Validation of a photographic tool for assessing consumer perception and acceptability of doneness of beef

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Abstract—

Consumer perception and acceptability of doneness of beef was assessed using cooked meat and corresponding photographs. Vacuum packed half sirloin was cut into 25mm thick slices (approximately 100g). Steaks were cooked on a clam-shell grill (plate temperature 200°C) to achieve the following internal temperatures: 60°C, 70°C, 75°C, 80°C, 85°C representing 5 levels of doneness, (rare, medium, medium-well, well-done and very well-done, respectively).

Consumers (n=40) were recruited to participate in two sensory evaluation sessions. In the 1st session, steaks of each level of doneness were presented to consumers and photos of each individual steak (both external & internal surface views) were taken in a D65 lighting booth. Consumers assessed the external and internal surface of each meat sample for acceptability of appearance and perception of doneness. Two weeks later, corresponding photos of the steaks (viewed in 1st session) were similarly evaluated by the same consumers. Data was analysed using a split plot ANOVA and least significant test.

Perception scores (for both external and internal surface views) between different presentation methods: steak samples and corresponding photos, were not significantly different ($p>0.05$). The only significant difference observed was the consumer acceptability of the internal surface ($p<0.05$).

The photographs developed were shown to be a valid tool for assessing perception of meat doneness and are suitable to assess heterocyclic amine exposure in dietary studies.

Keywords— **end-point temperature, sensory evaluation, food photographs**

I. INTRODUCTION

Heterocyclic amines (HCAs) are mutagenic and suspected carcinogenic compounds produced when protein-rich muscle foods are cooked using normal household cooking temperature [1]. The dietary intake of these HCAs depends on 2 main factors: cooking method and level of doneness. Since the consumer has different perceptions of doneness level, food photographs were included in some dietary questionnaires to improve the accuracy of data collection [2]. In a recent review, Zheng & Lee [1] commented that use of photographs to assess usual HCAs exposure had not been validated. It is important to standardise photographic conditions and set up ICC profiles throughout the workflow from capturing the image to printing, which aims to reflect the actual colour of the meat sample [3].

Therefore, the objective of this study was to compare perception of doneness between cooked meat and its corresponding photos as a means of assessing reliability and accuracy of using food photographs.

II. MATERIALS AND METHODS

A. Cooking protocol

Vacuum-packed half sirloins (L. lumborum ~4kg) were purchased at a local wholesaler on the day of experiment. The skin and any external fat of the sirloin were trimmed and it was further cut into 25 steaks (25mm thick and approximately 110g each). All samples were kept in the fridge (4°C) until use on the same day. Prior to cooking, a type K thermocouple (Omega Engineering Inc., Manchester, UK) was inserted into the middle of one steak in each batch (n=5) to monitor internal temperature during cooking. Five steaks (pre weight) were placed on a clam-shell grill (model no.: S-143, Silesia, York, UK) set at 200°C and the top side of the grill was closed 15 seconds later. Steaks were cooked for different lengths of time to achieve different level of doneness (Table 1). After the designated cooking time, steaks were removed from the grill immediately, thermocouples were kept in position in steaks for an additional 1 minute to record the end-point temperature. Steaks

were weighed again after removing the inserted thermocouples.

Table 1 The total cooking time required for reaching the expected internal end-point temperature for various doneness of steaks.

Doneness	Total cooking time (mins)	Expected internal end-point temp. (^{o}C)
Rare	3	60
Medium	4	70
Medium well	4.5	75
Well done	5	80
Very well done	5.5	85

B. pH Measurement

Raw steak samples were selected from each batch for pH measurement before the start of cooking. The pH of steak samples was measured in duplicate using a TPS WP-80 pH-mV-temperature meter (Aquaspex, Blackwood, Australia).

C. Shear force and cooking loss measurement

Cooked samples were chilled immediately after cooking and Warner-Bratzler Shear Force (WBSF) was completed within 24 hours. Cores (13mm diameter) were sheared perpendicular to the muscle fibres using a Warner–Bratzler shear attachment mounted on an Instron Universal Testing Center (Model 3366, Instron, Norwood, USA). Percentage weight loss was calculated using pre-and post-cooking weights of steaks.

