HOW TO MAKE SAFE, JUICY AND ROSE BEEF PATTIES FOR THE FOOD SERVICE SECTOR

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The purpose of this study was to determine the reduction of *L. monocytogenes* during heat treatment of beef patties at 53, 58, 60 and 63°C and to evaluate the sensory quality of beef patties cooked at low temperatures for a long time (LTLT). LTLT cooking is ideal for reducing toughness and improving juiciness, although it is important that the treatment ensures inactivation of pathogens. Beef patties were inoculated with a 5-strain cocktail of *L. monocytogenes* ($D_{60°C}$= 0.5 – 1.8 min) in the centre of beef patties and heated at the selected temperatures. Samples from the centre of the meat were analysed four times during the heat treatment. Beef patties heat treated at 55, 60 and 75°C with holding times of 210, 27 and 0 min., respectively, were evaluated by a trained sensory panel. LTLT ensures > 6.7 log reduction of *L. monocytogenes* if the heating time is 300 min. at 53°C, 30 min. at 58°C, 20 min. at 60°C and 3 min. at 63°C. The sensory analysis showed that cooking to 55°C and 60°C compared with 75°C resulted in beef patties with a bright rose colour, a juicier and less crumbly texture and a 10-14% lower moisture loss during LTLT cooking.

Key Words – LTLT, beef patties, safety, sensory profiling

I. INTRODUCTION

Prolonged cooking of meat at a low temperature (LTLT) is ideal for enhancing the eating quality of meat by reducing toughness and cooking loss and improving juiciness. Furthermore, it is possible to obtain a rose colour in the centre of the meat [2].The safety aspect of heating meat at low temperatures is important because pathogenic bacteria, such as *L. monocytogenes*, are able to survive mild heat treatments and multiply at low temperatures [4]. Using the log D/z-concept, the mean log $D_{70°C}$ (min) for *E. coli* (n=383), *Salmonella* (n=1141), *L. monocytogenes* (n=940) [1] were recalculated to the mean $D_{60°C}$-values (min) of 1.88, 1.86 and 2.33, respectively. The $D_{60°C}$-values indicate that *L. monocytogenes* is generally more heat resistant than *E. coli* and *Salmonella* and is therefore an appropriate test organism in heat treatment experiments at temperatures below 60°C.

The prevalence of *L. monocytogenes* in fresh meat is expected to be low. Rhoades [8] reported that, in an FSIS survey, 52 *L. monocytogenes* positive samples were found in 100 samples of ground beef. The positive samples contained 2.9 MPN/g. Nørrung [7] detected *L. monocytogenes* at a level of 10-100 cfu/g in 12 of 343 samples of fresh meat. The highest contents were found in ground beef. Gunvig [5] showed that *L. monocytogenes* can increase by 2 log in pork roasts stored at 5°C for 19 days. Therefore, it is assumed that, in the worst case, fresh meat can contain 4 log of *L. monocytogenes*/g, and an LTLT heat treatment that ensures a 4-log reduction of *L. monocytogenes* must be regarded as safe.

Danish legislation requires that food products are heated to 75°C or that it can be demonstrated that another heat treatment is as safe as heating to 75°C [10]. The USDA has introduced new recommendations that allow pork, beef and lamb roasts, chops and steaks to be cooked to a minimum internal temperature of 62.8°C followed by a 3-minute rest time [11].

The Danish catering sector requires documentation for safe heat treatment at temperatures below 75°C. Documentation of food safety at temperatures below 75°C will provide an opportunity to serve juicy beef patties with a rose-coloured centre.

In the present study, the reduction of *L. monocytogenes* was determined during heat treatment of beef patties at 53°C, 58°C, 60°C and 63°C, and sensory profiling of patties cooked at low temperatures was conducted.

II. MATERIALS AND METHODS

Determination of D-value: Selected strains: *L. monocytogenes* DMRICC 3012 (from meat environment), DMRICC 4106 (human outbreak), DMRICC 4124 (meat), DMRICC 4127 (sausage) and DMRICC 4140 (bacon).The D-values were determined using a modified version of the method described by Juneja [6]. A diluted overnight culture (10 ml) of each of the strains was added to 40 g meat slurry consisting of sterile ground pork (3-6% fat) and sterile water in a ratio of 1:1. The D-values were determined at 53, 60, 65 and 70°C for the five strains.

