Technical paper

Consumer Evaluation of Chinese Instant-boiled Beef

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The objective of this study was to determine the consumer perceptions of color, tenderness, juiciness, flavor, and residue of Chinese instant-boiled beef from 12 cuts of Qinchuan cows. The results of this study revealed that color, tenderness, juiciness, flavor, and residue were highly correlated to overall liking (P < 0.01). These sensory attributes were significantly correlated to each other (P < 0.01). Residue explained most of the variation in overall approval (R² = 0.403), whereas flavor, tenderness, and color explained 13%, 4%, and 2%, respectively, of the variation. SF values >9.08 kg and <6.83 kg belonged to tough and tender beef samples, respectively. All the cuts were accepted by the consumers; rib-eye roll, blade oyster, tenderloin, chuck-eye roll, and chuck tender were the most suitable for Chinese instant-boiled beef products.

Keywords: Chinese instant-boiled beef, shear force, consumer sensory evaluation

Introduction

Consumers are focusing on meat quality (Almli et al., 2013), especially, on meat tenderness, juiciness, flavor, residue, and color (Joo et al., 2013). But eating quality of beef was a parameter with great variation. The high variability of beef sensory quality (include tenderness) were influenced by the differences in intrinsic, productive (breed, sex, age, muscles/cuts, slaughter weight or diet) and technological factors (management, refrigeration and especially the ageing time) (Oliver et al., 2006; McKenna et al., 2004; Li et al., 2013; Hildrum et al., 2009; Realini et al., 2009).

Several studies have reported that the eating quality of beef varies based on consumer experiences and cultural backgrounds and on the country, according to studies conducted in USA, Italy, Brazil, Venezuela, Belgium, Japan, and Korea (Delgado et al., 2006; Desteefanis et al., 2008; Rodas-González et al., 2009; Cho et al., 2010; Van Wezemael et al., 2013; Lepper-Blilie et al., 2014; McKenna et al., 2004; Sasaki et al., 2014). However, studies focusing on the sensory attributes and eating quality of Chinese beef are few (Mao, 2008; Liu, 2008).

Most studies have focused on the sensory quality of beef steak. However, in China, the consumption of beef steak is limited. On the other hand, instant-boiled beef, which is considerably different to beef steak, is highly consumed by the Chinese population. Instant-boiled beef is different from beef steak in thickness (1 – 2 mm versus 1.27 – 2.54 cm, respectively), core temperature degree (100°C versus 45 – 92°C, respectively), and force direction (parallel to the fibers versus perpendicular to the fibers, respectively) (Oliver et al., 2006; Realini et al., 2009; Cho et al., 2010; Sasaki et al., 2014). However, it is not clear whether the sensory quality of beef steak is different from that of instant-boiled beef.

Therefore, the objective of this study was to evaluate the eating quality of instant-boiled beef by assessing the consumer perceptions of color, tenderness, juiciness, flavor, and residue of different cuts of beef.

Materials and Methods

Materials In this study, 6 steers of Qinchuan cattle (about 40 months of age; 210 ± 15 kg cold carcass weight), reared in a grass-based system supplemented with concentrates, were slaughtered at...
a local beef processing company. The carcasses were stored at 0 – 4°C for 48 h. Ten cuts (blade oyster, 2303; chuck tender, 2310; chuck-eye roll, 2268; rib-eye roll, 2240; striploin, 2140; tenderloin, 2150; inside, 2010; outside flat, 2050; eye round, 2040; and eye of rump, 2093) and two muscle tissues (knuckle cover and eye of knuckle) were deboned from the right carcasses of each animal based on the Bovine Meat Carcass and Cuts guidelines (UNECE standard, 2004). Each cut was divided into two samples and stored at -20°C prior to analyses. One was used for WBSF analysis and the other was used for consumer evaluation.

**Sample preparation** Samples were thawed at 4°C for 4 – 6 h, and the edges of each cut were trimmed before the evaluation. Then cut into 2-mm slices (5 cm × 5 cm × 2 mm) parallel to the muscle fibers using a WED-B250A-1 full-automatic slicer (Welldone Machine Equipment Company, Shandong, China), and labeled with three-digit random numbers. Then transferred to the consumer panel for color score (raw color), after that put into a boiling water bath (100°C) for approximately 1 min.

**Untrained consumer sensory evaluation** Consumer sensory evaluation was performed at a local restaurant in Xi'an. In this experiment, 288 consumers participated. Participants who consumed Chinese instant-boiled beef at least once a week were recruited from customers consumed in the restaurant. The participants were divided into small groups (6 – 10 consumers). Participants were seated at separate tables under white lighting and test room temperature was maintained by air-conditioner set at 22°C. The sensory evaluation tests were carried out at 3 – 4 p.m. and the time of each trial was approximately 20 min.

