

# **Evaluation of prerigor beef burger 1. Effects of rigor state and processing procedures**

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## **SUMMARY**

Several experiments were conducted to evaluate the effects of rigor state and processing procedures on quality attributes of beef burger. Prerigor beef round muscles were excised from four beef carcasses within two hours from Exsanguination. Processing procedures included preparation of beef burgers from hot prerigor beef, frozen prerigor beef, 24 hours post rigor beef, 48 hours post rigor beef and acidified prerigor beef samples. The measurements included pH, cooking loss, water index, colour and sensory evaluation. The results indicate that the burger prepared from the frozen prerigor beef had the highest cooking loss and was the lowest in tenderness, water index and juiciness compared with the rest of the treatments. The different treatments did not differ significantly in colour or flavour of the cooked samples. The frozen acidified prerigor beef burger was found equivalent to the 48 hours post rigor beef acidified ground prerigor beef had the highest scores in tenderness and juiciness compared with the rest of the treatments. The results of the experiments suggest that the toughness and shrinkage associated with the burger prepared from prerigor beef muscles result from a cold induced rigor contraction.

## **INTRODUCTION**

Little research has been conducted on prerigor meat compared with the post rigor meat and the information concerning the palatability is contradictory. Marsh (1964) has shown that meat cooked immediately after slaughter is relatively tender, although a reduction in tenderness was reported by Montgomery *et al.*, (1977).

It has been shown that overeffective chilling of hot carcass can lead to toughness. Lawrie (1979) indicated that. freezing prerigor beef muscle induces an immense contraction and excessive dripping upon thawing. The solution of the problem of the prerigor meat toughness seems to lie in the rigor contraction phenomenon Marsh, (1977). There is a close relationship between myofibrillar contraction and the tenderness of cooked meat Marsh and Leet, (1966).

If the problems of toughness and shrinkage associated with. prerigor meat are solved, consumers of prerigor meat will have access to a better meat quality.

For the above mentioned reasons, some experiments were designed to investigate the problem associated with the utilization of prerigor beef in the manufacture of beef burger. The objectives are to evaluate the effects of rigor state on quality parameters of prerigor beef burger and to find practical solutions for associated problems.

## **MATERIALS AND METHODS**

## Meat treatments

Four beef carcasses of similar age, sex and breed were used in each experiment. They were obtained from the fattening department at Kuku Research Center. Prerigor beef round muscles were excised from the beef carcasses at two hours postmortem.

### Experiment (1)

Four kgs prerigor beef round muscle samples were excised from one side of the carcass and divided into two parts : (1) Hot prerigor samples and (2) Frozen prerigor samples.

The round cut of the other side of the carcass was chilled for 24 hours in a chilling room (2 °C). It was then deponed and four kgs of Lean meat were taken and divided equally into two parts : One part was used as the 24 hours post rigor samples and the other part was left in the chilling room for another 24 hours to be used as the 48 hours post rigor samples.

### Burger preparation

For each of the four burger treatments, the meat was ground through a3.5mm plate using an electrical meat grinder. Peeled potato was similarly ground after being blanched in water (90 °C) for 5 minutes and incorporated with the rest of the ingredients (table 1) into burger products after mixing and regrinding. The burger products were processed using a manual burger machine (each pattie weighed about 60 gms). The burgers were left to freeze in a home freezer (-18 °C) for

24 hours and then packaged in polyethylene bags and stored at -18 °C for two weeks before they were subjectively evaluated.

Table 1. Burger formulation (all the treatments)

| Ingredients               | Weight (gm) |
|---------------------------|-------------|
| Meat                      | 3000        |
| Potato                    | 200         |
| Non fat dried milk (NFDM) | 100         |
| Bread crumbs              | 200         |
| Water                     | 400         |
| Salt                      | 60          |
| Sugar                     | 20          |
| Black pepper              | 20          |
| Nutmeg                    | 20          |

**Sensory evaluation**

The burger samples, randomly selected for evaluation, were separately cooked in a pan using vegetable oil at constant temperature (90 °C). 10 semitrained panelists were used to determine sensory differences. The colour, flavour, juiciness, tenderness and overall acceptability of the burger samples were scored on a seven-point scale where 1 = extremely dislike and 7 = extremely desire.

**Experiment (2)**

Based on the results of experiment 1, this experiment was conducted with the objective of minimizing rigor contraction associated with the use of pre rigor meat in the manufacture of beef burger.

Acidification of muscle was the method used in this experiment. Addition of 1% citric acid (10 grams of citric acid in 990 ml distilled water) was used to acidify the prerigor samples (10 grams of 1% citric acid solution / 1 kg of meat).

**Meat treatments**

Three kgs prerigor beef round muscles were equally divided into three treatments and stored at – 18°C for two days. The three treatments included :

1/ frozen prerigor beef.

