A survey of Mexican retail chain stores for fresh U.S. pork

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21 **Abstract**

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23 An overview of fresh US pork in the Mexican market was achieved by surveying fresh US pork packages (n=342)
24 for sale in five Mexican cities. Data on cut, primal/sub-primal from which the cut was sourced, subcutaneous and
25 seam fat thicknesses, marbling scores, and presence of bone gaining were collated. The most prevalent
26 identifiable retail cuts were *milanesa* (thin slice of pork, breaded or non-breaded) and *trozos* (diced pork) derived
27 primarily from the leg and accounting for 68 % of the total US pork on sale. Over 90 % of the retail cuts were
28 trimmed to 3.2 mm or less of external fat and the average marbling score was 2.26. Differences in distribution
29 and fat measures were observed with chain, location and socio-economic status of clientele indicating potential
30 for a targeted marketing approach in Mexico.

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39 Keywords: pork retail, external fat, marbling, merchandising, Mexico, seam fat

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41 1. Introduction

42 Pork is a traditional source of protein in popular Mexican cuisine. Over the last decade, the average per
43 capita consumption of pork in Mexico increased from 13.9 kg in 2003 to 16.8 kg in 2014 (U.S. Meat Export
44 Federation-Mexico, unpublished results) with the national annual demand reaching approximately 2 million tons
45 (Gobierno de la República de México, 2015). Concomitantly, pork production in Mexico has steadily increased,
46 but is insufficient to meet domestic demand. The ratio of consumption to production has increased from 1.22 to
47 1.38 in the decade to 2013, appearing to have levelled off at 1.35 in 2014 (U.S. Meat Export Federation-Mexico,
48 unpublished results). The discrepancy between supply and demand is met through pork imports of which the
49 USA is Mexico's most important trade partner, not in the least due to geographical proximity, provisions of the
50 North American Free Trade Agreement (NAFTA), the high production efficiency of the U.S. pork supply and the
51 availability of high demand cuts for the Mexican market. The processing industry and large retail chains are the
52 principal buyers of U.S. pork in Mexico (Díaz-Carreño, Mejía-Reyes, & del Moral-Barrera, 2006). While the
53 retailing sector in Mexico is highly fragmented and small independent businesses play an important role, the small
54 corner grocery stores and open air markets are slowly being replaced by large grocery stores and supermarkets.
55 Today, 67% of all food products in Mexico are reported to be purchased through supermarket chains (Agriculture
56 and Agri-Food Canada, 2014).

57 The *per capita* consumption of fresh pork has increased in Mexico, but is hindered by perceptions of
58 safety and nutrition concerns, such as parasites and high fat content (Rocha-López & Padilla-Vera, 2006).
59 Although a preference of Mexican consumers for lean pork has been observed (Ngapo, Martin & Dransfield,
60 2007a; Rubio, Méndez, & Huerta-Leidenz, 2007), studies on the levels of fat and marbling in pork in the Mexican
61 retail market are not reported. Huerta-Leidenz and Ledesma Solano (2010) suggested that Mexican retailers have
62 developed merchandising strategies for both pork and beef of US origin based on the type of cut (sub-primals and
63 derived retail cuts), the retailing cutting style (portion size and thickness) and overall leanness to meet consumer
64 preferences. Such strategies are likely impacted by extrinsic factors, including supermarket chain, geographical
65 location and characteristics of the targeted clientele. However, no studies reporting the influence of these
66 extrinsic factors on pork merchandising in Mexico are found in the literature.

67 The objectives of this study were therefore a) to achieve an overview of fresh US pork on sale in the five
68 Mexican cities where most of the pork imported from the US is sold, and b) to examine type, retail cutting style,
69 subcutaneous and seam fat levels, and marbling of pork cuts of US origin and determine variations by city,
70 geographical region, supermarket chain, and reported socio-economic status of the targeted clientele.

