



Mexican consumers at the point of meat purchase. Beef choice



T.M. Ngapo^{a,*}, D. Braña Varela^b, M.S. Rubio Lozano^c

^a Saint Hyacinthe Research and Development Centre, Agriculture and Agri-Food Canada, 3600 boul. Casavant Ouest, St-Hyacinthe, Québec J2S 8E3, Canada

^b Elanco Animal Health, Av. Americas no. 1592, Guadalajara 44620, Jalisco, Mexico

^c Meat Science Laboratory, Centro de Enseñanza Práctica e Investigación en Producción y Salud Animal, Facultad de Medicina Veterinaria y Zootecnia, Universidad Nacional Autónoma de México, Cruz Blanca 486, San Miguel Topilejo, Mexico DF 14500, Mexico

ARTICLE INFO

Keywords:
 Preferences
 Consumers
 Choice
 Attribute levels
 Images
 Beef

ABSTRACT

Within-consumer preference replication achieved through systematic image manipulation was used in consumer surveys in four cities across Mexico (Mexico City, $n = 195$; Guadalajara, $n = 100$; Hermosillo, $n = 132$; Veracruz, $n = 61$) to study beef preferences. Images of beef steaks controlled for lean and fat colour, fat cover and marbling were presented to consumers to determine the characteristics used in beef choice and the levels of preference of these characteristics. The most important choice criteria were fat cover (62% preferring little fat cover) and marbling (59% preferring non-marbled). Lean colour was also important with 24% and 29% choosing light and dark red beef, respectively. Fat colour was the least important of the four attributes studied (18% and 19% choosing white and yellow, respectively), but was nevertheless important given that 43% of consumers used three or four characteristics to make their choice. Imported and domestic beef in the Mexican marketplace appear to respond to the range of consumers' beef preferences at the point of purchase.

1. Introduction

In 2015, the per capita consumption of beef in Mexico was 9.9 kg equating to a total domestic consumption of 1.77 M metric tons of beef (OECD, 2016). Mexico has significant beef production and is one of the top eleven beef exporters in the world (USDA, 2016). However, domestic production does not meet domestic demand. In 2015, beef production totaled 1.85 M metric tons of which 0.23 M metric tons was exported (USDA, 2016) and the equivalent imported, mostly from the US (USMEF, 2015). A carcass and meat classification regulation exists in Mexico, but locally produced beef, which is equivalent to about a USDA Standard grade, is generally retailed without a visible grading (Rubio, Méndez, & Huerta-Leidenz, 2007; Secretaría de Economía, 2002). In contrast, US beef in the Mexican market is generally readily identified as the higher USDA Select grade imported from the US, and is often separated from local beef in the meat counter (Huerta-Leidenz, Ruíz-Flores, Maldonado-Siman, Valdéz, & Belk, 2014). Several studies describe the intrinsic cues of beef quality in the Mexican marketplace (Chávez et al., 2012; Delgado et al., 2005; Méndez et al., 2009), but reports of Mexican consumers' preferences for beef at the point of purchase are lacking. Given the significant Mexican market demand for beef met through international trade, it is in the interest of not only the local, but also the global beef industry to be aware of Mexican market preferences.

A number of studies have been undertaken on consumer preferences for beef at the point of purchase in countries other than Mexico and, although differences do exist among countries, common trends are evident. Lean colour and fat (cover and/or marbling) are the most important intrinsic factors in quality determination at the point of purchase; country of origin, brand, store and price are important extrinsic cues (for example, Banović, Fontes, Barreira, & Grunert, 2012; Danner, 1959; Forbes, Vaisey, Diamant, & Cliplef, 1974; Glitsch, 2000; Grunert, 1997; Killinger, Calkins, Umberger, Feuz, & Eskridge, 2004; Realini et al., 2014; Savell et al., 1989; Schnettler et al., 2010; Steenkamp & van Trijp, 1996). These findings are not surprising in that often these are the only cues available to the consumer when purchasing fresh meat and more often than not, few extrinsic cues are present. Theoretical models have been developed, in particular including expectation and experience in purchasing behaviour of beef. A recurring finding in these studies appears to be that regardless of the gustative experience, the consumer generally does not relate marbling or fat content to eating quality (Brunso, Bredahl, Grunert, & Scholderer, 2005; Forbes et al., 1974; Grunert, 1997; Pearson, 1976).

To study the importance of different intrinsic cues of beef at the point of purchase, historically a range of methods have been used from self-reporting the importance of attributes (Glitsch, 2000) to recording eye movement (Banović, Chrysochou, Grunert, Rosa, & Gamito, 2016). Pearson (1976) cited five studies from 1955 to 1963 that used

* Corresponding author at: Saint Hyacinthe Research and Development Centre, Agriculture and Agri-Food Canada, 3600 boul. Casavant Ouest, St-Hyacinthe, Québec J2S 8E3, Canada.
 E-mail address: tania.ngapo@agr.gc.ca (T.M. Ngapo).

photographs of beef to determine consumer preferences at the point of purchase. More recently techniques using photographs have been coupled with information of origin or grade (Realini et al., 2014; Schnettler et al., 2010) or correlated with CIE L*a*b* scores and show that consumer preference is actually defined by the lightness (L*) and yellowness (b*), rather than redness (a*) (Brugiapaglia & Destefanis, 2009; Holman, Mao, Coombs, van den Ven, & Hopkins, 2016). Repetition in consumer choice is rarely employed in these studies, often only one intrinsic character is studied at a time, and online studies are subject to colour variation of the consumers' screen settings. In 2000, to respond to such research shortcomings and taking into consideration the perishable nature of fresh meat, a method was developed to identify and compare the most important characteristics of fresh pork that determine consumer choice (Ngapo, Martin, & Dransfield, 2004). The survey method used manipulation of digital photographs to allow the systematic assessment of the impact of varying appearance characteristics on consumer choice. Sixteen commercially obtained pork chops were digitally modified to give two levels of each of the characteristics of fat cover, colour, marbling and drip. The resulting 256 images were published as a book (Dransfield, Martin, Miramont, & Ngapo, 2001) in which every double page contained the 16 different chop shapes and each chop shape represented one of the combinations of the four characteristics studied. The books were presented to consumers in 23 countries (Ngapo, Martin, & Dransfield, 2007a, 2007b) with every consumer choosing a preferred image from each of eight double-pages giving repeatability in choice. Comparisons of actual with random simulations of choice demonstrated that the levels of these characteristics used in the books were not extreme and allowed the consumer to make conscious choices. Significant differences were observed in the choice strategies, not only among countries (Ngapo et al., 2007a, 2007b), but also among regions in South Korea, France and Canada where responses had been obtained from a range of sites (Cho et al., 2007; Ngapo, Fortin, Aalhus, & Martin, 2010; Ngapo et al., 2004). Mexico is a geographically and culturally diverse country and therefore, the potential also exists for regional differences in Mexican consumer preferences.

Using the pork model as a base, the current study aims to identify the most important characteristics of fresh beef which determine consumer choice in cities in four regions of Mexico, to determine the preferred and acceptable levels of four intrinsic meat characteristics and to show how Mexican consumer segmentation in choice relates to socio-demographic, behavioural and regional differences.

2. Materials and methods

2.1. Preliminary interviews

To help guide the selection of characteristics to focus testing on, in-person interviews of about 60 min were conducted with a select consumers in Mexico City (16) and Hermosillo (16) in December 2012. The interviews were conducted by staff of a marketing research consulting company and were recorded. A standardized invitation was used to recruit participants by phone. Consumers were the member of the household responsible for buying the pork and were evenly distributed for gender, age (4 levels) and socioeconomic level (2 levels). An interview guide comprising open-ended questions obtained perceptions of purchasing habits (Table 1). Consumers spontaneously responded to questions, after which a list of eighteen attributes prompted responses to uncited attributes and consumers were given the option to add others. The eighteen attributes were intrinsic and extrinsic, related to quality and safety, and relevant to purchase and consumption. The participants did not constitute random samples of the population of Mexico or the cities in which they were interviewed. Inferences are drawn on claimed or self-reported behavior and it is recognized that responses may be subject to social desirability, post-rationalization or cognitive dissonance or consonance. Reported behaviors may deviate from actual or overt behavior.