The order of presentation of the samples was randomized for each group for each consumer. Each consumer evaluated three samples. On average, each sample was evaluated by 12 consumers. Participants were instructed on how to evaluate each sample and each filled out a demographic questionnaire. Participants were instructed to take a sip of apple juice first, followed by a small bite of unsalted saltine cracker and then water before tasting each meat sample.

Each consumer rated color (raw beef), tenderness (define as the opposite of the force required to bite through the sample with the molars), juiciness (amount of moisture releases by the sample after the first two chews), flavor, residue (amount of tissue perceived after swallowing in the mouth), and overall liking using a 5-point scales (5 = like very much; 4 = like moderately; 3 = neither dislike nor like; 2 = dislike moderately; 1 = dislike very much; Beriain et al., 2009).

**Shear force (SF)** Prior to SF analyses, samples were thawed at 4°C for 48 h and SF was determined as described by Li et al. (2012). Samples were cut into rectangular pieces (6×6×3 cm) parallel to the muscle fibers, transferred to polyethylene bags, and heated in an 80°C water bath until the core temperature was 70°C. Temperature was monitored with a digital meat thermometer Oakton temp-300 (Cole-Parmer Instrument Company, Illinois, USA). Samples were subsequently stored overnight at 4°C. Six cores (1.27-cm diameter) parallel to the muscle fibers were removed from each sample and subjected to a texture analysis machine (TA.XT Plus Stable Micro System, Stable Micro System, Ltd, UK) equipped with an HDP/BSW blade with a test speed of 1.0 mm·sec⁻¹. The average of the maximum force necessary to shear the sample was used in data analyses.

**Statistical analysis** Data were analyzed by Spearman correlation coefficients (Proc Corr), and simple regression analysis (Pro Reg Stepwise) using SAS, Version 9.1. A mixed model of ANOVA was applied to study the effect of gender, age and cuts on sensory attributes (color, tenderness, juiciness, flavor, residue and overall liking). In this model, gender, age and cuts were included as fixed effects, and consumer (1 – 288), samples (1 – 72) and consumer*samples as random effect.

**Results and Discussion**

**Consumer demographics** The demographics of untrained consumers are shown in Table 1. Among the consumers, 41.3% were female, 44.8% were ≤30 y of age, 38.0% were 31 – 44 y of age; 13.8% were 45 – 59 y of age; and 3.4% were ≥60 y of age. Our results revealed that 82.8% of the consumers were young individuals.

Table 2 show that no significant differences (P > 0.05) were found between male and female consumers for color, juiciness, flavor, residue and overall liking, and no apparent trend was found for the effects of ages of consumers on their ratings of Chinese instant-boiled beef (P > 0.05). This was consistent with the finding of Huffman et al. (1996) and Monsón et al. (2005). There was a significant negative effect of gender for male on tenderness and females gave lower tenderness scores than males (P < 0.05, Table 2), this was consistent with the previous study by Delgado et al. (2006).

**Correlations and regression analyses of sensory attributes** Correlation coefficients between sensory attributes and overall liking scores are shown in Table 3. Color (r = 0.57), tenderness (r = 0.62), juiciness (r = 0.54), flavor (r = 0.63), and residue (r = 0.64) were significantly correlated to overall liking (P < 0.01) and to each other (P < 0.01).

Few studies have reported associations among sensory attributes of Chinese instant-boiled beef. However, several studies have focused on the associations among sensory attributes of beef steak. The results obtained in this study with instant-boiled beef were similar to those obtained with beef steak. Neely et al. (1998) reported that tenderness (r = 0.85), juiciness (r = 0.77), flavor (r = 0.86), and beef flavor intensity (r = 0.79) were significantly correlated to consumer overall liking (P < 0.001). Monsón et al. (2005) reported that flavor and tenderness were highly correlated with overall acceptability (r = 0.78 and r = 0.52, respectively). Oliver et al. (2006) and Realini et al. (2009), who studied the correlations among different attributes evaluated by the consumer...
in several countries, reported that tenderness and flavor were highly correlated to overall acceptability ($r \geq 0.67$ and $r \geq 0.74$, respectively). Additionally, Killinger et al. (2004) reported that flavor ($r = 0.86$), juiciness ($r = 0.75$), and tenderness ($r = 0.74$) were highly correlated to overall acceptability ($P < 0.01$). Although Chinese instant-boiled beef is different from steak in thickness and cooking method, they share similar sensory attributes. The results revealed that consumers evaluate beef products based on several sensory attributes, and not on a single attribute.