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72 **2. Materials and Methods**

73 *2.1. Data Collection*

74 Preliminary assessments were undertaken in grocery stores in Mexico City from January to April, 2008
75 (Huerta-Leidenz & Ledesma-Solano, 2010) to understand the handling of wholesale US pork cuts and how cuts
76 are presented to the consumer, as described for beef in Huerta-Leidenz, Flores, Maldonado-Siman, Valdez &
77 Belk (2014). Ground pork was not included in the list of cutting styles since the origin of the product is not
78 identifiable. Using meat merchandising guides of Sonora Agropecuaria S.A. de C.V. (SASA) for local pork cuts
79 (SASAPORK, undated), regulations on national pork cuts nomenclature from the Normas Mexicanas (NMX-FF-
80 081-2003, 2003) and experienced retail supervisors of the USMEF, Mexican pork cuts were aligned with North
81 American Meat Processors Association (NAMP) cuts (NAMP, 2011) as best possible. Tables 1 and 2 present the
82 wholesale pork cuts and their retail cutting styles surveyed.

83 Upon completion of the preliminary assessments, a survey was carried out in grocery stores in five
84 Mexican cities between April 4 and August 8, 2008. The five cities comprised Mexico City in the Federal District
85 and its surrounding area (number of retail packages, n=177), Querétaro, Querétaro (n=20), León, Guanajuato
86 (n=14), Guadalajara, Jalisco (n=49), and Monterrey, Nuevo León (n=82). These five cities are reported to
87 account for 59.7 % of total food store sales in 2012 (Asociación Nacional de Tiendas de Autoservicio y
88 Departamentales, ANTAD, unpublished data) and fall in the three most economically important regions in
89 Mexico according to the Instituto Nacional de Estadística y Geografía (INEGI, 2012) representing the largest
90 markets for imported US pork. The majority of the stores surveyed were supermarkets and hypermarkets
91 belonging to large retail chains in Mexico, but also included wholesale club-style stores, meat boutiques and

traditional grocery stores where US meats were sold. The retail chains comprised Soriana (Mexico City, Guadalajara, Monterrey, Querétaro, and León), Chedraui and Mega (Mexico City, Guadalajara, Querétaro and León), Comercial Mexicana (Mexico City, Guadalajara and León), Superama (Mexico City) and Walmart (Monterrey). Three to six supermarket chains per city were surveyed.

Surveyors were USMEF personnel with one to three years of experience in supervising US meat merchandising practices. The surveyors were trained in-store by a meat scientist as described in beef in Huerta-Leidenz, Flores, Maldonado-Siman, Valdez & Belk (2014).

2.2. Statistical Analyses

Means and standard deviations were generated using SAS (SAS Institute, 2012). Equality of frequencies were conducted only to determine differences between the socio-economic status of clientele of certain locations by chi-square (χ^2) test using the GENMOD procedure of SAS 9.3 (SAS, 2014) with an alpha level of 0.05. Risk ratios were calculated using epidemiology-based analyses since they indicate measures of association rather than cause and effect relationships (Dohoo, Martin & Stryhn, 2003). The risk ratio is a measure of association rather than a measure of statistical significance, the latter of which gives no estimate as to the magnitude of a difference and is highly dependent on sample size (Dohoo et al., 2003). In epidemiology these measures typically evaluate the risk of a disease occurring in the portion of a population exposed to a factor relative to the risk in the unexposed portion. Cumulative incidence gives a proportion (p) that provides a measure of risk, and a relative risk (or risk ratio) is computed by taking the ratio of two proportions, p_1/p_2 . In the current study, the risk ratio was determined as the risk of finding a retail cut, primal source or marbling score in a given city, socio-economic status or supermarket chain relative to the risk of not finding the cut, source or score in the given extrinsic factor. Using risk ratio methodology for the analysis of survey data that included non-respondents was deemed appropriate by Rubin (1987) and recently this methodology has been applied to data from the North American Beef Tenderness Survey 2011-2012 to determine the risk of “tough” beef steaks at retail (Howard et al., unpublished). Limited sample sizes in certain portions of the current survey population mean that frequency data could be misleading and the use of risk ratios allows differences to be evaluated by comparing proportions

118 thereby allowing for determination of differences between large and small sample sizes. Nevertheless, in order to
119 achieve a sufficiently large sample size for the risk ratio analyses to be valid, some variables were combined for
120 comparison and only select variables were used. Furthermore, only the retail cuts and primal/sub-primal sources
121 with more than 25 samples on sale were used for analyses. Probabilities (p-values) and confidence intervals (CI)
122 at the 95 % level were calculated. Noting that the null value of the confidence interval for the relative risk is one,
123 if the CI for the relative risk included the null value of 1, then there was insufficient evidence to conclude that the
124 groups were statistically significantly different.