Table 1

Open-ended questions in the interview guide.

1. What is the most important attribute when choosing beef? For what reasons?
 2. What other things are important to you when you choose beef? For what reasons?
 3. In addition to the attributes mentioned, do you take into account [attribute] when choosing beef? For what reasons?
 4. What attributes do you consider to be basic and essential, that is, if beef did not have these attributes, you would not buy it? Why these attributes?
 5. What attributes do you consider give added value, that is, if the beef did not have these attributes it would not be an impediment to choosing it, but if it did have these attributes you would prefer this beef over another similar cut?
 6. How would you describe each of the attributes mentioned?
 7. For which cuts is each of the attributes important and why?
 8. Where do you purchase beef and why there?
 9. Do you consider that the beef you buy is natural or do you think that it has had some sort of preparation prior to its sale?
- If the consumer believes that there is some sort of preparation prior to sale, they ask:*
10. What preparation was undertaken or additive added? And for what reasons?

2.2. Survey tools

2.2.1. Beef steak images

The method employed was based on the image-based consumer preference methods used for pork by Ngapo et al. (2004). Photographs of 16 commercially obtained beef steaks were digitally modified to give two levels of each of the characteristics of lean colour, fat cover, marbling and fat (including marbling) colour. Colour corresponded to Aus-Meat Limited (2011) standards for lean of 1B to 1C for the light red and 3 to 4 for the dark red beef, and fat of 0 for the white and 4–6 for the yellow fat. Fat cover levels were equivalent to 4 to 6 mm for the little cover and 12 to 16 mm for the fatty cover for a steak of 140 mm length and 70 mm height. Marbling scores were estimated as 1–2 for the non-marbled and 4 for the marbled meat using the Japan Meat Grading Association (2000) beef marbling standard. The resulting 256 images formed an album in which every double page contains the 16 different steak shapes and each steak shape represents one of the combinations of the four characteristics studied. That is, every double page contains all 16 combinations of the two levels of each of the four characteristics. The position of the steaks and the order of representation of the characteristics with respect to the steak shape in a double-page were randomised. Steak shape was not a factor studied, but was instead a distraction and a means to realistically present a range of characteristics to the consumer.

2.2.2. Levels of characteristics

Booklets of images of beef steaks were produced from photographs of four different steak shapes, using a different steak for each characteristic. The photographs were digitally modified to give a range of levels of the four characteristics; eight lean and seven fat colour levels corresponding to the Aus-Meat Limited (2011) standards 1A (pink), 1B, 1C, 2, 3, 4, 5, 6 (deep red) and 0 (white), 1, 2, 3, 4, 6, 7 (dark yellow), respectively, seven marbling levels corresponding to the Japan Meat Grading Association (2000) standards 1 (practically devoid of marbling), 2, 3, 4, 5, 6, 8 (highly marbled) and seven fat cover levels giving the equivalent of 2, 4, 6, 8, 10, 15 and 20 mm for a steak of 140 mm length and 70 mm height. Each characteristic was presented on a separate page in a single column of steaks. Two booklets were produced, one with the order of the characteristic from least prevalent to most prevalent and the second with the order reversed.

2.3. Surveys

2.3.1. Consumers

In February and March of 2013, consumers were randomly intercepted in shopping centres in four cities in Mexico and invited to participate in the survey. Consumers who accepted the invitation (Mexico City in the Distrito Federal in central Mexico, $n = 195$; Guadalajara in

Table 2
Questionnaire composition, responses, and significant links by χ^2 test (P -value < 0.05 shown in bold) between questionnaire items and choice-based clusters.

Question	Response options	Consumers		P -value
		(number)	(%)	
What is your age (years)?	16–24	48	10	0.13
	25–34	67	14	
	35–44	91	19	
	45–54	101	21	
	55–64	57	12	
	> 64	124	25	
Gender?	female	364	75	< 0.01
	male	124	25	
Marital status?	single/widowed	194	40	0.96
	married/ cohabitating	294	60	
How many people live in your household?	1	26	5	0.38
	2	61	13	
	3	116	24	
	4	108	22	
	5	93	19	
	6 +	82	17	
Number of children	0	225	46	0.22
	1	131	27	
	2	78	16	
	3 +	54	11	
	< 2000	20	4	
2000–5999	107	22		
6000–9999	81	17		
10,000–29,999	122	25		
30,000–75,999	108	22		
Education?	no education	37	8	0.13
	compulsory	150	31	
	secondary	115	24	
	tertiary	157	32	
	higher	28	6	
	yes	128	26	
no	360	74		
Are you the member of your household who normally shops for meat?	no	90	18	0.22
	yes	398	82	
Where do you normally purchase your meat?	butcher	275	56	0.16
	supermarket	276	57	
	market	136	28	
	street market	18	4	
everyday	49	10		
Do you cook the main meals in your household?	several times/week	264	54	< 0.01
	once/week	70	14	
	< once/week	16	3	
	grill	31	6	
fry	128	26		
If you do the cooking, how do you normally cook beef?	roast	203	42	0.21
	stew	213	44	
	boil	182	37	
	< 30 min	126	32	
30 min–1 h	201	51		
> 1 h	71	18		
How often do you eat meat?	every meal,	19	4	0.09
	everyday			
	once/day,	28	6	
	everyday			
	several times/week	234	70	
	once/week	79	16	
How often do you eat beef?	< once/week	19	4	0.10
	everyday	22	5	
	≥ once/week	434	89	
	≥ once/month	24	5	
Have you changed your consumption of beef in the last few years?	< once/month	8	2	0.33
	same	299	61	
	changed	189	39	
	increased (% changed)	23	12	
	decreased (% changed)	166	88	
Do you like beef?	yes	479	98	0.66

Table 2 (continued)

Question	Response options	Consumers		P -value
		(number)	(%)	
For what reasons:	no	9	2	–
	availability	7	1	
	nutritional quality	83	17	
	versatility	44	9	
	taste	157	32	
	price	8	2	
The beef meat that you buy is of good quality:	other reasons	117	24	0.16
	always	236	48	
	almost always	202	41	
	sometimes	44	9	
	almost never/ never	6	1	
You freeze the beef you buy:	always	62	13	0.26
	almost always	54	11	
	sometimes	104	21	
	almost never	84	17	
	never	184	38	
Is beef expensive?	no	181	37	0.92
	yes	307	63	
Survey was completed in (noted, not asked):	Guadalajara	100	21	< 0.01
	Hermosillo	132	27	
	Mexico City	195	40	
	Veracruz	61	13	

Jalisco in the west, $n = 100$; Hermosillo in the northwestern state of Sonora, $n = 132$; Veracruz in the state bearing the same name on the eastern gulf, $n = 61$) were asked to select their preferred steak from each double-page of the beef choice albums showing the 16 combinations of two options of each of the characteristics of lean colour, fat cover, marbling and fat colour. The selection process was repeated using 8 different double-pages that showed the same 16 appearance characteristics and steaks, but in different combinations as previously described in pork (Ngapo et al., 2004). The consumers were then asked to select their preferred and maximum and minimum acceptable levels of the characteristics in the supplementary booklet. The booklets were alternated for order of levels with each consumer so that the orders were used approximately equally throughout a survey period. Finally, the consumer completed a questionnaire asking basic socio-demographic and purchase-, cooking- and eating-behaviour information and some perceptions of beef (Table 2). The questionnaire was exploratory in nature since it was neither embedded in a theoretical economic or attitudinal framework nor based on hypotheses. A total of 488 responses were obtained.

