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Composition and quality of Mexican and imported retail beef in Mexico

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Abstract

Randomly selected New York steaks from domestic and imported beef were purchased in three major Mexican cities, comparing Mexican beef (from northern, central, and southern regions of the country) and American beef (USDA-Choice and ungraded No Roll). The meat was analyzed for chemical composition, Warner-Bratzler shear force (WBSF), cooking loss, color and consumer acceptability. All sources of Mexican beef and No Roll US beef had similar chemical composition. USDA-Choice beef had a higher fat content and a lower moisture and total collagen content. Mexican beef from the northern region and USDA-Choice beef had lower WBSF and redness values than the other beef sources. Overall desirability was high regarding all Mexican beef sources, and USDA-Choice beef. No Roll US beef had the lowest overall desirability score. Results indicate Mexican beef is in an advantageous position when competing with imports in the current open market.

Keywords: Beef quality; Chemical composition; Consumer acceptability

1. Introduction

Several production and biological factors, such as differences in management, nutrition, age and genetic background among others, are considered responsible for the large variation in beef quality. In Mexico, beef cattle production is centered in three main geographical regions, well differentiated by prevailing climate, feeding system, and the exploited breeds, among other characteristics. In most of the northern part of the country, the land is arid and cattle are fattened on concentrates. Production in arid zones is strongly oriented towards the export of calves to the US. Therefore, specialized breeds like Angus, Hereford, and Charolais are predominant (Sánchez, Gómez, Avalos, Iruegas, & Roseta, 1999). On the other hand, production in central and southern regions is largely based on pasture and the *Bos indicus* (Indobrasil, Brahman, Guzerat, Gyr, among others) are the principal breeds being exploited (Villegas, Bolaños, & Olguín, 2001). In spite of this, it has not been established whether the different sources of Mexican beef differ in chemical composition, quality and consumer acceptability. Increasingly, after the approval of the North American Free Treaty Agreement (NAFTA), increasing quantities of imported beef, mostly originated in the US, are available at the retail level. Mexican beef cattle producers claim the largest part of imported beef is of poor quality and represents a hindrance for the development of the Mexican beef

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industry, which has demonstrated poor growth in the past few years.

Under these circumstances, it is vital for the beef industry to establish a benchmark for the composition and quality of retail beef. Accordingly, it is worth considering the differences in chemical composition and quality traits of meat at consumer level since they can both influence the consumer's decision to purchase beef. The purpose of this investigation is to present empirical data regarding chemical composition, quality traits and consumer acceptability of both Mexican and imported retail beef samples.

2. Materials and methods

The study was conducted from November 2002 through January 2003 in three Mexican cities (Monterrey, Mexico City, and Villahermosa). These cities were selected because they permit the sampling of retail beef from the three main beef cattle producing regions (northern, central, and southern regions, respectively), and also represent some of the largest metropolitan areas (INEGI, 2003), important distribution points for beef.

2.1. Sampling

Prior to sampling, a supermarket inventory was obtained from the National Retailers Association of Mexico (ANTAD, 2001). The surveyed supermarkets were randomly selected within cities. Since imported beef was not available in all stores, in some cases it was necessary to sample certain stores repeatedly. However, these stores were visited in different days. Each city was visited once. Mexico City and Villahermosa were surveyed in October and November 2002, respectively, while Monterrey was visited in January 2003. Samples of packaged (film-wrapped) refrigerated New York steaks of approximately 1 inch thick (up to three per shop in the same visit) were purchased from a total of 80 different supermarkets and transported – refrigerated – to the National Autonomic University of Mexico for analysis. Meat samples of Mexican, USDA-Choice, and No Roll US beef were purchased, depending on the availability of the relevant sources of beef in the shops. The aging period of the meat at the point of sale was unknown. Overall, 90 samples of Mexican beef (30 from Monterrey, 40 from Mexico City and 20 from Villahermosa), 36 samples of USDA-Choice beef and 54 samples of No Roll US beef were analyzed in the study. Table 1 shows detailed information on the

Table 1
Surveyed retailers, number of samples taken per retail chain and type of beef available in the stores at purchase