Stepwise regression analysis for predicting overall liking was performed (Table 4). The first variable in the regression equation was residue liking with an $R^2 = 0.403$. The following variables included flavor, tenderness, and color ($R^2 = 0.529, 0.572$, and $0.594$, respectively). Flavor, tenderness, and color only explained $13\%$, $4\%$, and $2\%$, respectively, of the variation in overall liking.

Huffman et al. (1996), Neely et al. (1998), and Miller et al. (2001) reported that flavor, tenderness, and juiciness affected overall acceptability by consumers; both tenderness and flavor significantly contributed to overall acceptability. However, flavor, tenderness, and juiciness explained different variations in overall acceptability. Miller et al. (1995) reported that tenderness explained $44\%$ and $53\%$ of the variation in overall acceptability in at-home and at-restaurant evaluations, respectively. Huffman et al. (1996) reported that tenderness, flavor, and juiciness explained

### Table 1. Demographics of untrained consumers evaluating Chinese instant-boiled beef

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Female</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td></td>
<td></td>
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<tr>
<td>Male</td>
<td>41.3</td>
<td></td>
</tr>
<tr>
<td>Female</td>
<td>58.7</td>
<td></td>
</tr>
<tr>
<td>Age (y)</td>
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<td></td>
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<tr>
<td>≤30</td>
<td>44.8</td>
<td></td>
</tr>
<tr>
<td>31–44</td>
<td>38.0</td>
<td></td>
</tr>
<tr>
<td>45–59</td>
<td>13.8</td>
<td></td>
</tr>
<tr>
<td>≥60</td>
<td>3.4</td>
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</tr>
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</table>

### Table 2. Effect of gender, age and cuts on sensory attributes ($\text{color, tenderness, juiciness, flavor, residue and overall liking}$) in Chinese instant-boiled beef

<table>
<thead>
<tr>
<th>Effect</th>
<th>Color</th>
<th>Tenderness</th>
<th>Juiciness</th>
<th>Flavor</th>
<th>Residue</th>
<th>Overall liking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gender</td>
<td>NS</td>
<td>*</td>
<td>NS</td>
<td>NS</td>
<td>NS</td>
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<tr>
<td>Male</td>
<td>3.84</td>
<td>3.55</td>
<td>3.37</td>
<td>3.57</td>
<td>3.70</td>
<td>3.85</td>
</tr>
<tr>
<td>Female</td>
<td>3.85</td>
<td>3.67</td>
<td>3.37</td>
<td>3.57</td>
<td>3.77</td>
<td>3.80</td>
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<tr>
<td>Age</td>
<td></td>
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<td></td>
<td></td>
<td>NS</td>
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<tr>
<td>≤30</td>
<td>3.80</td>
<td>3.52</td>
<td>3.26</td>
<td>3.50</td>
<td>3.77</td>
<td>3.78</td>
</tr>
<tr>
<td>31–44</td>
<td>3.84</td>
<td>3.59</td>
<td>3.28</td>
<td>3.58</td>
<td>3.69</td>
<td>3.85</td>
</tr>
<tr>
<td>45–59</td>
<td>3.91</td>
<td>3.69</td>
<td>3.44</td>
<td>3.57</td>
<td>3.69</td>
<td>3.95</td>
</tr>
<tr>
<td>≥60</td>
<td>3.82</td>
<td>3.65</td>
<td>3.50</td>
<td>3.64</td>
<td>3.8</td>
<td>3.72</td>
</tr>
<tr>
<td>Cuts</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>**</td>
</tr>
<tr>
<td>Blade oyster 2303</td>
<td>3.82</td>
<td>3.75</td>
<td>3.44</td>
<td>3.71</td>
<td>3.79</td>
<td>4.04</td>
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<td>Chuck tender 2310</td>
<td>3.96</td>
<td>3.72</td>
<td>3.44</td>
<td>3.66</td>
<td>3.83</td>
<td>3.93</td>
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<td>Chuck-eye roll 2268</td>
<td>3.91</td>
<td>3.90</td>
<td>3.59</td>
<td>3.79</td>
<td>3.93</td>
<td>3.96</td>
</tr>
<tr>
<td>Rib-eye roll 2240</td>
<td>3.80</td>
<td>3.77</td>
<td>3.58</td>
<td>3.77</td>
<td>3.69</td>
<td>4.03</td>
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<tr>
<td>Striploin 2140</td>
<td>3.88</td>
<td>3.65</td>
<td>3.51</td>
<td>3.64</td>
<td>3.84</td>
<td>3.77</td>
</tr>
<tr>
<td>Tenderloin 2150</td>
<td>4.02</td>
<td>3.84</td>
<td>3.50</td>
<td>3.66</td>
<td>3.78</td>
<td>3.97</td>
</tr>
<tr>
<td>Inside 2010</td>
<td>3.61</td>
<td>3.35</td>
<td>3.25</td>
<td>3.30</td>
<td>3.49</td>
<td>3.65</td>
</tr>
<tr>
<td>Outside flat 2050</td>
<td>3.69</td>
<td>3.36</td>
<td>3.01</td>
<td>3.35</td>
<td>3.68</td>
<td>3.66</td>
</tr>
<tr>
<td>Eye round 2040</td>
<td>3.97</td>
<td>3.58</td>
<td>3.34</td>
<td>3.44</td>
<td>3.75</td>
<td>3.72</td>
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<td>Eye of rump 2093</td>
<td>3.77</td>
<td>3.21</td>
<td>2.89</td>
<td>3.43</td>
<td>3.56</td>
<td>3.59</td>
</tr>
<tr>
<td>Knuckle cover</td>
<td>3.89</td>
<td>3.62</td>
<td>3.37</td>
<td>3.53</td>
<td>3.86</td>
<td>3.84</td>
</tr>
<tr>
<td>Eye of knuckle</td>
<td>3.82</td>
<td>3.58</td>
<td>3.51</td>
<td>3.59</td>
<td>3.66</td>
<td>3.74</td>
</tr>
</tbody>
</table>