2.4. Analyses and statistical methods

2.4.1. Simulation

For each consumer, the greatest repeatability within the 8 choices of the book of images was designated as the “main choice”. For example, a main choice of 2 means that the most repeated combination of all four characteristics for that consumer was chosen 2 times out of 8. The probability of achieving the main choice at random was determined by simulation whereby 8 numbers between 1 and 16 were randomly and independently selected 1000 times and the main choices determined.

2.4.2. Analysis of choices

The choices were divided into three categories for each characteristic; in the first two categories the consumer actually chooses one of the two levels of the given characteristic, in contrast with the third category where the characteristic is not consistently selected (Ngapo et al., 2004). The results can be quantified by the definition that if 6 of 8 choices for one consumer are the same for a given characteristic, the choice is a ‘real’ choice ($P < 0.14$) and not random. The number of choices must be a whole number and therefore selection of a cut-off

giving a $P < 0.10$ or $P < 0.05$, as is commonly used in statistical analyses, was not possible. A cut-off of 7 out of 8 choices ($P < 0.03$) was considered too severe for this type of consumer-based selection, and hence the selection of 6 out of 8 choices. If < 6 choices are the same for a given characteristic, the selection is considered to be ‘inconsistent’ or, in other words, randomly selected. This test assumes a binomial distribution of the results ($P = 0.5$). For each characteristic, significant differences in the number of choices were observed using the χ^2 test.

A hierarchical cluster analysis of consumer choice was undertaken using the SAS CLUSTER procedure (SAS, 2007). Four clusters were retained by considering the ‘distance’ between clusters and the profile of the resulting graph. A disjoint cluster analysis was then carried out using the SAS TREE procedure (SAS, 2007) forcing the consumers into the four different clusters.

2.4.3. Analysis of the levels of characteristics

Preferences that did not fall within the minimum and maximum acceptable levels were removed. Frequencies of the levels of preference and acceptable minimum and maximum for three characteristics were tabulated.

2.4.4. Analysis of the questionnaire

Relationships between the consumer choice-based clusters and questionnaire items were determined using χ^2 test. Note that the χ^2 test requires a minimum of 5 responses and therefore where a strong bias existed for a given response the χ^2 test was not valid. All the results are shown, and where significant, the validity was checked; when not valid, the relationship between clusters and the criterion was not further investigated.

Relationships between the levels of characteristic and questionnaire items were determined using χ^2 test. Lean colour categories 1A, 1B and 1C were assumed to be equidistant and were recoded as 1.00, 1.33 and 1.66 in order to be treated numerically for statistical analyses. The numbers of questionnaire items and characteristic levels were reduced to facilitate both analyses and interpretation of the links, in particular noting the small numbers of consumers in some of the response categories. The combined levels for analyses were lean colour scores of 5 + 6, fat cover of 8 + 10 mm and of 15 + 20 mm, marbling scores of 4 + 5 and of 6 + 10, and fat colour levels of 4 + 5 and 6 + 7. The questionnaire items selected for analyses were:

- What is your age (years)?
- Gender?
- Are you the member of you household who normally shops for meat?
- Where do you normally purchase your meat?
- Do you cook the main meals in your household?
- If you do the cooking, how do you normally cook beef?
- How often do you eat beef?
- Do you freeze the beef you buy?
- Survey was completed in (noted, not asked).

3. Results

3.1. Preliminary interviews

Consumers spontaneously reported 17 beef attributes as important at the point of purchase, including brand or farm from which the beef came, in the ‘other’ response category (Fig. 1). Colour, freshness and quantity of fat were cited the most often of the nine attributes reported as the most important at purchase. When prompted, all attributes were considered important for some consumers. The meat-bone-fat ratio and presentation were not essential for purchase for any of the consumers, but were considered to add value (Fig. 2). Almost all attributes were believed important for almost all cuts in a carcass (Table 3).

Descriptions of the 19 attributes were obtained from all consumers. The following are summaries of the descriptions and/or comments common to most consumers.

- Beef lean should be red, but neither too red nor pale. “Very red” beef may indicate meat from another species, pale beef is not fresh, and dark colouring and green or brown hues are signs of decomposition. Fat should be white.
- Redness, visible, but not excessive drip on the cut surface, and a natural, not bad or old smell indicate freshness. ‘Best before’ or ‘packed on’ dates were not mentioned by any consumers. Frozen then thawed meat is not considered fresh and is less desirable than meat that has never been frozen. Throughout the interviews it was reiterated that frozen meat is undesirable, particularly because quality traits are unable to be evaluated in frozen beef and freezing results in a reduced eating quality.
- Appearance, described as the first impression, must be attractive for other characteristics to be considered. Presentation in clean, refrigerated counters and sealed packaging is preferred to freezers and unsealed or no packaging, respectively.
- A little fat is important for flavour, but fat is considered unhealthy. Some consumers prefer fat in the form of fat cover, while others prefer marbling.
- Beef is neither cheap nor expensive. Discussions of cost focused on meeting the family budget, shopping around for the cheapest or reduced prices, and how price variability can render beef inaccessible.
- Tenderness and texture were not differentiated and are reportedly used at the point of purchase being associated with freshness and eating quality. Texture should be soft, but firm to the touch, smooth, but not slimy, and not rigid, spongy or fibrous. Some consumers mentioned that tenderness is observed upon consumption, but is a consequence of freshness or the age of the animal (older animals giving tougher meat).
- Hygiene was described in terms of the cleanliness of the place of purchase. It was noted that meat should be washed, in particular, prior to mincing. Quality seals are defined as an endorsement by a governing body indicating that meat handling has been undertaken in a manner meeting certain standards of hygiene or sanitation.
- Juiciness was defined as the liquid or moisture within meat structure retaining the flavor. Beef should be neither dried out nor watery and if not juicy at purchase, will be dry and tough when cooked.
- Beef taste was described as “delicious”. Juiciness, good appearance, some fat, and a smooth, but firm texture are thought to favour good taste. Some consumers believe that the presence of fat and bone define taste, while others cited smell at purchase as an indicator of taste.
- Brand is a quality guarantee or an indication of the origin (farm, processor, packer, butcher and/or store). If the product comes from afar, it is concluded that it must be frozen and therefore of a lower quality than fresh meat.

Consumers mentioned trust and freshness as reasons for their preferred place of purchase, be it the supermarket, butcher shop or market. Supermarkets were preferred by some consumers for the convenience of all grocery shopping under one roof and refrigerated display, while the personalized service of the butcher was important for consumers who frequent a butcher shop.

Finally, a majority of the consumers think that the meat they purchase is ‘natural’. Some do believe that additives are used to prolong the shelf life (viewed positively) and some commented on the use of hormones and growth promoters during production (viewed negatively).