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126 **3. Results and Discussion**

127 *3.1. US pork on sale in Mexico*

128 Packages of US pork cuts on sale with corresponding primal or sub-primal source, fat thicknesses,
129 marbling scores and presence of bone are presented in Table 3. The *milanesa* (thin slice of pork, breaded or non-
130 breaded; 35 % of total packages of US retail cuts) and *trozos* (diced pork; 33 %) were the most common retail
131 cuts on sale comprising more than two thirds of the derived products when combined. At a fifth of the total
132 packages on sale, cuts that were not labeled by the retailer and were unable to be identified by the surveyors
133 (listed as “unidentifiable” in Table 3) comprised a significant proportion of the US retail cuts on sale being the
134 third most prevalent. The leg was by far the most predominant source of the derived retail cuts (59 %) accounting
135 for 62 % of milanesa and 71 % trozos. Like the unidentifiable retail cuts, a fifth of the primal/sub-primal source
136 were unknown or unable to be determined (listed as “unknown” in Table 3) and this category was the second most
137 prevalent source of retail cuts followed by the loin at 11 %. The most common loin-derived retail cut was the
138 *chuleta* (chop) which comprised 8 % of the total packages of US retail cuts on sale.

139 A majority of the retail cuts had no external or seam fat (71 and 69 %, respectively; Table 4), and those
140 that did were generally closely trimmed with the overall averages for the US retail cuts on sale being a meagre 1
141 mm for both external and seam fat, albeit with a high variability. While still well trimmed, chuleta was the main
142 source of external fat at about 3 mm average and hence the loin was the main primal source. The seam fat was
143 mainly attributable to the unidentifiable category (1.50 mm), followed by the trozos (1.24 mm). A mean marbling

score of 2.26 (trace to slight) was achieved for all the packages combined and for the most part, the average marbling scores for individual cuts varied less than half a unit from the overall average. Few packages had bone present with two exceptions being the chuletas, which were all bone-in, and more than half of the unidentifiable cuts.

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3.2. Overall frequencies of fat measurements

Table 4 shows the distribution of total packages by level of fat and marbling score. Admittedly, data from Table 4 includes measurements from a variety of retail cuts, however almost all of the pork retail cuts (93 %) were trimmed to very little (3.2 mm) or to no external fat, with more than 70 % of all packages having none. Almost all cuts had seam fat measurements of less than 3.2 mm, of which seam fat was absent in more than two thirds of the packages. The level of marbling in retail cuts was also low with three-quarters of the packages of retail cuts surveyed exhibiting marbling scores of 1 (practically devoid) and 2 (trace).

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3.3 Retail cuts and primal/sub-primal source by city

The number and proportion of the packages of retail cuts and their whole muscle sources by city are presented in Table 5. The milanesa and trozos were the two most common cutting styles observed in Mexico City, Querétaro and León, cuts which may be derived from any of several muscles, but in Mexico are most often from the leg. Not surprisingly, therefore, the leg was the most popular primal source at 60 % of the whole muscle cuts. More than twice as many samples were surveyed in Mexico City (n=176) as in the other cities combined, and while one of the top two most common sources of retail cuts for all five cities, the prevalence of the leg as the most common primal source is largely attributable to Mexico City where it outnumbered the next most popular whole muscle source by more than four times. In addition, in León the leg was the only primal source and in Querétaro two thirds of retail cuts were derived from the leg, albeit with small sample sizes in these cities (n=14 and n=20, respectively). In Monterrey, the highest number of packages of retail cuts was the unidentifiable category, followed by chuleta. The chuleta is generally derived from the loin and accordingly, the loin (n=27) was equally as common as the leg (n=28) as the principal sources of retail cuts in Monterrey. Furthermore, unlike