(1) Least-squares means (±standard errors) are shown. Standard errors are the same within main effects; (2): Score based on a five-point scale (5 = like very much; 4 = like moderately; 3 = neither dislike nor like; 2 = dislike moderately; 1 = dislike very much); (3): Different superscripts represent significant differences ($P < 0.05$); (4) NS: not significant, $*P < 0.05$, $**P < 0.01$, $***P < 0.001$. 

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11%, 67%, and 1%, respectively, in at-home evaluations and 56%, 8% and 2%, respectively, in at-restaurant evaluations of the variation in overall acceptability. Goodson et al. (2002) suggested that flavor had the highest correlation to overall liking; 74.7% ($R^2$) of its variation was attributed to flavor. The results of this study revealed that residue played a significant role in beef consumer satisfaction and explained 40.3% of its variation. However, a large proportion of the variation was unexplained (40.6%) probably due to the dining environment (Huffman et al., 1996). Due to the thickness and muscle fiber orientations, the samples of instant-boiled beef may be relatively tender, allowing consumers to concentrate on other sensory attributes (Goodson et al., 2002).

**Sensory tenderness and SF** Spearman correlation coefficients were used to determine the relationship between SF and tenderness. Results revealed the presence of negative correlations ($r = -0.22$; $P < 0.05$). Sensory tenderness scores were divided into five categories to which five classes of SF were assigned. As shown in Table 5, sensory tenderness scores 1, 2, 3, 4, and 5 corresponded to very tough, tough, intermediate, tender, and very tender, respectively. Based on the results, 59.72% and 36.11% of the samples belonged to the intermediate and tender categories, respectively, and only 1.39% and 2.78% of the samples belonged to the tough and very tender categories, respectively. No sample belonged to the very tough category. The mean SF values of the tough, intermediate, tender, and very tender categories were 9.08 kg, 7.17 kg, 6.83 kg, and 5.13 kg, respectively. Therefore, the tenderness thresholds of Chinese instant-boiled beef had SF values <6.83 kg (tender) and >9.08 kg (tough).

Several studies have reported the correlations between SF and tenderness and the threshold values of SF. However, these studies focused on beef steak. Our study evaluated the similarities and differences between Chinese instant-boiled beef and beef steak.

The correlation between SF and tenderness was low, which was in accordance with the findings of Rodas-González et al. (2009) and Powell et al. (2011). Lorenzen et al. (2003) reported low correlation coefficients ($r = -0.26$) of SF values with at-home consumer ratings. Caine et al., (2003) and Destefanis et al., (2008) reported that the correlations of beef tenderness were variable, with $r$ values ranging from −0.32 to −0.94. The variability in the results could have been attributed to the muscle type, sample preparation,
measurement method, sensory panel, cooking method, doneness of the steaks, and shear apparatus (Destefanis et al., 2008; Schmidt et al., 2010). Subjective factors including former consumption experiences, personal preferences, habits, social influences, and available information contributed to low correlation coefficients (Van Wezemael et al., 2013). Individual- and environment-related factors (e.g., dining environment) may also affect consumer sensory evaluations of beef tenderness as reported by Huffman et al. (1996). In this study, several factors may have contributed to the low correlation coefficients.