3.2. Survey consumer panel

The consumer panel composition is given in Table 2 (translated

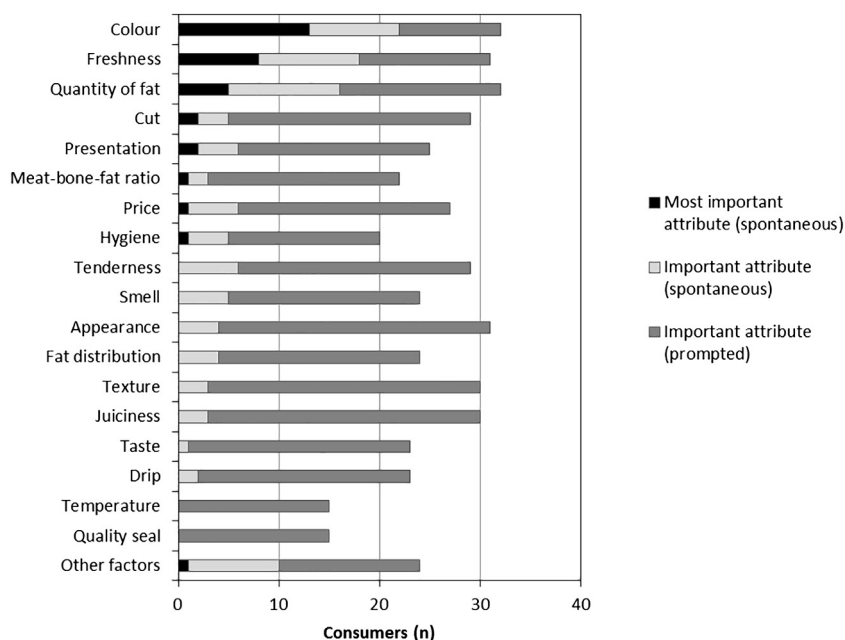


Fig. 1. Characteristics of beef self-reported as important at the point of purchase.

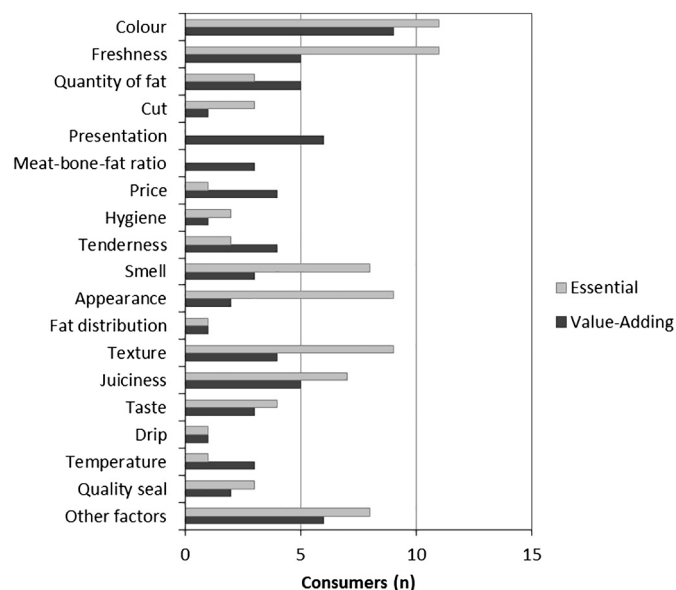


Fig. 2. Characteristics of beef self-reported as essential or value adding at purchase.

from Spanish). Briefly, a relatively even spread of consumers was obtained ranging from 10% aged 16–24 years to 25% aged 65 years and older. Three quarters of the respondents were women, 60% of consumers were married and only 5% of consumers lived in single person households. At 26%, the proportion of consumers with false teeth was relatively high. Almost all consumers (94%) claim to eat beef at least once a week. Of the 39% of consumers who say they have changed their consumption of beef recently, most (88%) claim to have decreased their consumption. Only 307 consumers responded with reasons as to why they like beef and of these, 51% claimed taste, with the next most popular reason being nutritional quality at 27%. More than a half of consumers (55%) never or almost never freeze the beef that they buy. Indeed, in the preliminary interviews many consumers expressed a dislike of meat at the point of purchase that is frozen or has been frozen and thawed equating these processes with a deterioration in quality. In the current survey, however, the remaining 45% of consumers sometimes, almost always or always freeze beef after purchase, with the latter two categories claiming 24% of consumers. Finally, 89% think

Table 3

Mexican beef cuts translated from Spanish (in parentheses) for which attributes were considered important in consumer interviews.

Attribute	Round (Pulpa)	Chuck (Diezmillo)	Steak (Bistec)	Grilling meat (Carne para asar)	Stewing meat (Carne para cocer)	All
Colour	X					X
Freshness		X			X	X
Quantity of fat		X		X	X	X
Cut				X		X
Presentation						X
Meat-bone-fat ratio				X	X	X
Price				X	X	X
Hygiene						X
Tenderness		X		X		X
Smell						X
Appearance						X
Fat distribution		X		X	X	X
Texture	X	X			X	X
Juiciness	X	X	X			X
Taste			X	X		X
Drip				X		X
Temperature						X
Quality seal						X
Other (brand)	X			X		X

that the beef they buy is almost always, if not always good quality, and 63% of consumers think it is expensive.

3.3. Range of characteristics

Defining the greatest repeatability within the 8 choices for a given consumer as the ‘main choice’, Table 4 compares the probability of randomly achieving the main choice versus the respondents’ main choices. Fewer single or double choices were made, and more choices were made 3, 4, 5 and 6 times than would be expected randomly. The distribution of the repeatability illustrates that the levels of the characteristics used were sufficiently different to allow the consumers to make a positive (as opposed to random) choice, but were not extreme which would have resulted in more consistent preferences. Additionally, all of the 256 images were selected. No matter what the combination of the four characteristics and shape, for each steak there

Table 4
Simulated probabilities of randomly achieving main choices and the percentage of consumers with these main choices.

Main choices	Number of times (out of 8) that the same combination of all four characteristics was chosen (% of consumers)							
	8	7	6	5	4	3	2	1
Simulated probability at random	0	0	0	0.1	1.8	15.6	71.0	11.5
Mexican (% of 488 consumers)	0	0	0.2	3.7	13.3	36.1	43.2	3.5

was at least one consumer who found that steak not only acceptable, but preferred that particular steak to 15 other steaks on the same double-page.

3.4. Real choices?

Significant differences in the choices were observed for all four characteristics ($P < 0.0001$; Table 5). About two thirds of the consumers used fat cover and/or marbling in their decision making process for beef. In addition, a little more than half of consumers used lean colour and 37% used fat colour in their choices suggesting that lean colour is less important in the decision than fat cover and marbling, and fat colour even less important. Of the consumers who use fat cover and marbling, little fat cover was preferred fifteen times more than fatty cover and the non-marbled, seven times more than the marbled beef. Consumers who did use colour in their choice, were relatively evenly divided between the two options, be it dark and light lean or white and yellow fat.

3.5. Number of characteristics used

Based on the ‘real’ and ‘inconsistent’ choices above, 74% of consumers used two or more characteristics to make their choice (Fig. 3). Only 6% did not consistently use any of the given characteristics in their decision making process and 19% used only one of the characteristics.

Table 5
Consumer selection (%) of steak characteristics for each cluster with the most important differences (determined by χ^2 compared to results of the entire panel) shown in bold.

Characteristic	Level	Overall consumer selection ^a		Proportion of consumers choosing the given characteristic in cluster (%)				Proportion of consumers in cluster choosing the given characteristic (%) ^b			
		(n)	(%)	1	2	3	4	1	2	3	4
Colour	Dark	118	24	63	31	1	6	100	64	0	5
	Light	142	29	0	0	73	27	0	0	46	29
	Inconsistent	228	47	0	9	53	38	0	36	54	65
Fat cover	Fatty	20	4	10	20	0	70	3	7	0	11
	Little	300	62	20	8	71	0	82	45	95	1
	Inconsistent	168	34	7	16	7	70	15	48	5	89
Marbling	Marbled	37	8	0	73	5	22	0	48	1	6
	Not	290	59	25	0	56	19	99	2	72	41
	Inconsistent	161	33	1	17	39	43	1	50	28	53
Fat colour	White	86	18	22	12	52	14	26	18	20	9
	Yellow	91	19	10	14	40	36	12	23	16	25
	Inconsistent	311	64	15	11	46	28	62	59	64	66
	Total (%)		100	15	12	46	27	15	12	46	27
	Total (n)	488		74	56	225	133	74	56	225	133

^a For all four characteristics, significant differences in the number of choices were observed using the χ^2 test ($P < 0.0001$).

