OPTIMUM OVEN COOKING PROCEDURE TO IMPROVE PALATABILITY AND COLOUR ATTRIBUTES FOR BEEF INSIDE ROUNDS

Argenis Rodas-González[1], Ivy L. Larsen[1], Bethany Uttaro[1], Lorna L. Gibson[1], Joyce Parslow[2], Manuel Juárez[1], and Jennifer L. Aalhus[1]

[1]Agriculture and Agri-Food Canada, Lacombe Research Centre, 6000 C & E Trail, Lacombe, Alberta, Canada T4L 1W1

[2]Beef Information Centre, 2000 Argentina Road, Plaza 4, Suite 101, Mississauga, Ontario, Canada L5N 1W1

Abstract – To determine optimum oven cooking procedures, the effects of searing temperature (232 or 260°C) and time (0, 10, 20 or 30 min), as well as roasting temperature (160 or 135°C) on palatability and colour attributes of *semimembranosus* (SM) muscle were examined. The SM muscles seared for 0 or 10 min at 232°C followed by roast at 135°C had lower cooking loss, higher external browning colour, more uniform internal colour, and were more tender and flavourful. As a simplified method, roasting at low temperature without searing is the preferred oven cooking procedure.

Key Words: cookery method, digital imaging, tenderness

I. INTRODUCTION

The Canadian Beef Information Centre (BIC) currently has five different cooking instructions for beef roasts: Pot Roast, Rotisserie Roast, Quick Roast, Oven Roast and Premium Oven Roasts. However, a market research study [1] indicated that consumers can not clearly differentiate between them. At the same time, consumers are expecting a "premium" eating experience without complicated cooking procedure [2]. A generally accepted method of cooking roast cuts is to dry roast at a constant temperature throughout the cooking time, particularly for cuts of beef with low connective tissue content. However, most muscles with high connective tissue content (i.e. *semimembranosus*; SM) are thought to require moist heat cookery, such as braising. In this sense, an experiment was carried out in order to evaluate the effects on palatability and colour attributes of searing at different temperatures (232 or 260°C) and times (0, 10, 20 or 30 min) on SM (inside round) muscle, combined with roasting temperatures (160 or 135°C).

II. MATERIALS AND METHODS

Sample collection and cooking

A total of 48 inside round sub-primals (~4.5 kg) from graded Y1 AA [3] carcasses were obtained from a commercial slaughter plant and shipped to the Lacombe Research Centre (Lacombe, AB, Canada). The sub-primals were aged at 2°C in vacuum packages for 14 d. Twelve inside rounds were then assigned for each searing time (0, 10, 20, or 30 min). Inside round sub-primals were removed from their packaging, dissected and SM were obtained four days prior to cooking. The SM muscles were trimmed to a square shape and two steaks from the proximal portion of the muscles were removed for determination of initial shear force (2.5 cm thick) and moisture and fat content [4]. The remainder of the SM muscle was divided longitudinally (proximal to distal) into two equal weight roasts (~1.28 kg each). The cut portions were assigned randomly in pairs equally distributed for searing and roasting temperature combinations, and replicated 6 times in two cooking days. Roasts were labelled, placed into polyethylene bags and stored in a refrigerator at 4°C until the appropriate cooking day. The SM roasts were cooked to a final cooking temperature of 68°C.

Shear force analysis and sensory evaluation

For initial shear force, samples were cooked on an electric grill according to AMSA [5] to a final temperature of 71°C. After cooking, steaks were held in a cooler for a 24 h period and then three cores per steak were obtained (1.9 cm in diameter; parallel to the fibre direction) [5]. From the roasted muscle, a 2.5 cm thick steak was obtained and chilled overnight for assessment of objective shear.

With regard to taste panel samples for sensory evaluation, slices with similar vertically/ lengthwise size from the SM (3 mm thickness) were obtained. A detailed description of handling samples prior serving to panellists was described by Aalhus *et al*. [6]. Attribute ratings were evaluated using an eight-point descriptive scale according to AMSA [5].

Sensory and instrumental evaluation of colour
Two trained panellists evaluated the external surface according to a six-point scale (1=Slight brown; 2 = Light brown; 3 = Red brown; 4 =Dark brown; 5 = Excessive brown; 6 = Charred and almost burnt. Internal degree of doneness was evaluated according to a 6-point scale based on AMSA guidelines [5] with the addition of a “medium well” category (1 = Very rare; 2 = Rare; 3 = Medium rare; 4 = Medium; 5 = Well done; 6 = “Medium well”; 7 = Very well done).
A 1.9 cm-thick steak was obtained from the centre portion of the roasted muscle for instrumental colour evaluation of crust browning and degree of doneness, utilizing image analyses. Images of each surface were digitally captured (2272 × 1704 pixels; 72dpi) with a Canon PowerShot A80 fitted with a polarizing filter adjusted 90° to the orientation of polarizing filters on the two GE 100W Reveal lights illuminating the sample from 45° to the horizontal. A custom white balance was set from a Kodak 18% grey card. Image J (v 1.32j; available at http://rsb.info.nih.gov/ij; developed by Wayne Rasband, National Institutes of Health, Bethesda, MD) was used to select the area of interest, divided the 256 × 256 × 256 RGB colour space into 16 × 16 × 16 bin for a total of 4096 bins, and recorded the number of pixels found within each bin.