the milanesa and trozos which are boneless, the chuleta was all bone-in and hence explains at least in part the relatively high frequency of bone-in cuts compared to the other cities. However, the proportion of bone-in cuts is not explained entirely by the proportion of chuleta and most of the remainder is the unidentifiable category, which is relatively high in both Monterrey and Guadalajara. The unidentifiable category and milanesa were the most predominant retail cuts in this latter city, Guadalajara, with the most prevalent source being the unknown category (53 % of the retail cuts being derived from this category). The relatively high external fat cover of the retail cuts in Monterrey (1.82 mm) can be explained by the high proportion of chuleta compared to the other cities where the averages of external fat in retail packages were <1 mm. The average marbling score was also the lowest in Monterrey, with the highest being in León. While the marbling scores are in fact similar and relatively low across all five cities with less than a unit separating the averages, there is no evident trend in marbling scores with distribution of retail cuts and corresponding whole muscle sources by city. Generally the leg muscles have higher intramuscular fat content than the loin muscles (Kim et al., 2008), but high significant proportions of cuts in the “unidentifiable” and “unknown” categories negate any obvious trends.

3.4. Socio-economic status of supermarket clientele

The distribution of retail cuts, sources from which the cuts are derived and the stores as a function of socio-economic status of the targeted clientele is presented in Tables 5 and 6, with the former in terms of the city in which the survey was undertaken. While the socio-economic status of the targeted clientele reported by the managers was not distributed equally between cities ($P < 0.05$; Table 5), the predominant clientele for almost two thirds were reported as consumers of a medium status and for 89 % of the grocery stores were of high and medium status. Indeed, in Querétaro and León, no managers reported targeting clientele having low socio-economic status while the largest proportion was in Monterrey and equated to only 3 % of all 145 stores. The socio-economic status of the target clientele for the majority of stores surveyed in Mexico City and Querétaro was the medium status while in Guadalajara, Monterrey and León both high and medium were well represented. It is interesting to note in Table 6 that the breakdown of the retail cuts was similar in the stores reporting to target both high and low socio-economic status clientele being relatively evenly distributed among the milanesa, trozos and

unidentifiable retail cuts (23-33 %) with about half as much chuleta (12-16 %). The stores reporting to target the medium socio-economic status clientele had a higher proportion of milanese and trozos (37-41 %) on sale than the stores targeting the other statuses, and corresponding lower unidentifiable and chuleta cuts. In the stores targeting high socio-economic status clientele, twice as much leg as loin or as the unknown category were used as the source of the retail cuts, stores targeting medium status clientele had three quarters of cuts derived from the leg and in those targeting the low status, the unknown and leg sources were the most prevalent at 39 and 30 %, respectively. Noting that the medium socio-economic status had a lower proportion of chuleta, it is not surprising that the average external fat cover of these packages was two thirds of the low and high status clientele. The marbling scores were similar across the three socio-economic status and ranged from 2.21 to 2.51.

3.5. Supermarket chains surveyed

One supermarket chain comprised 39 % of the stores surveyed (designated supermarket chain A; Table 7). The profile of most common retail cuts on sale in this chain differed from the four following chains (chains B to E) that accounted for another 50 % of the stores surveyed. Chain A had about 30 % packages of each of milanese, trozo and unidentifiable cuts on sale and 60 % of the total chuleta surveyed, whereas chains B, C and E had almost 50 % of each of milanese and trozos on sale and chain D had 39-44 %, with the remainder unidentifiable. A third of chain A and a quarter of chain C cuts were from unknown sources compared to 6-15 % in the other chains. Chain A, having a relatively high proportion of chuleta also had a correspondingly high proportion of loin as source of the derived cuts compared to the other chains. All chains targeted predominantly medium socio-economic status clientele, but chain A also had a relatively high proportion (20 %) of stores targeting the low status compared to the other chains. While little difference in mean marbling scores and seam fat thicknesses were observed, the average external fat cover was particularly low (0.22 mm) in the packages in chain B compared to the other chains.