^b Significant differences in the distribution of choices across the clusters were observed for colour, fat cover and marbling ($P < 0.0001$) and for drip ($P = 0.0185$) using the χ^2 test. The bold percentages within clusters do not have an associated P -value, but instead are those values in the table with greater differences between the expected values from the total panel and the observed values using the χ^2 test and are therefore the values with the greatest influence on the significant differences within clusters.

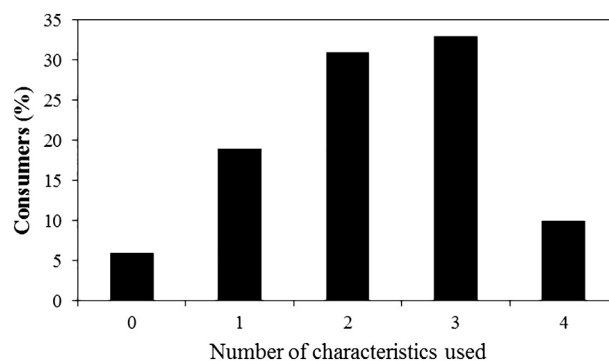


Fig. 3. Number of the four characteristics studied that consumers used in their choice process.

3.6. Choice-based clusters and links to questionnaire responses

Consumers were grouped into four similar-sized clusters with similar strategies for beef steak selection (Table 5). Significant relationships were observed among clusters and all four beef characteristics ($P \leq 0.0185$). Relationships between the consumer choice-based clusters and the questionnaire items were then determined. The number and percentage of consumers in each item of the questionnaire are presented in Table 2. Differences in distributions among the four choice-based clusters were observed for responses to gender, cooks, likes beef for its nutritional quality and survey site (Table 6). The individual clusters can be defined from the percentages of consumers significantly different to the entire panel and can be summarised as:

- Cluster 1 of 74 consumers (15%): strongly preferred dark red, non-marbled beef and a slight preference for white fat colour. Fewer of these consumers like beef for its nutritional quality than in the other clusters.
- Cluster 2 of 56 consumers (12%): preferred dark red beef and did not choose the non-marbled meat (note that three quarters of the consumers who chose marbled meat were in this cluster). Compared to the other clusters, this cluster is comprised of more men, fewer consumers who like beef for its nutritional quality, a higher proportion of consumers from Hermosillo and no consumers from Veracruz.
- Cluster 3 of 225 consumers (46%): strongly preferred beef that is not

Table 6
Distribution of significant questionnaire items ($P < 0.050$) by χ^2 test in each choice-based cluster.

Questionnaire item	P-value	Response options	Distribution of selection (% consumers) ^a				
			All	1	2	3	4
Gender	0.002	Female	75	73	55	80	74
		Male	25	27	45	20	26
Cooks main meals ^b	0.007	Every day	12	15	8	9	18
		Several times/week	66	62	60	72	61
		Once/week	18	17	28	18	13
		< Once/week	4	7	5	1	8
Like beef for nutritional quality	0.024	No	83	91	91	82	77
		Yes	17	9	9	18	23
Survey site	0.001	Guadalajara	21	18	13	23	21
		Hermosillo	27	32	48	22	23
		Mexico City	40	43	39	40	39
		Veracruz	13	7	0	15	17

^a Bold percentages within clusters do not have an associated P -value, but instead are those values in the table with greater differences between the expected values from the total panel and the observed values by χ^2 test and are therefore the with the greatest influence on the significant differences within clusters.

^b The responses to this question are reported as percentages of the 399 consumers who responded to this question.

dark red and has little fat cover and no marbling. In this cluster are fewer men, fewer consumers who cook less than once a week and a lower proportion of consumers from Hermosillo than in the other clusters.

- Cluster 4 of 133 consumers (27%): did not use fat cover in their choice (and the few that did, preferred the fatty beef) and showed a slight preference for yellow fat. In this cluster are more consumers who cook every day, who cook less than once a week, who like beef for its nutritional quality and who are from Veracruz than are in the other clusters.

While these distributions of questionnaire items vary significantly among the choice-based clusters, none of the questionnaire items strongly differentiated any given cluster. Note that in this study the recruitment of consumers was not limited to only those who shopped for the meat for the household. Rather, this responsibility was identified in the questionnaire and analysed as a characteristic of the consumer, showing no significant impact on consumer preference.

3.7. Levels of characteristics

The distributions of consumer preferences and acceptable minimums and maximums of levels of colour, fat cover, marbling and fat colour are presented in Table 7. Consumers who consistently chose dark red beef showed a strong preference for a colour score of 2. In contrast, the colour score preferences of consumers who consistently chose the lighter red beef option were spread from 1B to 2. It is interesting to note that while the profiles of preference scores of consumers who chose light and dark red beef differed, the most prevalent colour score preference in both groups was 2. These findings agree with the stated preferences during the interviews where the consumers expressed that beef must be red, but neither too red nor pale. Combining colour scores 1A and 1B accounted for almost two thirds of consumers' minimal acceptable colour scores. The maximum acceptable colour scores were less marked.

The profiles of the preference and acceptable limit scores for fat cover were similar and at the lower end of the scale with 2–4 mm cover preferred by about two thirds of consumers. However, consumers who consistently chose fatty cover showed a different preference profile,

with a peak in preferred level observed at 8–10 mm. These consumers constituted only 15 of the 331 total consumers or of the 214 consumers who used fat cover in their decision-making process (5 or 7%, respectively). While 61% of consumers chose 2 mm as the minimum acceptable levels of fat cover, the maximum acceptable levels were relatively evenly spread across the range of scores. None of the consumers who consistently chose fatty fat cover selected the highest or even the second highest levels of fat as their preferred levels. Yet of the 199 consumers who consistently chose little fat cover, six chose the highest fat cover (20 mm) as their preferred level and another 4 chose the second highest level (15 mm).

The profiles of preference scores and acceptable minimum and maximum levels for marbling were very similar to those for fat cover, being at the lower end of the scale and with about two thirds of consumers preferring scores of 1–2. The small group of consumers who consistently chose marbled meat (32 consumers or 10% of the total consumers) showed a peak in marbling score preference of 3.

Preference levels for fat colour were spread across the range of colours presented. As might be expected, consumers consistently choosing white fat showed a peak in preference for fat colour score of 0 (the whitest option) while those consistently choosing the yellow fat colour option showed a peak score of 7 (the yellowest option). However, consumers preferring white also show a peak at score 3 and those preferring the yellow option also show a peak at scores 1–2. The minimum acceptable levels for about two thirds of consumers were scores 0–1 and for more than half of consumers the maximum acceptable levels were scores 6–7, that is, the whole range of white to yellow colour fell between the acceptable levels for a majority of consumers.

Eighteen significant ($P \leq 0.05$) relationships were observed between questionnaire items and characteristics levels. However, given that a 5% significance level was used, it can be expected that one in twenty of the tests will be significant, even if there is no real effect. In the 192 tests made, about 10 false relationships might therefore be expected and consequently it is important that caution is taken in the interpretation of significant results near the $P = 0.05$ threshold. Furthermore, of particular note in the current data sets, regardless that the questionnaire items and characteristic levels were reduced, in many instances the consumers reporting a given response level by characteristic score was less than five, often rendering the Chi-square test invalid. Taking these constraints into account, eight relationships are retained.

Significant differences between survey sites were observed for lean colour ($P = 0.0058$) and marbling ($P = 0.0117$) preferences. The differences in lean colour were mainly a result of high proportions of consumers in Hermosillo choosing scores of 3 (50% consumers) and 4 (60%) while Hermosillo comprised only 29% of the consumers surveyed. Conversely, no consumers from Hermosillo chose score 1A. In addition, high proportions of consumers in Guadalajara and Veracruz chose score 1C (29% each), but no consumers from Veracruz chose score 3. The marbling score differences mainly stem from the high proportion of consumers (67%) from Hermosillo who chose marbling scores of 4 + 5.