D. Consumer panel

Consumer-based sensory panels were conducted (4 separate panels of n=10 panellists) to evaluate the visual acceptability and perception of steaks cooked to 5 different end-point temperatures. Each consumer attended two evaluation sessions separated by a 2-week interval. At the first session, they visually evaluated the steak samples. At the second session, consumers evaluated the corresponding photographs of steaks they had evaluated in the first session. Sensory software Fizz (Biosystems, France) was used to create a computer-based questionnaire (described below).

E. Sensory evaluation

All the evaluation sessions were conducted in sensory booths equipped with D65 fluorescent lights (closest to daylight). In session 1, panellists were served 5 steaks in total, corresponding with each degree of doneness and each half steak was placed on a paper plate with random three-digit numbers to identify the samples. Photographs of each steak were taken to capture the external appearance before serving to the consumer. To avoid the possible influence from viewing the internal appearance of steak, consumers were presented steaks with the internal side facing away from their view (view A).

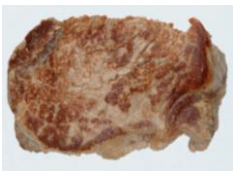
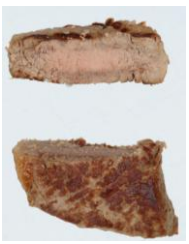


Fig. 1a) View A



1b) View B

After evaluating View A and completing the questionnaire, participants were then asked to cut the steak in half to evaluate the internal appearance (view B). After completing the questions, the steaks were removed from the panellists and the next steak presented. Photographs of the internal surface (view B) were taken after evaluations completed.

Two weeks later, the same group of consumer panellists were recalled to evaluate the photographs corresponding to the steaks they had evaluated in the 1st session. Photos were presented in the same order as steaks had presented in session 1 and panellists answered the same questions. After completing questions, consumers were given duplicated photos for medium and well done steaks again to assess their consistency in scoring and evaluating samples.

For each view of the steak sample (view A and view B), participants were asked to rate the acceptability (1 = extremely unacceptable, 4=neither acceptable nor unacceptable, 7= extremely acceptable) and perception of doneness (1= very rare, 4= medium, 7= very well done) on a 7-point box scale.

F. Photography of steak samples

D65 fluorescent light was chosen as the standard illuminant in photo shooting. The cooked steak samples were photographed using a NIKON D70 digital SLR camera equipped with a 60mm lens (model: f/2.8D AF Micro NIKKOR, Nikon, UK) mounted on a photographic stand. The camera was fixed perpendicularly to the surface of meat sample with a focal distance of 33 cm. Following preliminary experiments, the following camera parameters were chosen: manual mode; shutter speed, 1/20; aperture size, F8; ISO, 400. A GretagMacbeth mini Colour-Checker (Colour-confidence, UK) which contains 24 coloured patches was photographed with each meat sample for checking the colour reproduction capability. International colour consortium profiles (ICC) were created for each device and they were used throughout the workflow to achieve the purpose of colour management.

G. Statistical analysis

Data were analysed using the Genstat (2007) split plot ANOVA and Fisher's protected least significant difference test (LSD) to compare score between meat and photo. The panel performance was assessed using two sample sign test on the duplicated photos used in the photo session. Difference was accepted if $p < 0.05$ for both the LSD and two sample sign test.

III. RESULTS AND DISCUSSION

A. Internal temperature, cooking loss, WBSF and pH measurement

In general, the internal end-point temperatures, cooking loss and WBSF increased as the cooking time increased from 3 to 5.5 minutes (Table 2), which is similar to the results reported by other workers [4].

The end-point temperature for medium cooked steaks was slightly higher and close to the expected temperature for medium well (75^{o}C). As a result, no significant difference ($p>0.05$) was observed in the cooking loss and WBSF between medium and medium well. Similar trends were also observed between well done and very well done steaks as there was no significant difference ($p>0.05$) in the end-point temperature. However, the WBSF measurement for very well done steak (43.47 N) was significantly higher ($p<0.05$) than the well done steak (39.81 N). As expected, pH of the raw meat samples was not significantly different ($p<0.05$) between samples ranging from 5.71 to 5.72.