3.6. Selected risk ratios

The risk ratios and CI comparing city sociodemographic status and supermarket chain are presented in Table 8. Packages of milanesa and trozos of US origin were about twice as likely to be observed in Mexico City as all other locations combined ($P<0.01$). In contrast, few unidentifiable retail cuts and chuleta were found in Mexico City with 85 % and 77 % lower risks of occurrence, respectively, than in the other cities combined ($P<0.01$). Retail cuts found in Mexico City were also 75 % less likely to include bones than in all other locations ($P<0.05$). The differences in retail cut sales are particularly marked between Mexico City and Monterrey. The occurrence of milanesa in retail display was nine times more likely in Mexico City than in Monterrey, and trozos three times more likely, whereas the unknown cuts and chuleta were about 90 % less likely to be found in Mexico City than in Monterrey. Chuleta, which may contain bone, were ten times more likely to be found in Monterrey than in Mexico City and are sourced from the loin, explaining at least in part, the seven times greater chance of occurrence of loin as a primal source in Monterrey than in Mexico City. Similarly, the prevalence of milanesa and trozos in Mexico City is in accordance with the 64 % greater chance of leg as a primal source than in all other locations combined ($P<0.01$). A marbling score of 2 was almost twice as likely in Mexico City as in the other cities combined and 2.6 times as likely as in Monterrey. Differences in marbling scores with city do not appear to reflect differences in the primal/sub-primal cuts from which the retail cuts are derived. Generally, leg muscles have a higher intramuscular fat content than loin muscles and so it might be expected that the greater chance of loin in Monterrey than in Mexico City might equate to a lower marbling score. However, not only was the likelihood of a marbling score of 1 greater in Monterrey than in Mexico City, the marbling scores of 3 and 4 were also more likely in Monterrey. It must not be forgotten that the risk ratio is a relative measure and so while the likelihood of occurrence of marbling scores significantly differs with city, the absolute differences are relatively small with three quarters of the retail cuts having marbling scores of 1 and 2.

Retail cuts in stores targeting clientele with a high economic status were six times more likely to be derived from the loin than cuts targeting clientele with medium socio-economic status. It is not surprising therefore that chuleta was four times more likely in the sales for the higher than medium socio-economic status target. And noting that the majority of stores targeting the higher socio-economic group were in Monterrey, León

and Guadalajara, these findings are in agreement with the lower likelihood of loin-derived cuts in Mexico City than in the other cities combined or than in Monterrey alone.

Five supermarket chains accounted for 75 % of the retail cuts and significant differences were observed between chain A and chains B, C, D and E combined. Chain A was more than twice as likely to merchandise pork products from unknown sources and 1.79 times more likely to merchandise cuts from the loin ($P < 0.01$). Accordingly, chains B, C, D and E combined were 50 % more likely to merchandise cuts from the leg ($P < 0.05$). Chain A was the only retailer of the four that was located in Monterrey which was the most prevalent market for cuts from the loin.

4. Discussion

A significant proportion of the US retail cuts surveyed were ‘unidentifiable’ as a result of wholesale cuts losing identifiable visual characteristics (shape, bone and connective tissue references) after size reduction and preparation for retail display. Otherwise, pork retail cuts derived from the leg predominated in the Mexican retail display cases, particularly the boneless cuts of milanesa and trozos, illustrating a means for the merchandising of affordable and convenient retail cuts from relatively inexpensive leg muscles. These findings parallel those of a survey of US beef in Mexican stores where a predominance of boneless, thinner and smaller portions of retail beef cuts, such as the milanesa, fajita (15 mm strips of beef) and sabana (4 mm slices of beef) styles, were observed, all derived from the relatively inexpensive rounds and chucks (Huerta-Leidenz et al., 2014). While these smaller retail cutting styles require extensive size reduction, slicing and trimming and are therefore labor intensive, these practices are coupled with relatively low labor costs of retailing meat (Anderson et al., 2002; Durand, 2005). Furthermore, inexpensive labor in the Mexican retail market makes these cutting styles a sustainable practice.