Geographical region/city	Retail chains			Type of beef available at purchase			
	Commercial name	Existing units[a]	Sampled units	Number of samples taken[b]	Mexican	USDA-Choice[c]	No Roll[d]
North/Monterrey	HEB	5	5	26	x	x	
	WalMart	5	2	4		x	x
	Carrefour	2	1	2	x		
	Soriana	7	7	10	x		
	Gigante	24	10	12	x		
	Others[e]	5	5	6	x	x	
	Subtotal	48	30	60			
Center/México City	WalMart	62	20	40	x	x	x
	Gigante	25	10	16	x		
	Commercial Mexicana	29	10	18	x		
	Carrefour	9	2	6	x		
	Subtotal	125	42	80			
South/Villahermosa	WalMart	2	2	17			x
	Soriana	2	2	8	x		
	Chedraui	2	2	9	x		
	Carrefour	1	1	3	x		
	Grijalva	1	1	3		x	
	Subtotal	8	8	40			
	Total	181	80	180			

[a] *Source of data*: National Retailers Association of Mexico, ANTAD (2001).
[b] No more than three samples per store were taken in the same visit .
[c] Beef labeled as USDA-Choice at the point of sale.
[d] US beef with no quality grade specified on the label at the point of sale.
[e] Retail stores specialized on beef.

sampling. A sample unit consisted of three New York steaks from the same primal cut. One steak was used for chemical analyses, one for quality trait determinations, and one for sensory evaluation. Upon arrival at the laboratory, the data from each sample was recorded and each steak was assigned a random number, individually vacuum-packed and frozen (−30 °C). Before the analyses were performed, the steaks were thawed for 24–30 h at 2–4 °C. Prior to chemical composition and pH analyses, the external fat and epymisium were trimmed and the lean meat was thoroughly ground in a food processor unit.

2.2. Chemical composition

Samples of ground beef – in duplicates – were analyzed for moisture, fat and protein content following the procedures described by the AOAC (1990). Total and soluble collagens were estimated from the levels of hydroxyproline. Ground meat samples (4 g) –in duplicates– were heated for 60 min at 77 °C in 0.25 strength Ringer's solution (Hill, 1966). Following centrifugation, supernatant and residue fractions were individually hydrolyzed in 6 N HCl for 3 h at 130 °C in an autoclave. The hydrolizates were neutralized with 12 N NaOH and the hydroxyproline content was determined according to Bergman and Loxley (1963). Collagen content was calculated by multiplying the hydroxyproline content of the residue by 7.25 and that of the supernatant by 7.52 (Cross, Carpenter, & Smith, 1973). Total collagen was calculated as the sum of the collagen content in the two fractions. Percentage soluble collagen was calculated by dividing the collagen content of the supernatant by the total collagen content.

2.3. Meat quality traits

The pH was measured in refrigerated ground meat samples (2–4 °C) using a pH meter with automatic temperature compensation (HANNA pH meter, Model 8521) (AOAC, 1990). Briefly, duplicate samples (10 g) were suspended in 100 ml distilled water and thoroughly homogenized for about 30 s before pH readings. Warner-Bratzler shear force (WBSF) and cooking loss were determined according to AMSA Research Guidelines for Cookery, Sensory Evaluation and Instrumental Tenderness Measurements of Fresh Meat (AMSA, 1995). The steaks were broiled in open-hearth broilers to an internal temperature of 70 °C, which was monitored with iron-constantan thermocouples (Omega Engineering Inc., Stamford, USA) and a recording portable thermometer. The steaks were turned over upon reaching 35 °C, and allowed to cook until 70 °C. After removing from the broilers, the steaks were allowed to cool to room temperature (20–25 °C). Subsequently, a minimum of eight 2.5-cm cores with a diameter of 1.27 cm were removed from each steak parallel to the muscle fiber and sheared once across the center of the core perpendicular to the muscle fiber in a Warner-Bratzler shearing device. The average shear force (N) of each sample was recorded. The weight of each steak was measured prior to and after cooking, in order to calculate cooking loss. Objective color measurements were performed in two different sites of each steak, by means of a Minolta Chroma Meter CR-310 (Minolta, Osaka, Japan) after the steaks were allowed to bloom for 15 min at room temperature (20–25 °C). The average lightness (L^*), redness (a^*), and yellowness (b^*) of each sample were recorded.