Safety experiment: Each strain was grown for 24 h at 37°C, and then the strains were mixed with brain heart infusion (BHI, Oxoid) and then mixed with green fruit colouring (Dr. Oetker) in a ratio of 2:1. The beef patties (minced beef (9-15% fat) were inoculated in the geometric centre by placing 2 g meat, mixed with 0.1 ml of the coloured cocktail, between two beef patties each weighing 70 g, resulting in a beef patty weighing 140 g (thickness = 1.5 cm, diameter = 10 cm) which was subsequently vacuum-packed in boilable pouches (CN300 CRYOVAC®). The vacuum-packed samples were placed in a water bath at 53, 58, 60 or 63°C. After the core-temperature (Tc) was reached, and during the holding time, three samples from each heat treatment were analysed at three times. The coloured area in the geometric centre was aseptically transferred to BHI. Serial dilutions in physiological saline with 0.1% Bacto-peptone were made and samples werespread onto the surface of Oxford agar (Oxoid, CM0856) and incubated at 37°C for 48 h.

Sensory analysis: Minced beef (9-15% fat), purchased from a local retailer, was formed into 140 g patties (thickness = 1.5 cm). The patties were placed in boilable pouches (CN300 CRYOVAC®) in single layers and vacuum-packed. The beef patties were sous-vide cooked in a Classic Gastro A/S with a capacity of 40 kg. The heating time was equivalent to the heating required to achieve a 4 log reduction of *L. monocytogenes*. The time to a 4-log reduction was estimated using the DMRI model ($D_{60°C}$ = 8.7 min. and z = 6.3°C, [3]) to be equal to 210 min. at 55°C, 27 min. at 60°C and 0 min. at 75°C. The beef patties were stored at 0°C until sensory analysis was performed. Before being served, the beef patties were tempered at room temperature and then fried on a pre-heated pan (160°C) to a core temperature of 63°C. Each beef patty was cut into halves and served to two assessors. Samples were evaluated on a 15-point unstructured scale anchored at the extremes (0 = low intensity and 15 = high intensity) by an 8-member trained sensory panel. The sensory data were analysed using PanelCheck V1.4.0. with a 2-way ANOVA. The means were calculated and separated using probability of difference. Levels of significance: $p > 0.05$ = non-significant (ns), $0.05\ p > 0.01$ = *, $0.01\ p > 0.001$ = **, $p < 0.0001$ = ***.

Moisture loss: Patties were weighed before and after sous-vide cooking and before and after frying. The weight loss was calculated as: $(weight_{raw} - weight_{cooked})*100\%/weight_{raw}$.

III. RESULTS AND DISCUSSION

Determination of D-values: In the experiment, a 5-strain cocktail of *L. monocytogenes* was selected to represent different contamination possibilities.

Table 1 shows the D-values for the five strains of *L. monocytogenes*. The D_{60}-values are in the interval 0.5 to 1.8 min. Asselt [1] calculated a mean $D_{60°C}$= 2.33, σ=±0.4 min. The two strains with D-values of approx. 1.8 min. are included in the interval mean ±2σ, and the strains can be regarded as strains with a mean D-value. The highest D-value was measured for the strains isolated from the meat environment and meat.

Table 1. D-values and z-values for five strains of *L. monocytogenes*.

DMRICC	3012	4106	4124	4127	4140
D_{53} (min.)	28.3	17.1	36.6	24.9	14.9
D_{60} (min.)	1.77	0.58	1.67	0.58	0.55
D_{65} (min.)	0.30	0.09	0.21	0.09	0.09
z-value, °C	6.0	5.3	5.4	4.9	5.4

Safety experiment: L. monocytogenes was inactivated by 0.5 log to 4.6 log during heating to

the respective temperatures (Table 2). Figure 1 shows the time and temperature profiles for heating beef patties, and it can be seen that long time cooking at temperatures above 50°C increases the reduction during the heating (Table 2). On the other hand, it is expected that prolonged heating at temperatures between 50 and 60°C results in heat adaptation of *L. monocytogenes* [9]. In theoretical assessment, it would be appropriate to use a D-value higher than 2.33 min. to include a safety margin. The author recommends a $D_{60°C}$ -value of 8.7 min. [3], which is a mean value between Asselt´s mean value ($D_{60°C}$=2.33 min) and PI 95% ($D_{60°C}$=14 min).