A gender influence on maximum acceptable lean colour ($P = 0.0100$) was mainly attributable to higher proportions of men choosing scores of 4 (38% consumers) and 5 + 6 (36%). In addition, few men chose scores of 1C (5%) and 2 (14%). Men represented only 23% of the consumers surveyed.

An effect of age of the consumer on the maximum acceptable marbling scores ($P = 0.0407$) was a result of three age groups. High proportions of the 45–54 age group (38%) selected marbling score 1, of the 55–64 age group (24%) selecting score 3, and of 25–34 age group (27%) chose scores 4 + 5. These groups represent, respectively, 22, 12 and 14% of the total consumers.

A difference in maximum acceptable marbling with 'purchases beef at a market' ($P = 0.0093$) is largely a consequence of a low proportion (15%) of the consumers who buy meat at markets (which totals 32% of

Table 7

Distribution of levels of consumer preference and acceptable minimum and maximum of colour, fat cover, marbling and fat colour.

Consumers – level	Consumer selection (%)								Total consumers
<i>Lean colour (Aus-Meat scale)</i>	<i>1A</i>	<i>1B</i>	<i>1C</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	
All – preference	3	18	17	46	12	5	0	0	392
Used colour – preference	3	18	15	49	9	5	0	0	206
Chose dark red – preference	0	10	9	67	7	7	0	0	113
Chose pale red – preference	5	26	20	35	10	4	1	0	94
Used colour – acceptable minimum	31	32	17	17	2	0	0	0	206
Used colour - acceptable maximum	0	4	10	28	22	17	9	11	206
<i>Fat Cover (mm)</i>	<i>2</i>	<i>4</i>	<i>6</i>	<i>8</i>	<i>10</i>	<i>15</i>	<i>20</i>		
All – preference	32	32	17	10	5	2	2		331
Used fat cover – preference	34	36	13	8	5	2	3		214
Chose fatty cover – preference	13	33	7	27	20	0	0		15
Chose little cover – preference	36	36	13	7	4	2	3		199
Used fat cover – acceptable minimum	61	25	9	1	2	0	0		214
Used fat cover - acceptable maximum	10	27	17	15	10	6	15		214
<i>Marbling (JMGA scale)</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>5</i>	<i>6</i>	<i>8</i>		
All – preference	33	27	22	10	4	2	2		329
Used marbling – preference	42	30	19	5	2	1	2		213
Chose marbled – preference	16	18	25	9	9	6	6		32
Chose no marbling – preference	46	30	18	4	1	0	1		181
Used marbling – acceptable minimum	64	28	4	3	0	1	0		213
Used marbling - acceptable maximum	14	25	17	15	9	3	16		213
<i>Fat Colour (Aus-Meat scale)</i>	<i>0</i>	<i>1</i>	<i>2</i>	<i>3</i>	<i>4</i>	<i>6</i>	<i>7</i>		
All – preference	20	16	16	17	9	7	15		346
Used fat colour – preference	19	16	14	17	9	6	19		124
Chose white fat – preference	31	14	5	26	10	3	10		58
Chose yellow fat – preference	9	18	21	9	8	9	26		66
Used fat colour – acceptable minimum	57	15	9	6	6	2	5		124
Used fat colour - acceptable maximum	4	6	10	16	10	15	40		124

consumers) choosing maximal marbling scores of 4 + 5.

An effect of ‘cooks beef by frying’ on lean colour preference ($P = 0.0449$) is mainly explained by the high proportion of consumers who fry beef (33%) preferring colour score 2 noting that this group of consumers comprises 23% of those surveyed. Of the consumers who stew meat (43% of total consumers), a high proportion (67%) choosing 1.5 + 2.0 mm as acceptable maximum fat cover largely explain the effect of ‘cooks beef by stewing’ on fat cover ($P = 0.0028$). Inversely, this effect may be a result of the small proportion of consumers who don't cook beef by stewing (33%) who chose the 1.5 + 2.0 mm fat cover as acceptable maximum. Finally, the effects of ‘cooks beef by boiling’ on the maximum acceptable lean colour ($P = 0.0228$) is largely explained by the higher proportions of those who stew beef choosing scores of 1B (67%) and 1C (60%) and the lower proportion choosing score 4 (24%) noting that the consumers who stew beef make up 38% of the consumers surveyed.

4. Discussion

Lower proportions of consumers in the inconsistent category for fat cover and marbling suggest that these characteristics were more important in consumer choice than the lean colour, which was in turn more important than fat colour. The less fatty options of both fat cover and marbling were the choice of preference when two levels of characteristics were on offer. Consumer desire for leanness in animal products is far from new and is reported in studies on beef more than 80 years ago (Moulton, 1928; Watkins, 1936) as reviewed by Pearson (1976). More recent studies demonstrate that the amount of fat (or lack of) is of prime importance for consumers in Europe and North America in determining the quality expectation at the point of purchase of beef (Forbes et al., 1974; Grunert, 1997; Killinger et al., 2004; Realini et al., 2014; Steenkamp & van Trijp, 1996). Forbes et al. (1974) found that for some consumers marbling was thought to enhance the eating quality of beef, while for others, marbling was a waste or comparable to sinew

and gristle. It was suggested that those who deliberately avoided marbling incorrectly interpreted the significance of marbling to eating quality.

Perceived as a healthier or more economic product than beef with visible fat, the consumer desire for meat with low or no fat is at odds with the desire for a good eating experience, a particularly important anomaly for the beef industry given that a third of consumers in the current study like beef for its taste. Savell et al. (1989) also found taste the most important factor in the purchase of beef self-reported by 84–89% of US consumers surveyed. The use of brands and generic labelling to remedy the disconnect between the desire for low fat content and good eating experience were suggested by Brunso et al. (2005), but these workers also expounded on the caveats of such systems of communication. Grunert (1997) suggested that a grading system developed between the producer and the retailer might overcome consumer uncertainty in evaluating the quality of beef. In some countries beef industries do provide grading systems aimed at helping the consumer in their selection process and assuring a certain level of eating quality. Unfortunately, grading systems based on eating quality and developed at a time in which the role of marbling in palatability was perhaps overvalued (Pearson, 1976), mean an inherent disconnect between the grades of beef that the industry markets as superior and consumer preferences of intrinsic cues at the point of purchase. Indeed, specified amounts of marbling are prerequisites to higher grades of certified beef in Australia where a rib fat of 3 mm or more is also required (Meat & Livestock Australia Limited, 2014), the US where degree of marbling and maturity are the primary determinants of quality grade (USDA, 2016), and Canada where grade A and premium beef require at least a slight degree of marbling and a 2 mm fat cover (Beef Cattle Research Council, 2016).

When eight levels of fat cover were presented, about a third of all consumers, of consumers who consistently used fat cover and of consumers who consistently chose the lean fat cover option preferred the lowest level of cover (2 mm). However, about another third of these

consumer categories preferred the second lowest level (4 mm) and about 30% of consumers preferred the second level of marbling (score 2). So while a preference for no or very little marbling coupled with as little possible fat cover possibly results in a compromised gustative experience (Pearson, 1976), a significant proportion of consumers showed a preference for a small amount of fat cover and/or marbling and not the leanest options offered. Preferences spanning at least two levels of each of fat cover and marbling are good findings for the industry in that fat cover is largely a matter of trimming and natural product variation allows the market to respond to the majority of marbling preferences. Furthermore, while the consumers who grill (6%), fry (26%) and roast (42%) may experience compromised gustative quality if choosing the lowest fat levels, it must be noted that 37–44% of the consumers stated that they stew and/or boil beef. Unlike grilling, frying and roasting where the fat content may have a direct and significant impact on the sensory quality of the cooked meat, dishes prepared by boiling and stewing, particularly with other ingredients, may not be impacted in the same manner.