2.4. Sensory evaluation

A total of 144 panelists – students and employees, voluntarily recruited – from two different universities (National Autonomic University of Mexico, and University of La Salle; public and private, respectively) located in Mexico City participated in the sensory evaluation. The test was carried out in two different sessions with 81 and 63 panelists, respectively. Steaks of Mexican and both categories of imported beef (USDA-Choice and No Roll US beef) were cooked following AMSA guidelines, as previously described (AMSA, 1995). Upon reaching the desired internal temperature (70 °C), steaks were removed from the broiler, the edges of each steak were trimmed and the lean meat was portioned into cubes of uniform dimensions (2 cubic cm). Each panelist received three samples served individually in disposable plastic dishes labeled with three-digit random numbers. The samples were presented simultaneously to the panelists. An affective test evaluation was accomplished using a seven-point hedonic scale from (1) I dislike it very much; to (7) I like it very much. Panelists were asked to assign scores to each sample for tenderness and overall desirability.

2.5. Statistical analysis

The effect of the origin of beef (Mexican beef from northern, central and southern regions, and imported USDA-Choice and No Roll US beef) was tested for significance using one-way analysis of variance (Lentner & Bishop, 1986). Means were discriminated using the Tukey's range procedure (Statgraphics Plus 2.1).

3. Results

3.1. Chemical composition and quality traits (Tables 2 and 3)

All sources of Mexican beef and No Roll US beef were comparable in terms of moisture, fat, protein, total

Table 2
Mean values for chemical composition of *Longissimus dorsi* muscle meat samples according to their origin

	Mexican beef (by region)			Imported beef		
	North	Center	South	USDA-Choice[a]	No Roll US beef[b]	SE ±
n	30	40	20	36	54	
Moisture (%)	72.9a	73.6a	72.2a	69.9b	73.1a	1.9***
Fat (%)	3.0b	2.7b	3.6b	6.3a	2.9b	2.1***
Protein (%)	21.7	22.3	22.3	21.7	22.2	1.2
Total collagen (mg/g)	12.0a	11.3a	11.2a	9.7b	12.1a	5.2*
Soluble collagen (%)	17.4	15.8	17.0	17.2	14.6	6.0

a, b, c: means with different letters in the same row are significantly different ($P < 0.05$).
[a] Beef labeled as USDA-Choice at the point of sale.
[b] US beef with no quality grade specified on the label at the point of sale.
* $P < 0.05$.
*** $P < 0.001$.

Table 3
Mean values for quality traits of *Longissimus dorsi* muscle meat samples according to their origin

	Mexican beef (by region)			Imported beef		
	North	Center	South	USDA-Choice[a]	No Roll US beef[b]	SE ±
n	30	40	20	36	54	
pH	5.72	5.71	5.73	5.77	5.70	0.2
WBSF, N	35.6b	45.3a	46.2a	30.0c	44.9a	10.6***
Cooking loss, %	24.5b	23.5b	20.9c	25.9a	23.2b	4.2***
L^* (lightness)	39.4b	39.1b	38.3b	39.1b	41.0a	2.8***
a^* (redness)	14.3b	17.1a	17.1a	14.1b	16.6a	2.6***
b^* (yellowness)	7.3	7.0	6.4	7.0	7.4	1.6

a, b, c: means with different letters in the same row are significantly different ($P < 0.05$).
[a] Beef labeled as USDA-Choice at the point of sale.
[b] US beef with no quality grade specified on the label at the point of sale.
*** $P < 0.001$.

collagen, and soluble collagen content ($P > 0.05$). The USDA-Choice beef had lower moisture content ($P < 0.05$), higher fat content ($P < 0.05$), and lower total collagen content ($P < 0.05$) than the other beef types. No significant differences were found in the protein content or collagen solubility between beef sources.

The pH of the meat was similar across beef sources ($P > 0.05$). USDA-Choice beef had the lowest WBSF value, followed by Mexican beef from the northern region. No Roll US and Mexican beef from the central and southern regions had greater WBSF values, indicating these beef-types are less tender. The highest cooking loss was found in USDA-Choice beef. Mexican beef from the northern and central regions, as well as No Roll US beef had intermediate values, while Mexican beef from the southern region had the lowest cooking loss. Mexican beef from the northern region and USDA-Choice beef had the lowest a^*-values ($P < 0.05$), reflecting these are less red than the other beef sources. No Roll US beef and Mexican beef from the central and southern regions had similar a^*-values ($P > 0.05$). However, the last two sources of beef had lower L^*-values than No Roll US beef, suggesting these are the darkest among the types of beef studied.