Statistical analysis
Data collected were analyzed using PROC MIXED of SAS (Cary, NC) version 9.2 [7]. The model was a completely randomized design with split-split-plot arrangement. Initial shear force and fat content were included in the models as covariates. Random variable included replication and its interaction with searing time, searing temperature and roasting temperature. Least squares means were separated (F test, $P < 0.05$) by using least significant differences generated by the PDIFF option. The degrees of freedom in the denominator were adjusted using the Kenward-Roger procedure

III. RESULTS AND DISCUSSION

Cooking traits of beef SM cooked roasts are presented in Table 1. Searing for 0 and 20 min had lesser cooking loss ($P < 0.05$) than searing for 10 min. At the same time, roasting at 135°C had lesser cooking loss ($P = 0.01$) with respect to roasting at 160°C. With regard to cooking time, searing for 0 min required more time to reach 68°C, followed by searing 10 and 20 min and finally searing for 30 min. As well, searing at 232°C required more time than searing at 260°C ($P < 0.05$).

On colour evaluation of cooked product (Table 1), external browning was affected mainly by roasting temperature ($P < 0.01$); where roasting at lower temperature (135°C) produced a higher browning score than roasting at 160°C without affecting the degree of doneness. On the contrary, searing for 0 and 10 min had higher internal degree of doneness score than searing for 30 min ($P < 0.05$). Searing for 20 min resulted in intermediate values.

Results from image analysis of SM cooked roasts (Table 1) indicated that searing up to 20 min got fewer bins held 75% of the pixels (BH75P) compared to searing for 30 min ($P <$ 0.05). This result indicates a more uniform colour across the surface (a higher amount of pixels in a lower amount of bins) in searing up to 20 min.

With regard to WBSF, there were no differences in WBSF values for any main effect in this study ($P > 0.05$). For palatability traits, a significant searing time × searing temperature interaction was detected ($P = 0.02$) on browning flavour score, where searing until 20 min either at 232 or 260°C did not produce changes on browning flavour score between both temperatures, but when the SM samples were seared for 30 min at 260°C, they got higher browning flavour score (3.06; “moderately bland”) than those seared during the same time but at 232°C (2.57; “very bland”). In contrast, roasting at 135°C resulted in higher scores on initial tenderness; beef flavour intensity, browning flavour, and overall tenderness when compared with roasting at 160°C ($P < 0.05$); being described by trained panellists as more tender, and more flavour (beefy and browning) than roasts cooked at 160°C.

Jeremiah and Gibson [2] evaluated five different beef roast cuts (including SM) and all of them required more cooking time to reach a final endpoint temperature (67.5°C) with constant dry heat roasting (DHR) at 140°C, without difference on cooking loss (%); with exception of rump, which had more cooking loss compared to an initial moist heat with a dry heat finish protocol (IMDF). These findings agree with the results of the current study. On the other hand, Powell *et al.* [8] compared beef ST roasts cooked in a conventional forced-air convection oven (CFACO; at 163°C and internal endpoint of 65°C) versus multi-stage cooking (MULTI; preheating, holding 60 min at 55°C internal core, and finishing at 65°C) and no differences were found in cooking yields. However, Ko *et al*. [9] found greater cooking loss in two-step oven heating process (TSOHP; long low temperature and finishing with short high temperature) than CFACO in beef LM.

Slowing heating rates result in a longer time range, causing denaturation of myoglobin, which results in a uniform meat colour surface [10, 11]. The longer cook time also ensures meat surface browning through the Maillard reaction [10]. The diminishing of the degree of doneness linked to increases in the searing time is likely due to a reduced cooking time, although others have suggested that searing at high temperature may create a surface barrier to heat transfer, diminishing the denaturation of the myoglobin [10]. Publications addressing the effect of meat cooking procedures on digital image analysis variables (distribution of colour pixels into bins) do not exist to author's knowledge.

On palatability traits, Jeremiah and Gibson [2] did not find any difference in tenderness between DHR at 140°C and IMDF at 160°C on five muscles (including SM). Powell *et al*. [8] found a lower shear force value for the MULTI roasts (3.3 kg) than for CFACO roasts (4.73 kg), due to less percentage of total insoluble fractions. However, Ko *et al*. [9] found no differences on palatability traits between TSOHP and CFACO in beef LM.