While fat content plays a primary role in the aforementioned quality assurance systems, bright cherry red colour is also a criterion. However, aside from eliminating dark-cutting beef, mention of colour in grading systems is generally in the context of consumer appeal given that beef within the normal colour range is not an indicator of meat quality (Breidenstein, Cooper, Cassens, Evans, & Bray, 1968; Jeremiah, Carpenter, & Smith, 1972). With limited means to visually determine perceived beef quality at the point of purchase, it is not surprising that beef colour is an important cue for the consumer. Indeed, Glitsch (2000) found that in five of six European countries studied, consumers self-reported colour as the most helpful of seven characteristics in assessing beef quality, while fat cover and marbling generally ranked second and/or third. Steenkamp and van Trijp (1996), Grunert (1997), Realini et al. (2014) and Forbes et al. (1974) also observed that the lean colour was an important characteristic in consumer choice, albeit second to fat and/or marbling. With more than half of consumers in the current study consistently choosing lean colour, this trait was an important selection criterion after fat cover and marbling. However, unlike the bias observed for the lower fat and marbling levels, the lean colour preferences were relatively evenly divided. Indeed, 24 and 29% of consumers consistently chose light and dark red beef, respectively, while more than fifteen times the consumers showed a preference for little fat cover than fatty fat cover and more than seven times for the non-marbled than marbled steaks. Interestingly, when the consumers who consistently used lean colour in their choice were asked to choose their preferred level of lean colour (all other characteristics equal), 50% preferred a lean colour score of 2. Indeed, a score of 2 was the most preferred lean colour level for both consumers who consistently chose the dark red option and for those who consistently chose the light red option.

The colour of the fat was the least important of the four characteristics studied and as observed for lean colour, preferences of those choosing this characteristic were evenly divided. Furthermore of the consumers who consistently used fat colour, the preferences were relatively evenly spread over the eight levels presented from white to yellow. Forbes et al. (1974) also observed a much smaller proportion of consumers were concerned about the colour of the fat than the quantity of fat or the lean colour. However, of those that did take fat colour into consideration, these authors found that the majority of consumers self-reported preferring a white or light coloured fat.

In the current study, a higher proportion of consumers from the northern city of Hermosillo were found in the cluster preferring beef that is not light red and not non-marbled compared to the other clusters. A lower proportion of consumers from Hermosillo made up the cluster preferring dark red meat with little fat cover and no marbling. No consumers from the eastern city of Veracruz were in this cluster, but a higher proportion of consumers from Veracruz were observed in the cluster that showed a preference for yellow fat than in other clusters.

While the current study is unable to conclude the reasoning for geographical differences in preferences, it is suggested that perhaps familiarity with product characteristics explains greater acceptance of yellower fat in Veracruz and marbling in Hermosillo. Méndez et al. (2009) reported that beef production in the North of Mexico is largely based on feedlots and demonstrated whiter fat and higher marbling scores than carcasses from the central and southern regions, where production relies more on pastures and corroborating other studies comparing feedlot and pasture-fed cattle (Duckett, Neel, Lewis, Fontenot, & Clapham, 2013; Leheska et al., 2008).

Four clusters of consumers were apparent based on choices for the beef characteristics and eight consumer characteristics were significantly linked to the clusters. Although these distributions varied significantly among the clusters, none of the questionnaire items strongly differentiated any given cluster. However, it is worthy to note that all four clusters did show preferences for at least two characteristics. Indeed, three quarters of the consumers used two or more characteristics to make their choice and 43% used three or four. Investigating a characteristic in isolation does not take into account such dependencies in consumer preference. Furthermore, investigation of an individual characteristic which may be of low importance to the consumer, such as fat colour in the present study, could result in erroneous findings or exaggerate their influence on choice.

Taking the ensemble of preferences observed in the current study, it appears that the beef on offer in the Mexican marketplace responds well to consumer preferences. It is difficult to find recent statistics detailing the share that US beef holds in the Mexican marketplace, but in 2002, it was reported that 40% of meat sold in Mexican retail outlets was imported from the US (Rubio et al., 2007). This study reports not only this significant market share, but also beef that differs in intrinsic characteristics to that produced locally. Rubio et al. (2007) described how locally produced Mexican beef corresponds to USDA Standard grade, but is generally marketed without grades, while imported US beef for the Mexican retail sector is the higher USDA Select grade. Furthermore, other studies have found that marbling scores of slight, trace or practically devoid are reported in 94% of locally produced carcasses (Méndez et al., 2009) compared to only 70% of US beef on sale in Mexico (Huerta-Leidenz et al., 2014). These latter workers also found that another 24% of the US beef had small to modest marbling scores. Information of fat cover of both local and imported beef also suggests a lean meat. Huerta-Leidenz et al. (2014) observed 93% of samples of US beef in the Mexican market had fat cover at 0.32 mm or less, and in locally produced beef average carcass backfat thicknesses of 3–7 mm are reported (Méndez et al., 2009). These studies also show a lighter lean colour and wider range of white to yellow fat colour in beef produced locally than imported from the US. The reported differences in marbling scores and colour of fat and lean are complementary in the export and domestic beef found in the Mexican marketplace and combined, appear to respond to the range of Mexican consumer preferences for beef at the point of purchase.

5. Conclusions

Using within-consumer preference replication achieved through systematic image manipulation it was observed that consumers in four cities across Mexico had similar strategies for beef choice. Fat cover and marbling were the most important choice criteria. Preferences for both light and dark red beef lean were almost equal, while preferences for fat cover and marbling were strongly biased towards the less fatty options. Indeed, more than fifteen times the consumers preferred little than fatty fat cover, and seven times more preferred the non-marbled than marbled steaks. Fat colour was the least important of the four attributes studied, but nevertheless important in choice given that 43% of consumers used three or four characteristics to make their choice. Imported and domestic beef in the Mexican marketplace appear to respond to the range of Mexican consumer preferences for beef at the point of

purchase.

Acknowledgements

The authors gratefully acknowledge the financial support of the Fondo Sectorial Sagarpa - CONACYT No. 109127 “Fresh meat quality indicators”. Thanks are also expressed to Victoria Lorenzana and her team at Facta Research México, Mexico City, Mexico for the data collection and to Claude Laberge of Experts-Conseils STATEX, Quebec City, Canada for the statistical analyses.