Table 4
Mean scores[a] for tenderness and overall desirability of *Longissimus dorsi* muscle meat samples according to their origin

	Mexican beef (by region)			Imported beef		
	North	Central	South	USDA-Choice[b]	No Roll US beef[c]	SE ±
n	50	54	40	144	144	
Tenderness	5.1a	4.4b	4.2b	5.3a	4.6b	0.1***
Overall desirability	5.4a	5.3a	5.1a	5.2a	4.6b	0.1**

a, b: means with different letters in the same row are significantly different ($P < 0.05$).
[a] Hedonic scale: 1 = I dislike it very much; 7 = I like it very much.
[b] Beef labeled as USDA-Choice at the point of sale.
[c] US beef with no quality grade specified on the label at the point of sale.
** $P < 0.01$.
*** $P < 0.001$.

3.2. Sensory evaluation (Table 4)

As regards tenderness, panelists preferred Mexican beef from the northern region and USDA-Choice beef. Mexican beef from the central and southern regions, as well as No Roll US beef rated lower for tenderness. The overall desirability was comparable in the three types of Mexican beef and USDA-Choice beef. No Roll US beef had the lowest overall desirability score.

4. Discussion

The high fat content found in USDA-Choice beef is in line with previous studies (Luchak et al., 1998). As pointed out by Resurreccion (2003), American cattle feeders get a higher price for prime and choice cattle, which are the top grades of the American beef carcass-grading system. Since marbling is one of the key factors determining carcass grade in the US, feeders tend to put more fat on animals in order to attain higher grades. The latter is commonly achieved by the use of fatty English breeds – Angus, Hereford – in combination with high-energy diets. Conversely, the genetic background and feeding system under which No Roll US cattle is produced may not guarantee a high percentage of fat in the carcass. That was clearly reflected by the lower percentage of fat found in No Roll US beef. Moreover, differences in carcass weight could also explain the lower percentage of fat in No Roll US beef and Mexican beef compared to Choice beef. Most likely, cattle producing USDA-Choice beef are slaughtered at a heavier weight (or have higher carcass fatness) compared to cattle producing No Roll US beef and Mexican beef. In that sense, it is important to note that Mexico lacks of a beef carcass grading system that encourages producers towards the production of more fatty meat.

As consumers become more concerned about animal fat consumption, USDA-Choice beef might be at a disadvantage competing in the Mexican market with the other beef sources, which tend to be leaner. A fat content equal or lower than 4% has been reported in USDA-Select beef (Wulf, Emnett, Leheska, & Moeller, 2002), Canadian beef (Jeremiah, Dugan, Aalhus, & Gibson, 2003) and European beef (Renand, Picard, Touraille, Berge, & Lepetit, 2001). No previous records were found regarding the fat content or any other chemical component of Mexican beef. With the exception of USDA-Choice beef, total collagen content was relatively high compared to that found in the *longissimus* muscle of cattle from Europe, US and Argentina (Boleman, Miller, Buyck, Cross, & Savell, 1996; Chambaz, Scheeder, Kreuzer, & Dufey, 2003; Cross et al., 1973; Raes et al., 2003; Renand et al., 2001; Torrescano, Sánchez-Escalante, Jiménez, Roncalés, & Beltrán, 2003). The latter studies reported total collagen values below 10 mg/g. However, the levels of total collagen determined in this study were similar to those found in the *longissimus* muscle of American crossbred steers (Miller, Tatum, Cross, Bowling, & Clayton, 1983). Collagen solubility was moderate, if compared to values (from 25% to 34%) reported by other researchers (Chambaz et al., 2003; Miller et al., 1983; Renand et al., 2001). Nevertheless, the percentages of soluble collagen found in this study are in the order of those reported by Listrat et al. (1999) and Silva, Patarata, and Martins (1999). The combination of relatively high collagen content and moderate collagen solubility suggests that a considerable part of retail beef in Mexico might be tough.

The WBSF values are in line with those reported by other workers (George, Tatum, Belk, & Smith, 1999; Lorenzen et al., 2003; Luchak et al., 1998; Tatum, Smith, Berry, & Murphey, 1980; Wheeler, Shackelford, & Koohmaraie, 1999). Belew, Brooks, McKenna, and Savell (2003) used a muscle tenderness classification, based on WBSF confidence intervals reported by Shackelford, Morgan, Savell, and Cross (1991). They categorized muscle groups into "very tender" (WBSF $<$ 31.36 N), "tender" (31.36 $<$ WBSF $<$ 38.22 N), "intermediate" (38.22 $<$ WBSF $<$ 45.08 N), and "tough" (WBSF $>$ 45.08 N). Based on this classification system, USDA-Choice beef would fit into the "very tender" category; Mexican beef from the northern region could be considered as "tender", while No Roll US beef and Mexican beef from the central and southern regions correspond to the "tough" category. From a consumer's point of view, a more practical approach might reduce the classification to two categories. A "tender" group (WBSF $<$ 38.22 N), including USDA-Choice and Mexican beef from the northern region, and a "tough" group (WBSF $\geqslant$ 45.08 N), including No Roll US beef and Mexican beef from the central and southern regions. Moreover, Huffman et al. (1996) evaluated the acceptability of loin steaks in a consumer affective test. They observed that 98% of American consumers considered steaks with WBSF equal or below 40.18 N acceptable. It is thus likely that Mexican consumers show a good level of acceptability for the tenderness of both USDA-Choice beef (WBSF 30.38 N) and Mexican beef from the northern region (WBSF 35.28 N).