2/ frozen acidified ground prerigor beef.

3/ frozen acidified prerigor beef.

In addition, 1 kg of 48 hours post rigor beef was used as a control, where the beef round muscle was left in a chilling room at 2°C for 48 hrs.

For all the treatments, formulation processing and sensory evaluation of the burger products were performed following the same procedures described in experiment 1. Other measurements included pH, cooking loss, water index and colour.

pH values of the burger samples were determined. About 10 gms of the burger samples were blended with 100 ml of distilled water at high speed for 1 minute before pH measurement.

The colour of the cooked burger samples was measured with a Hunter Lab Difference Meter Model D25. L, a and b measurements were determined; where “L” measures lightness. “a” measures redness and “b” measures yellowness.

Total cooking losses including drip and evaporation were determined from cooked and uncooked burger weights and expressed as percentage of raw weight.

Water index was measured by a method similar to that of Pederson J.W. (1987). It was expressed as the loss in weight of the sample X 100, divided by its original weight.

Statistical analysis were performed on all data using Analysis of Variance and the New man — keuls sequential range test to separate significantly different means Snedecor and Cochran, (1967).

## RESULTS

### Experiment 1

The burger prepared from the frozen prerigor beef had the lowest tenderness score compared with the rest of the treatments ( $P < 0.05$ , table 2). The results also indicate that the burgers processed using hot prerigor beef, 24 hrs post rigor beef or 48 hrs post rigor beef did not differ in tenderness ( $P > 0.05$ , table 2).

With regard to juiciness, the burger prepared from the frozen prerigor beef had the lowest juiciness score which was significantly different among the treatments ( $P < 0.05$ , table 2). The different treatments did not show any significant difference in flavour or colour of the cooked samples ( $P > 0.05$ , table 2). As for overall acceptability. The burger prepared from the frozen prerigor beef gave the lowest score among the treatments ( $P < 0.05$ , table 2).

### Experiment 2

The results indicate that the burger prepared from the frozen acidified ground prerigor beef had the highest scores in tenderness and juiciness, followed by the burger prepared from the 48 hrs post rigor beef and the burger from the frozen acidified prerigor beef respectively ( $P < 0.05$ , table 3). On the other hand, the burger prepared from the frozen prerigor beef had the lowest scores in tenderness and juiciness ( $P < 0.05$ , table 3). As for flavour and colour, the results show that both parameters were not significantly affected by the various treatments ( $P > 0.05$ , table 3). In rating for the overall acceptability, the results show that the burger prepared from the frozen prerigor beef had the lowest score, while the burger prepared from the frozen acidified ground prerigor beef had the highest rating among the treatments ( $P < 0.05$ , table 3). Generally, it was observed that most of the scores for flavour, juiciness, tenderness and overall acceptability were above moderately like.

Table 2. Means and Standard errors for quality Attributes of beef burgers from different treatments \* (Experiment 1) .

Beef burger treatments

| Independent Variables | Hot prerigor beef | Frozen prerigor beef | 24 hrs post rigor beef | 48 hrs post rigor beef | S.E.   |
|-----------------------|-------------------|----------------------|------------------------|------------------------|--------|
| Tenderness            | 6.28 <sup>b</sup> | 5.48 <sup>a</sup>    | 6.33 <sup>b</sup>      | 6.35 <sup>b</sup>      | ± 0.12 |
| Juiciness             | 6.23 <sup>b</sup> | 5.73 <sup>a</sup>    | 6.28 <sup>b</sup>      | 6.43 <sup>b</sup>      | ± 0.12 |

|                       |                   |       |                   |                   |        |
|-----------------------|-------------------|-------|-------------------|-------------------|--------|
| Flavour               | 6.28 <sup>a</sup> | 5.95' | 6.23 <sup>a</sup> | 6.18 <sup>a</sup> | ± 0.02 |
| Colour                | 5.93'             | 5.75' | 5.83 <sup>a</sup> | 5.93 <sup>a</sup> | ± 0.17 |
| Overall acceptability | 6.25 <sup>b</sup> | 5.5Qa | 6.38 <sup>b</sup> | 6.35 <sup>b</sup> | ± 0.13 |

**a.b.**

Means in the same row bearing different superscripts are significantly different ( $P < 0.05$ ).

\* 7 point scale was used by the taste panel where 1 = extremely dislike, 7 = extremely desire.

Table 3. Means and Standard errors for quality Attributes of beef burgers from different treatments \* (Experiment 2) .

Beef burger treatments

Independent Frozen Frozen Frozen 48 hrs post S.E.