Table 1. Cooking parameters and quality traits of beef s*emimembranosus* roasts cooked at different searing times and temperatures

Variable	STI, min				STE, °C		RTE, °C		SEM	*P*-value		
	0	10	20	30	232	260	135	160		STI	STE	RTE
Cook loss, %	24.9^b	26.6^a	24.9^b	25.8^{ab}	25.4	25.7	25.0	26.1	0.28	0.01	0.36	0.01
Cook time, sec.g^{-1}	6.97^a	6.38^b	6.30^b	5.50^c	6.43	6.14	7.14	5.44	0.11	<0.01	0.05	<0.01
Browning	2.25	2.30	2.53	2.20	2.45	2.19	2.80	1.83	0.13	0.58	0.14	<0.01
Doneness	5.02^a	4.98^a	4.66^{ab}	4.47^b	4.77	4.79	4.73	4.83	0.10	0.04	0.87	0.44
Total Bins used	144	141	141	150	141	147	146	142	2.71	0.35	0.12	0.24
Bins 75% pixel^y	6.40^b	6.23^b	6.65^b	7.47^a	6.69	6.69	6.92	6.46	0.12	0.03	1.00	0.09
WBSF, kg	7.91	7.65	6.90	7.65	7.51	7.54	7.28	7.77	0.22	0.14	0.93	0.12
Initial Tenderness^z	5.85	5.94	5.79	5.75	5.84	5.83	5.99	5.67	0.09	0.79	0.94	0.01
Juiciness^z	4.81	4.84	4.94	4.82	4.90	4.80	4.95	4.75	0.07	0.81	0.34	0.06
Beef Flavour^z	4.90	4.55	4.60	4.71	4.69	4.69	4.80	4.59	0.07	0.07	0.94	0.02
Brown. Flavour^z	3.14	2.91	2.87	2.81	2.91	2.96	3.04	2.83	0.06	0.06	0.62	0.01
Connective Tissue^z	6.51	6.61	6.49	6.36	6.42	6.56	6.57	6.41	0.07	0.54	0.20	0.15
Overall Tenderness^z	5.81	6.04	5.82	5.74	5.82	5.88	6.02	5.69	0.08	0.41	0.62	<0.01

STI = Searing time; STE = Searing temperature; RTE = Roasting temperature; SEM = Pool standard error of least square means

^{a,b,c} Least squares means within a row lacking a common superscript letter differ ($P < 0.05$).

Degree of external browning 1=a slight browning to 6=charred/ almost burnt

Degree of doneness 1= very rare to 7 = very well done

^{y}= related to total bins used

^{z} Sensory score were on an 8-point scale: 1=Extremely tough/dry/bland or none/abundant; 8=Extremely tender/juicy/intense/none detected.

IV. CONCLUSION

Searing 0 or 10 min at 232°C, followed by roasting at 135°C is the most recommendable oven cooking procedure. This cooking regimen resulted in higher external browning and colour uniformity, as well as more tender and flavourful rating characteristics. At the same time, results suggest consumers will be able to improve their eating experience without applying complicated cooking roasting procedure, driving to their satisfaction.

ACKNOWLEDGEMENTS

The financial support of the Beef Information Centre and the Beef Industry Development Fund is sincerely appreciated; as well, the Lacombe Meat Research Centre staff for their technical assistance.

REFERENCES

1. BIC. (2006). Beef Roasting Study. Beef Information Centre. Mississauga, ON. pp. 85.

2. Jeremiah, L. E., & Gibson, L. L. (2003). Cooking influences on the palatability of roasts from the beef hip. Food Research International, 36, 1-9.

3. Canada Gazette, C. (1992). Part II: Livestock and Poultry Carcass Grading Regulations. Part III. Grade names and grade standards for beef carcasses. In http://laws.justice.gc.ca/eng/regulations/SOR-92-541/page-1.html (pp. Accessed Nov 17, 2011).

4. AOAC. (1995). Association of Official Analytical Chemists. Official methods of AOAC international (16th ed.). Washington, DC: AOAC.

5. AMSA. (1995). American Meat Science. Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness of Fresh Meat. Natl. Live Stock and Meat Board, Chicago, IL.

6. Aalhus, J. L., Gibson, L. L., & Larsen, I. L. (2007). Evaluation of common beef cooking recommendations for optimal flavour, juiciness, tenderness and texture. Final report to the Canadian Beef Information Centre.

7. SAS. (2003). SAS/STAT user’s guide: Statistics: Cary, NC, USA: SAS Institute Inc.

8. Powell, T. H., Dikeman, M. E., & Hunt, M. C. (2000). Tenderness and collagen composition of beef semitendinosus roasts cooked by conventional convective cooking and modeled, multi-stage, convective cooking. Meat Science, 55, 421-425.

9. Ko, S., Yoo, S. H., Lee, S., Cho, S., Kim, K. H., & Hwang, R. (2011). Effect of long low temperature short high temperature cooking cycle on physicochemical properties of beef. Food Science and Technology Research, 17, 11-16.

10. Aalhus, J. L., Juarez, M., Aldai, N., Uttaro, B., & Dugan, M. E. R. (2009). Meat preparation and eating quality. In *55th International Congress of Meat Science and Technology*. Copenhagen, Denmark. pp. 1058-1063.

11. Bejerholm, C., & Aaslyng, M. D. (2004). Cooking of meat. In W. K. Jensen, Devine, C., & Dikeman, M. (Ed.), Encyclopedia of meat sciences (pp. 343-349). Amsterdam, London: Elsevier Academic Press.