Table 2 Internal end-point temperature, percentage cooking loss, WBSF for steaks cooked to different level of doneness

Doneness	Cooking time (mins)	Measured end-point temp. (^{o}C)	Cooking loss (%)	WBSF (N)
Rare	3	61.58^{a}	13.96^{a}	31.11^{a}
Medium	4	74.19^{b}	20.21^{b}	34.25^{b}
Medium well	4.5	76.25^{b}	22.41^{b}	35.98^{b}
Well done	5	81.18^{bc}	27.20^{c}	39.81^{c}
V. well done	5.5	84.98^{c}	30.13^{c}	43.47^{d}
SEM	N/A	1.94	1.15	0.85

Means with a common superscript does not differ ($p>0.05$)

B. Sensory evaluation of steaks

The two sample sign test showed no significant different ($p<0.05$) between duplicated photos for medium and well done steaks, which indicated that the panel has shown consistent performance in evaluating the appearance of steaks (data not shown).

The effect of different doneness and presentation methods (view cooked steak versus corresponding photos) on perception and acceptability of doneness are shown in table 3.

For internal surface, there was a significant effect ($p<0.01$) on the perception of doneness. There was a significant difference between the rare, medium and well done level of doneness, and a trend towards general increase in scores from rare to well done steaks. The results indicated that the panellists could distinguish doneness between rare, medium, medium well and well done, but difference between well done and very well done steaks was not significant ($p>0.05$).

Table 3 Effect of doneness and method of sample presentation on acceptability and perception of doneness

	External		Internal	
Doneness	Accept.	Percep.	Accept.	Percep.
Rare	4.85	4.55[a]	4.25	3.6[a]
Medium	4.99	5.14[b]	4.78	4.85[b]
Med-well	4.83	5.2[b]	4.56	5.46[bc]
Well done	5.11	5.55[b]	4.6	5.95[c]
V.Well done	4.76	5.51[b]	4.48	5.89[c]
Sig.	NS	**	NS	**
S.E.M.	0.08	0.177	0.29	0.28
Presentation method				
Meat	5.02	5.28	4.68	5.15
Photo	4.79	5.24	4.39	5.16
Sig.	NS	NS	*	NS
S.E.M.	0.15	0.25	0.33	0.40

Within a method of presentation means with a common superscript are not significantly different (p>0.05)
NS p>0.05; * p<0.05; ** p<0.01: ***p<0.001.

There was a significant difference (p<0.01) in the perception of external surface, which showed the panel could distinguish rare steaks from all the other steaks of different level of doneness but not between 4 doneness levels. There was a trend towards gradual increase in perception of doneness from medium to very well done steaks although this was not significant.

There was no significant difference in acceptability score (p>0.05) for both external and internal surfaces, which is similar to results reported by previous study [5]. This observation could be explained by consumer's variation in preference for doneness, i.e. rare versus well done, resulting in similar average scores across different doneness.

The difference in trend between internal and external surfaces could be due to variation in external surface. Preliminary experiments showed steaks cooked to same degree of doneness have similar variation in browning pattern, but they could not be controlled and variation depends on several factors, e.g. location on the grill, moisture on the surface.

On the other hand, it has been found that the internal colour changes were reproducible by achieving certain end-point temperature due to protein denaturation and a steak doneness guide was developed by the AMSA in 1995[6].

Overall, there was no significant difference (p>0.05) between presentation methods, i.e. cooked meat versus corresponding photo, expect for acceptability of doneness for internal surface. Cooked meat had a significantly higher score than photo although the difference was small (4.68 and 4.39 for cooked meat and photo respectively). The results indicate that there may be additional attributes in cooked meat which are absent in corresponding photographs. These additional attributes may account for enhanced acceptability of the cooked meat over the photographs.

IV. CONCLUSION

The results supported the hypothesis that photos is a reliable tool in assessing consumer perception of doneness but specifically, photos of internal view may better discern different doneness level.

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