Variables prerigor acidified acidified rigor beef

beef ground prerigor

prerigor beef

beef

|                       |       |                    |                   |                   |        |
|-----------------------|-------|--------------------|-------------------|-------------------|--------|
| Tenderness            | 5.20' | 6.43 <sup>b</sup>  | 5.85'             | 6.13'             | ± 0.10 |
| Juiciness             | 5.53' | 6.25 <sup>b</sup>  | 5.88              | 5.90 <sup>0</sup> | ± 0.09 |
| Flavour               | 6.15' | 6.35'              | 6.10 <sup>a</sup> | 6.03'             | ± 0.09 |
| Colour                | 5.00' | 5.03 <sup>a</sup>  | 5.05'             | 4.95'             | ± 0.30 |
| Overall acceptability | 5.45' | 6.30 <sup>bd</sup> | 5.73'             | 6.13 <sup>b</sup> | ± 0.12 |

**a. bcd**

: Means in the same row bearing different superscripts are significantly different ( $P < 0.05$ ).

\* 7 point scale was used by the taste panel where 1 = extremely dislike, 7 = extremely desire.

The burger prepared from the frozen prerigor beef had the highest cooking loss, while the 48 hrs post rigor beef burger had the lowest cooking loss among the treatments ( $P < 0.05$ , table 4).

As for Water Index, the results indicate that the burger prepared from the frozen prerigor beef was the lowest in water index compared with the rest of the treatments ( $P < 0.05$ , table 4).

Mean values for lightness (L), redness (a) and yellowness (b) as objectively determined, indicate that, there were no significant differences among the treatments ( $P > 0.05$ , table 5).

For pH values, the burger prepared from the frozen prerigor beef had a significantly higher pH value than the other treatments ( $P < 0.05$ , table 5). The results also indicate that the pH value of the burger prepared from the frozen prerigor beef was different and decreased significantly before cooking compared with the rest of the treatments ( $P < 0.05$ , table 6). Also the pH values in all the treatments increased slightly after cooking.

## DISCUSSION

As shown in the results of experiment 1 (table 2) and experiment 2 (table 3), the burger prepared from the frozen prerigor beef had the lowest tenderness and juiciness scores compared with the rest of the treatments. It has been observed that the frozen prerigor beef undergoes upon being thawed an immense, irreversible shortening which has been designated as thaw rigor (Luyet, 1966).

The results are in agreement with the findings of Marsh (1966). In a study of thaw rigor, in ovine muscle, he found that when complete thawing of frozen prerigor muscle had occurred, an immediate and very large contraction took place, accompanied by a large amount of exudation. Marsh (1964) showed that, the degree of shortening during the onset of rigor mortis has a direct effect on tenderness so when muscle goes into rigor mortis in contracted condition, there is considerable shortening. Lawrie (1979) showed that over effective chilling of hot carcasses can lead to toughness if the temperature of the muscles can be reduced below 15-19°C, whilst they are still in the early prerigor condition, and there is a tendency for shortening (cold shortening) and thereby, toughness on subsequent cooking. The tenderness of the hot prerigor beef burger may be due to cracking and tearing of the muscle structure as a result of the immense shortening during cooking (Marsh *et al*, 1974).

Table 4. Means and Standard errors for cooking Loss (Shrinkage % ), water index and colour of beef burgers from different treatments (Experiment 2)

Beef burger treatments

Independent Frozen Frozen Frozen 48 hrs post S.E.

Variables prerigor acidified acidified rigor beef

beef ground prerigor

prerigor beef

beef

|               |                    |                    |        |
|---------------|--------------------|--------------------|--------|
| Cooking Loss  | 16.61 <sup>a</sup> | 15.24 <sup>b</sup> | ± 0.93 |
| (Shrinkage %) |                    |                    |        |

|                |                    |                    |                    |                    |        |
|----------------|--------------------|--------------------|--------------------|--------------------|--------|
| Water index    | 19.25 <sup>a</sup> | 22.75 <sup>b</sup> | 25.25 <sup>'</sup> | 25.50 <sup>`</sup> | ± 0.39 |
| Lightness (L)  | 29.05 <sup>a</sup> | 28.45 <sup>a</sup> | 29.23 <sup>a</sup> | 29.20 <sup>a</sup> | ± 0.75 |
| Redness (a)    | 8.35 <sup>b</sup>  | 8.45 <sup>b</sup>  | 8.08 <sup>b</sup>  | 8.13 <sup>b</sup>  | ± 0.39 |
| Yellowness (b) | 8.35 <sup>'</sup>  | 8.00 <sup>`</sup>  | 8.20 <sup>'</sup>  | 8.01 <sup>`</sup>  | ± 0.27 |

a. be

: Means in the same row bearing different superscripts are significantly different (P< 0.05).

Table 5. Means and Standard errors for pH values of beef burgers from different treatments (Experiment 2) .