Tenderness thresholds of beef steak have been reported. Miller et al. (2001), who conducted a national consumer evaluation in stores, reported that the transition in consumer perception from tender to tough beef occurred between 42.18 N (4.3 kg) and 48.07 N (4.9 kg) of SF based on 86% consumer acceptability scores. Destefanis et al. (2008) found that beef with SF values >5.38 kg (52.68 N) and <4.37 kg (42.87 N) were perceived by most consumers as “tough” and “tender,” respectively. In previous literature, “tender” beef has been defined as having SF values <58.86 N or 6.0 kg (Shackelford et al., 1997), <45.13 N or 4.6 kg (Shackelford et al., 1995), <29.43 N or 3.0 kg (Wheeler et al., 1997), and <40.22 N or 4.1 kg (Huffman et al., 1996). These threshold values were within a milieu of limits in the literature, ranging from 3.0 kg to 6.0 kg (Johnson et al., 1990; Boleman et al., 1997; McKeith et al., 1985; Miller et al., 1993). However, tenderness thresholds were different and with large variations. Wheeler et al. (1997) observed that differences in the sensory panel training procedures, differences in the shear force assessment, or both contributed to different threshold tenderness scores. Miller et al. (1995) and Huffman et al. (1996) reported the differences in SF values between at-home and at-restaurant sensory evaluations. In our study, the tenderness threshold score of SF was <6.83 kg, which was significantly higher than that reported in other studies. The thickness of the beef and the muscle fiber orientation may have contributed to the results (Boles et al., 2008). The results revealed that slice thickness significantly affected tenderness and cooked yield and that muscle fiber orientation was very important; slices, which were perpendicular to the fiber orientation, had SF values that were 50% lower than those that were parallel to the fiber orientation.

**Sensory attributes of different cuts** The effect of cuts on sensory attributes was shown in Table 2. All beef cuts were accepted by consumers with scores >3, with the exception of the juiciness of eye of rump. Cuts had significant effects on flavor, color, tenderness, juiciness, residue, or overall liking (P < 0.05). The overall liking scores of blade oyster and eye of rump were the highest and lowest, respectively.

Subjective evaluation of color liking indicated that tenderloin were the highest, whereas inside had the lowest color parameter values. The tenderness score of chuck-eye roll was the highest; inside and eye of rump had the lowest tenderness scores. The juiciness scores of rib-eye roll and chuck-eye roll were higher than those of other cuts; consumers disliked eye of rump the most with scores <3. The flavor of chuck-eye roll was significantly higher than that of inside (P < 0.05). The residue scores of inside was the lowest and that of chuck-eye roll was the highest (P < 0.05). Based on the overall liking scores, consumers liked blade oyster the most and disliked eye of rump.

In this study, all beef cuts were accepted by consumers. A number of studies (Carmack et al., 1995; Shackelford et al., 1995; Jeremiah et al., 2003a; Jeremiah et al., 2003b; Von Seggern et al., 2005; Voges et al., 2007; Boles et al., 2008; Lepper-Blilie et al., 2014) reported that cuts differ in tenderness, juiciness, flavor, and overall liking scores. This may be related to high SF threshold of Chinese instant-boiled beef and the demand for the quality of Chinese instant-boiled beef was not high. However, rib-eye roll, blade oyster, tenderloin, chuck-eye roll, and chuck tender were the most appropriate for instant-boiled beef. This study revealed that suitable beef cuts are needed to meet consumer expectations.

**Conclusion**

Residue was correlated to the overall liking of Chinese instant-boiled beef. Overall liking of Chinese instant-boiled beef was affected by residue, flavor, tenderness, and color. The tenderness threshold of Chinese instant-boiled beef had SF values <6.83 kg (66.93 N, tender) and SF values >9.08 kg (88.98 N, tough). The results of this study revealed that all beef cuts were accepted by the consumers.

However, the present study had a number of limitations. Firstly, the use of consumer evaluators was not entirely representative of the Chinese population. Secondly, the samples were limited and not entirely representative of the Chinese beef products. Thirdly, only one cooking method was assessed in this study. Future studies should involve large number of different beef samples from several cities in China and subjected to different cooking methods.

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