Table 2. Log reduction of *L. monocytogenes* in beef patties at Tc[1] and after the specific holding time at 53, 58, 60 and 63°C

Temperature	Reduction at Tc	Total reduction (time[2])	Holding times[3]
°C	Log (min.)	Log (min.)	Minutes
53	0.5 (22)	> 6.7 (322)	300
58	1.1 (23)	> 6.7 (53)	30
60	2.7 (24)	> 6.7 (44)	20
63	4.6 (28)	> 6.7 (31)	3

[1] Tc = Time until the heat treatment temperature is reached in the core.
[2] Total process times
[3] Holding time = Time at the specific temperature

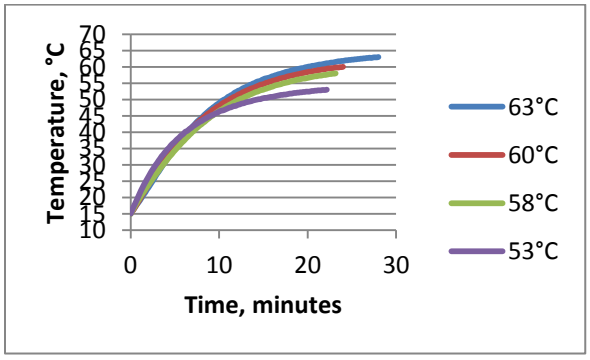

Figure 1.Time and temperature profiles for heating beef patties (thickness = 1.5cm) to a core temperature of 53, 58, 60 and 63°C

The time to reach the internal temperatures increased with increasing temperature, as expected. The difference in the time taken to reach the internal temperature varies only from 22 min. to 28 min. in 140 g beef patties (thickness = 1.5 cm).

The total reduction of *L. monocytogenes* was more than 6.7 log/g after holding times of 300, 30, 20 and 3 min at 53, 58, 60 and 63°C, respectively (Table 2). As the number of *L. monocytogenes* was below the detection limit (10 cfu/g) at the sampling time, it was impossible to determine the exact log reduction per time unit. It would have been appropriate with more samples during the holding time in order to determine the holding time to a 4-log reduction of *L. monocytogenes* more precisely.

The results indicate that the selected holding times ensure safe beef patties after heat treatment at the respective temperatures. The holding time of three minutes at 63°C corresponds with the rest time for e.g. a whole roast recommended by USDA.

Figure 2. Internal colour of sous-vide cooked beef patties at 55, 60 and 75°C.

Table 3. LSmeans for sensory attributes evaluated on LTLT-treated beef patties by an 8-member trained panel on 5 replicates (n=40).

	55°C	60°C	75°C	p
Doneness	1.9 a	2.1 a	10.6 b	***
Fried flavour	8.4 ab	7.6 a	9.4 b	*
Beef flavour	6.4	5.8	6.8	ns
Liver flavour	0.3	0.4	0.3	ns
Rancid flavour	0.6	0.8	1.0	ns
Burnt flavour	0.8 ab	0.6 a	1.6 b	*
Metallic flavour	1.4 b	1.6 b	0.6a	*
Acid taste	4.0	4.0	3.6	ns
Juiciness	7.3 b	6.9 b	3.1 a	***
Cohesiveness	4.9	4.2	3.4	ns
Crumbliness	7.2 a	7.7 a	10.8 b	**
Chewing time	8.5 a	9.3 b	9.7 b	**

Sensory analysis: Sensory attributes, in particular texture and appearance, were influenced by the cooking temperature. Beef patties cooked at 55 and 60°C obtained almost the same sensory profiles (Table 3), while cooking at 75°C

resulted in a much different profile. Cooking at 55-60°C, instead of the usual 75°C, resulted in beef patties with a bright rose colour (Figure 2), more juiciness, a less crumbly texture and a slightly more metallic flavour.

Temperature did not influence beef flavour, liver flavour, rancid flavour, acid taste or cohesiveness (Table 4).

Moisture loss: Moisture loss during sous-vide cooking increased with increasing temperature (Table 4). Cooking beef patties sous-vide at 75°C results in approx. 23% moisture loss. However, if patties were cooked at 60°C, the moisture loss was only 13% and therefore 10% lower compared with 75°C. If the temperature was even lower at 55°C, the loss is only approx. 9%, approx. 14% lower compared with 75°C. Pan-frying resulted in a moisture loss of 9-13%.

Table 4. Moisture loss (%) during sous-vide cooking (holding time = 4-log reduction *L. monocytogenes*) and pan-frying (n=20).

	55°C	60°C	75°C
Sous-vide	8.5	12.9	22.8
Pan-frying	12.9	11.2	9.6
Total loss	20.4	22.6	30.2

IV. CONCLUSION

LTLT cooking of beef patties (thickness = 1.5 cm and diameter = 10 cm) at 53, 58, 60 or 63°C with holding times of 300, 30, 20 and 3 min, respectively, ensured a 4-log reduction of strains of *L. monocytogenes* with a mean D-value.

Processing beef patties sous-vide at 55 and 60°C (220 and 27 min, respectively) resulted in juicier and less crumbly beef patties with a rose-coloured centre and 10-14% lower moisture loss compared with 75°C.

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