Beef burger treatments

| Independent      | Frozen            | Frozen                         | Frozen                  | 48 hrs post       | S.E.   |
|------------------|-------------------|--------------------------------|-------------------------|-------------------|--------|
| Variables        | prerigor beef     | acidified ground prerigor beef | acidified prerigor beef | rigor beef        |        |
| After processing | 6.10 <sup>a</sup> | 5.30 <sup>'</sup>              | 5.5bc                   | 5.4 <sup>k</sup>  | ± 0.08 |
| Before cooking   | 5.68 <sup>b</sup> | 5.18 <sup>'</sup>              | 5.33bc                  | 5.33bc            | ± 0.08 |
| After cooking    | 6.00 <sup>"</sup> | 5.40 <sup>k</sup>              | 5.55 <sup>b</sup>       | 5.68 <sup>b</sup> | ± 0.08 |

a be

: Means bearing different superscripts are significantly different

(N 0.05).

Judge *et al.* (1990) showed that meat that was ground while in the prerigor state and mixed with salt, has superior water-holding capacity and maximum juiciness. They postulated that the formation of lactic acid and the resultant drop in pH are responsible for an overall reduction of reactive groups available to bind water on the protein. This is due to the pH approaching the iso-electric point of the muscle protein (pH; 5.0-5.4), leading to decreased juiciness of the product.

The burger prepared from the 48 hrs post rigor beef had the highest tenderness score, as shown in the results, so it was considered as the control in all the experiments. Increased tenderness during conditioning presumed to be caused by the action of cathepsins, which are proteolytic enzymes that have been activated by the conditions that have been attained at that time. The results are in agreement with the findings of Jay (1966), who has reported that upon the completion of the process of rigor mortis there is a break down of proteins in the absence of bacterial action which

presumed to be caused by cathepsins. Marsh, (1952), postulated that, resolution or the softening of rigor mortis results from alteration in the structure of the muscle caused by action of cathepsin enzymes.

With regard to juiciness, the 48 hrs post rigor beef had the highest juiciness score. Conditioning the meat increases its water holding capacity at various environmental pH values due to changes in the ion-protein relationship Arnold *et al.* (1956).

The different treatments having similar ingredients, similar formulation and similar processing procedures did not show any significant difference in flavour or colour as indicated in the results of experiment 1 and 2.

The effect of acidification could be explained by its effect on Adenosine triphosphatase, the enzyme of the contractile system. As the pH of the muscle drops due to addition of the acid, there will be inactivation or suppression of the actomyosin — adenosine triphosphatase (ATP ase) that causes a marked shortening due to splitting of ATP Lawrie, (1979), consequently, there is increase in tenderness of the product.

The highest tenderness score of the burger prepared from the acidified ground prerigor beef could be due to the fact that, grinding increases the surface area of the muscle and more acid would be distributed throughout the muscle tissue swiftly causing rapid pI-I fall. Accordingly, more water is lost, but this can be restored again in the mixture and bound. The burger prepared from the frozen prerigor beef

had a significantly higher cooking loss and a lower juiciness score due to effect of thaw rigor phenomenon which causes a marked shortening that results, from a greater amount of contraction, and excessive amount of exudation. The cooking loss of the burger prepared from the frozen acidified ground prerigor beef was high, while the water Index was low. The losses due to the shrinkage on cooking, however, will be greater since the high temperatures involved will cause protein denaturation and a considerable lowering in water-holding capacity Wierbicki *et al.* (1957); Paul and Bratzler, (1955). Water index or Juiciness varies inversely with cooking losses Judge *et al.* (1990). The burger prepared from the 48 hrs post rigor beef had the highest cooking yield and a higher juiciness score.

Pederson, (1978). Postulated that conditioning of meat increases its water holding capacity at various environmental pH values and this reduces the cooking losses.

The high pH values of the burger prepared from the frozen prerigor beef result from elimination of glycolysis. Our results indicate that the high pH value of the prerigor beef burger was decreased significantly after processing, because the storage temperature does not suppress or inactivate the glycolytic enzymes. The low pH of the acid treated samples results from the addition of the acid to the muscle, and that of the 48 hours post rigor samples resulted from accumulation of Lactic acid and were increased during cooking. Roberts and Lawrie (1974) showed that the slight upward shift in pH of the muscle tissue during heating is due to denaturation changes in the protein.

In conclusion, the results of these experiments demonstrate that the problems of toughness and shrinkage of prerigor beef burger are associated with thaw rigor phenomenon. Practical solutions for these problems could be achieved by allowing the prerigor muscles to complete rigor mortis,

and further improvement is possible if processing is delayed until resolution of rigor mortis. Methods, that arrest or minimize rigor contraction like lowering of muscle pH could improve palatability characteristics.

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