standard of an internal temperature of 70°C for medium beef. Illing and Swan (1992) also said that the visual color changes relate roughly to internal meat temperatures: below 60°C there is little or no color change (rare); 65°C to 70°C, a decreasing pinkness (medium); and 75°C a complete loss of pinkness (well done). These corresponds quite well with our results.

The severing point threshold (see Figure 4), which is a measure of the tenderness of a meat sample, showed an increase in value for the grilled samples up to 15 minutes and changing little after that ($P<0.01$). In contrast, the boiled samples at both five and 10 minutes maintained a high value, being almost the same as for the 15 minute grilled sample, and fell off steadily from that point for longer cooking times (P0<.01). It is thought that since the core temperature of the grilled samples had reached 70°C at 10 minutes and continues at approximately that value thereafter, the protein that makes up the meat fibers in the 70°C region contracts due to heat, resulting in the increasing severing point threshold up to 15 minutes. As indicated in Figure 2, he core of the samples grilled 5, 10, and 15 minutes respectively correspond to rare, medium and well done, with the well done having the highest severing point threshold. When meat samples were boiled, the core temperature reached 85°C at five minutes and 95°C at 10 minutes. The muscle proteins had already strongly contracted by the five minute mark, but when the boiling had continued longer than 15 minutes, the protein collagen began to weaken. As cooking times increased, this factor became progressively more important. By the two hour mark, the severing point threshold value had decreased to half of the peak at the beginning. Beilken *et al.* (1986) showed the shear force value of beef cooked at above 80°C decreased faster. The pliability of meat (see Figure 5), which is thought to show its viscoelasticity or resiliency, shoed a rapid decrease for grilled samples in the beginning. At the five minute mark, the pliability value was still over two, but as cooking time increased to 15 minutes, that value decreased sharply, then continued to decrease at a slower pace ($P<0.01$). With boiled samples, the five minute sample had a high value, but it steadily decreased until it reached a minimum value in the 90 minute sample (P0<.01). The closer a meat sample is to being raw, the higher the pliability value is though to be, but in reality, this is so. The rarer a sample is, the higher the pliability value, which is more pronounced in grilled samples than in boiled samples. As cooking time increases, the pliability of grilled samples slowly decreased reaching a value of about 1.5. In the boiled samples, values decreased to almost 1.0, indicating very little pliability at all. This is apparently due to the fact that in grilled meat samples, the core temperature doesn't rise much above 70°C while in the boiled samples, the core temperature rises to near 100°C. At which point the collagen undergoes degradation resulting in its structure becoming very weak. Another important parameter of meat quality is toughness, which is defined as the total amount of energy necessary to sever the sample (see Figure 6). In the case of grilled beef, the toughness value increased sharply over the five minute to the 15 minute cooking period (P0<.01). From there, it leveled off, being the same at 20 minutes and then it increased again. The boiled beef samples increased from their lowest levels at five minutes until 30 minutes where they leveled off. They decreased again after 60 minutes ($P<0.01$). The toughness values for the grilled samples at 5, 10, and 15 minutes showed a similar rate of increase as the severing point threshold values but differed after that, as there was again an increase in toughness from the 25 minute mark. This can be explained by the decrease in water content in the interior of the sample. This means that while the core temperature of the grilled samples remained steady at about 70°C, which resulted in a stable severing point threshold value, the drying effect of longer cooking times resulted in an increase in the total energy required to severe the sample. The toughness values for the boiled samples, however, followed a different pattern than the severing point threshold values. The energy required to sever the sample was at a relatively low value at five minutes but increased steadily until 30 minutes. The fact that the amount of energy required for severing at the five minute mark is almost three times that at five minutes for the grilled sample indicates how rapidly the coagulation of the protein proceeded in the boiled sample. The observation that for boiled samples, the toughness reaches a maximum value between 30 and 60 minutes can be explained in terms of the rapid decrease in pliability, which is expressed as the increasing area of the curved triangle. After that point, the decrease in toughness is thought to be due to the weakening of the collagen protein, and other factors, which are expressed as the area of the curved triangle decreasing due to the rapid decrease in its height.

A comparison of the hardness and texture of the grilled and boiled samples with the results of sensory testing is shown in Figure 7. The sensory testing was performed by 14 testers using a system of 1 to 5 points for each of the properties. Five points given to very tough down to 1 point for very tender and 5 points for the most pleasing texture and 1 point for the worst. The hardness of the grilled samples increased from five minutes up to 15 minutes ($P<0.01$), while the boiled samples were evaluated to be the firmest at 10 minutes, becoming progressively tender for longer cooking times (P0<.01). The texture of the grilled samples was evaluated as being the most pleasing at the five minute mark, which corresponds to rare, and became progressively less so for longer cooking times ($P<0.05$). The texture of the five minute boiled sample was evaluated as being the same as the grilled sample at 15 minutes, and for boiling times of 10 minutes and longer, the samples were all evaluated as having low values ($P<0.01$). The evaluation of grilled beef samples getting tougher for longer cooking times corresponds well with the Tensipresser measurements of severing point threshold and toughness. Likewise, while the evaluation of boiled samples as being toughest at the 10 minute mark would appear to be a different from that of the Tensipresser data, it corresponds well with the combined curves of severing point threshold and boiled samples closely correlated to the measurements of pliability by the Tensipresser, showing that evaluations of the physical properties of meat as obtained by sensory testing can be accurately measured by a Tensipresser.

CONCLUSION

The results of our research has shown that the use of Tensipresser can give accurate results in evaluating marketplace meat while only requiring small samples. Likewise, it showed that the properties of grilled and boiled samples differed greatly, indicating the importance of proper cooking methods in accordance with the use of the meat.

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