References

- Aus-Meat Limited (2011). Australian beef carcass evaluation. Retrieved from <https://www.ausmeat.com.au/industry-standards/meat/beef.aspx>.
- Banović, M., Chrysochou, P., Grunert, K. G., Rosa, P. J., & Gamito, P. (2016). The effect of fat content on visual attention and choice of red meat and difference across gender. *Food Quality and Preference*, 52, 42–51.
- Banović, M., Fontes, M. A., Barreira, M. M., & Grunert, K. G. (2012). Impact of product familiarity on beef quality perception. *Agribusiness*, 28, 157–172.
- Beef Cattle Research Council (2016). Carcass grading. Retrieved from <http://www.beefresearch.ca/research-topic.cfm/carcass-grading-41#quality>.
- Breidenstein, B. B., Cooper, C. C., Cassens, R. G., Evans, G., & Bray, R. W. (1968). Influence of marbling and maturity on the palatability of beef muscle. I. Chemical and organoleptic considerations. *Journal of Animal Science*, 27, 1532–1541.
- Brugiapaglia, A., & Destefanis, G. (2009). Sensory evaluation of meat colour using photographs. *Italian Journal of Animal Science*, 8(Suppl. 2), 480–482.
- Brunso, K., Bredahl, L., Grunert, K. G., & Scholderer, J. (2005). Consumer perception of the quality of beef resulting from various fattening regimes. *Livestock Production Science*, 94, 83–93.
- Chávez, A., Pérez, E., Rubio, M. S., Méndez, R. D., Delgado, E. J., & Díaz, D. (2012). Chemical composition and cooking properties of beef forequarter muscles of Mexican cattle from different genotypes. *Meat Science*, 91, 160–164.
- Cho, S., Park, B., Ngapo, T., Kim, J., Dransfield, E., Hwang, I., & Lee, J. (2007). Effect of meat appearance on South Korean consumers' choice of pork chops determined by image methodology. *Journal of Sensory Studies*, 22, 99–114.
- Danner, M. J. (1959). *Beef preferences and purchasing practices*. Vol. 131, Agricultural Experiment Station of the Alabama Polytechnic Institute Circular 15.
- Delgado, E. J., Rubio, M. S. W., Iturbe, F. A., Méndez, R. D., Cassis, L., & Rosiles, R. (2005). Composition and quality of Mexican and imported retail beef in Mexico. *Meat Science*, 69, 465–471.
- Dransfield, E., Martin, J.-F., Miramont, J., & Ngapo, T. M. (2001). *Meat appearance: Pork chops. A tool for surveying consumer preferences*. France: INRA2-7380-0976-X.
- Duckett, S. K., Neel, J. P. S., Lewis, R. M., Fontenot, J. P., & Clapham, W. M. (2013). Effects of forage species or concentrate finishing on animal performance, carcass and meat quality. *Journal of Animal Science*, 91, 1454–1467.
- Forbes, S. M. C., Vaisey, M., Diamant, R., & Cliplef, R. (1974). The relationships between consumer criteria for choosing beef and beef quality. *Canadian Institute of Food Science and Technology Journal*, 7, 130–135.
- Glitsch, K. (2000). Consumer perceptions of fresh meat quality: Cross-national comparison. *British Food Journal*, 102, 177–194.
- Grunert, K. G. (1997). What's in a steak? A cross-cultural study on the quality perception of beef. *Food Quality and Preference*, 8, 157–174.
- Holman, B. W. B., Mao, Y., Coombs, C. E. O., van den Ven, R. J., & Hopkins, D. L. (2016). Relationship between colorimetric (instrumental) evaluation and consumer-defined beef colour acceptability. *Meat Science*, 121, 104–106.
- Huerta-Leidenz, N., Ruíz-Flores, A., Maldonado-Siman, E., Valdéz, A., & Belk, K. E. (2014). Survey of Mexican retail stores for US beef product. *Meat Science*, 96, 729–736.
- Japan Meat Grading Association (2000). *Beef carcass grading standard (English brochure)*. Tokyo, Japan: Japan Meat Grading Association.
- Jeremiah, L. E., Carpenter, Z. L., & Smith, G. C. (1972). Beef colour as related to consumer acceptance and palatability. *Journal of Food Science*, 37, 476–479.
- Killinger, K. M., Calkins, C. R., Umberger, W. J., Feuz, D. M., & Eskridge, K. M. (2004). Consumer visual preference and value for beef steaks differing in marbling level and colour. *Journal of Animal Science*, 82, 3288–3293.
- Leheska, J. M., Thompson, L. D., Howe, J. C., Hentges, E., Boyce, J., Brooks, J. C., ... Miller, M. F. (2008). *Journal of Animal Science*, 86, 3575–3585.
- Meat & Livestock Australia Limited (2014). Meat standards australia (MSA). Retrieved from <http://www.australianbutchersguild.com.au/Meat-Standards-Australia>.
- Méndez, R. D., Meza, C. O., Burruecos, J. M., Garcés, P., Delgado, E. J., & Rubio, M. S. (2009). A survey of beef carcass quality and quantity attributes in Mexico. *Journal of Animal Science*, 87, 3782–3790.
- Moulton, C. R. (1928). The show ring, the prize carcass contest, and the butcher's block as measures of quality in meats. *Proceedings of the American Society of Animal Production*, 21, 122–130.
- Ngapo, T. M., Fortin, J., Aalhus, J. L., & Martin, J.-F. (2010). Consumer choices of pork chops: Results from two Canadian sites. *Food Research International*, 43, 1559–1565.
- Ngapo, T. M., Martin, J.-F., & Dransfield, E. (2004). Consumer choices of pork chops: Results from three panels in France. *Food Quality and Preference*, 15, 349–359.
- Ngapo, T. M., Martin, J.-F., & Dransfield, E. (2007a). International preferences for pork appearance: I. Consumer choices. *Food Quality and Preference*, 18, 26–36.
- Ngapo, T. M., Martin, J.-F., & Dransfield, E. (2007b). International preferences for pork appearance: II. Factors influencing consumer choice. *Food Quality and Preference*, 18, 139–151.
- OECD. *OECD-FAO agricultural outlook: Meat consumption*. (2016). Retrieved from <https://data.oecd.org/agroutput/meat-consumption.htm> (web archive link, 18 November 2016) (accessed 18 November 2016) .
- Pearson, A. M. (1976). *The consumer desire for animal products* Washington (DC) National Academies Press (US).
- Realini, C. E., Kallas, Z., Pérez-Juan, M., Gómez, I., Olleta, J. L., Beriain, M. J., ... Sañudo, C. (2014). Relative importance of cues underlying Spanish consumers' beef choice and segmentation, and consumer liking of beef enriched with n-3 and CLA fatty acids. *Food Quality and Preference*, 33, 74–85.
- Rubio, M. S., Méndez, R. D., & Huerta-Leidenz, N. (2007). Characterization of beef *semimembranosus* and *adductor* muscles from US and Mexican origin. *Meat Science*, 76, 438–443.
- SAS (2007). *SAS users guide: Statistics. Version 9.1*. Cary, USA: SAS Institute Inc.
- Savell, J. W., Cross, H. R., Francis, J. J., Wise, J. W., Hale, D. S., Wilkes, D. L., & Smith, G. C. (1989). National consumer retail beef study: Interaction of trim level, price and grade on consumer acceptance of beef steaks and roasts. *Journal of Food Quality*, 12, 251–274.
- Schnettler, B., Ciesla, M., Candia, A., Llancanpán, F., Sepúlveda, J., Denegri, M., ... Sepúlveda, N. (2010). *Importancia del color, contenido de grasa y frescura en la compra de la carne bovina en Temuco, región de la Araucanía, Chile*. XX: Revista Científica, 623–632.
- Secretaría de Economía (2002). NMX-FF-078-SCFI-2002. Productos pecuarios – Carne de bovino en canal – Clasificación (cancela a la NMX-FF-078-1991). In Secretaría de Gobernación (Ed.), *El Diario Oficial de la Federación* (pp. 19–). México, D. F.: Secretaría de Gobernación.
- Steenkamp, J.-B. E. M., & van Trijp, H. C. M. (1996). Quality guidance: A consumer-based approach to food quality improvement using partial least squares. *European Review of Agricultural Economics*, 23, 195–216.
- USDA. *Foreign agricultural service: Market and trade data. production, supply and distribution online*. (2016). Retrieved from <https://apps.fas.usda.gov/PSDOnlinev2/app/index.html#/app/home> (web archive link, 18 November 2016) (accessed 18 November 2016) .
- USMEF. *Export statistics (2015)*. (2015). Retrieved from https://www.usmef.org/news-statistics/statistics/?stat_year=2015 (web archive link, 18 November 2016) (accessed 18 November 2016) .
- Watkins, R. (1936). Finish in beef cattle from the standpoint of the consumer. *Proceedings of the American Society of Animal Production*, 29, 67–70.