The cooking losses were within the range reported for beef (Camfield, Brown, Lewis, Rakes, & Johnson, 1997; Chambaz et al., 2003; Jeremiah et al., 2003; Johnson, Lunt, Savell, & Smith, 1988; Luchak et al., 1998; Silva et al., 1999; Wheeler et al., 1999). The higher cooking loss of USDA-Choice beef, which was the fattiest among beef types, does not support previous findings (Jeremiah et al., 2003) of a negative relationship between muscle fat content and cooking loss. It should be pointed out however, that cooking losses are influenced by the cooking method employed. In the study quoted above, the meat was roasted in an electric convection oven at 177 °C, in contrast with the broiling method used in the present investigation.

The lower redness of USDA-Choice and Mexican beef from the northern region, compared to No Roll US beef and Mexican beef from the central and southern regions, may be associated to chilling rates, subcutaneous fat, breed differences, slaughter age, type of feed and time on high energy diets of the cattle, among others. Several researchers have observed a darker color in *Bos indicus* cattle (Boles & Swan, 2002; Wulf, O'Connor, Tatum, & Smith, 1997) in relation to *Bos taurus* cattle. Again, the similarities of breeds being exploited in the US and in the northern region of Mexico (*Bos taurus* cattle), in contrast with the *Bos indicus* breeds exploited in the central and southern regions, may also account for the differences observed in meat color. Moreover, it is well known that meat from older animals is darker than meat from younger animals (Boleman et al., 1996; Page et al., 2001). Mexican cattle are slaughtered at a very wide age range, usually from 18 to 40 months (data from our lab). Therefore, differences in slaughter age among the different beef types may account for another source of variation in meat color. Another factor that could be influencing color differences is the fact that Mexican cattle (due to its genetic background or its lower slaughter weight or lower carcass fatness) have less subcutaneous fat than US cattle and therefore, the protection effect of the subcutaneous fat layer is not present in most of Mexican beef carcasses.

Results for tenderness in the sensory evaluation were in agreement with the WBSF values. Beef with lower WBSF values received higher tenderness scores. As expected, panelists did not show a greater preference for the tenderness of USDA-Choice beef in relation to Mexican beef from the northern region. This corresponds with the results obtained by Huffman et al. (1996) mentioned before. On the other hand, overall desirability scores were high for all sources of Mexican beef, despite the differences in WBSF values and tenderness scores observed between them. This is not surprising since beef consumption is a tradition in Mexico and it might have caused the familiarization of Mexican consumers with the taste, flavor and aroma of the locally produced beef.

The high overall desirability score of USDA-Choice beef was expected due to its excellent tenderness. It is generally agreed upon tenderness is the attribute most desired in beef by consumers (Boleman et al., 1997; Huffman et al., 1996). The lower overall desirability score of No Roll US beef in relation to Mexican beef might be due to a lower familiarization of Mexican consumers with the taste and aroma of this type of beef, which presence in the market is relatively recent. Furthermore, the quality traits of No Roll US beef were not as good as those of USDA-Choice beef and its fat content was also much lower.

5. Conclusions

The present study identified that retail beef in the Mexican market was variable in fat content, WBSF, cooking loss, redness (a^*-values), and consumer acceptability, depending on the origin of the meat, whereas differences in protein content, collagen characteristics, pH, lightness (L^*-values), and yellowness (b^*-values) are less evident. All sources of Mexican beef and No Roll US beef had comparable chemical compositions. Consumer overall acceptability was high for all sources of Mexican beef and for USDA-Choice beef. In general, Mexican beef from the northern region and USDA-Choice beef had better quality traits compared to the other types of Mexican beef, as well as to No Roll US beef.

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