In stark contrast to the predominance of the leg-derived cuts in the Mexican marketplace, the most popular pork retail cuts in the US are reported in the National Meat Case Studies to be those derived from the more expensive loin, including chops, roast, ribs, tenderloin and steak and the least popular, diced pork (Sealed Air Corporation, National Cattlemen’s Beef Association and National Pork Board, 2004, 2010). The variety of

271 retail cuts derived from the leg, and the low prevalence of those from the loin illustrate the demand of the
272 Mexican pork market for less expensive, lean, wholesale cuts to complement domestic pork sales. This
273 predominance of inexpensive pork cuts might suggest that price is the main driving factor for Mexican pork
274 demand. However, in a survey of consumer preferences for pork, Ngapo, Martin and Dransfield (2007) found
275 that of five possible responses with multiple choices permitted, 92 % of the Mexican consumers chose taste as the
276 reason for liking pork with only 1-4 % of consumers responding availability, nutritional quality, versatility or
277 price. A majority of the consumers in this study (82 %) also reported that pork was not expensive suggesting that
278 price is not a determining factor in the decision-making process, but rather that the consumer focuses on other
279 attributes.

280 While the most prevalent identifiable retail cuts were milanesa and trozos in all five cities and therefore
281 the most common known primal source from which the retail cuts were derived was the leg, in Monterrey loin-
282 derived cuts were equally as prevalent. Almost half of the targeted clientele in Monterrey was reported to be of
283 high socio-economic status, and therefore the greater proportion of loin derived cuts might suggest an effect of
284 price on the retail cuts for sale. Indeed, Sagarnaga-Villegas, Salas and Ochoa (1998) showed that the demand
285 structure for different fresh pork products varies with the social stratum. Families in Mexico with higher income
286 showed preference for leg, chop, loin and ribs, while middle-class consumers spent more on finely chopped pork
287 retail cuts (pulp, piece and ground pork) and pork variety meats. And making parallels to the beef industry,
288 Henneberry and Mutondo (2007) reported a growing preference for high cost, marbled beef and US-styles of
289 middle cuts, such as rib-eye, among more affluent Mexican consumers and Clark (2006) observed that
290 preferences of Mexican consumers in an improving economy shift towards higher quality beef. However, in the
291 current study 57 % of the targeted clientele in the supermarkets in León was also of high socio-economic status
292 and there were no loin-derived cuts surveyed in this city suggesting that the differences may be an effect of
293 geographical location. No reports of the effects of geographical location on Mexican consumer preferences for
294 pork cuts were found, but findings in the study of Ngapo et al. (2007b) suggest that while differences in retail cut
295 preferences between US and Mexican consumers may reflect differences in disposable income, these may equally
296 be attributable to geographical and cultural differences. When US consumers were questioned about cooking

297 habits and multiple responses were possible, 64 % stated that their main methods for cooking pork were grilling
298 (including barbeque), 29 % stated roasting and another 29 %, frying. In contrast, 64 % of Mexican consumers
299 claimed boiling/stewing and 64 % claimed frying as the most popular methods for cooking pork (Ngapo, Martin
300 & Dransfield, 2007b). And in a report on beef production in Mexico, it was reported that the close proximity of
301 Monterrey to the United States has resulted in substantial merging of Mexican meat preferences with U.S.
302 production styles (Peel, Mathews & Johnson, 2011). In the present study, Monterrey was the only city surveyed
303 in the North of Mexico and differences in retail cut preferences may therefore reflect geographic and cultural
304 influences on purchasing habits and local preferences. Regional effects on pork purchasing preferences have been
305 reported among cities in the same country (Ngapo, Martin, & Dransfield, 2004; Cho *et al.*, 2007). Noting the
306 differences in the proportions of the cuts on display in the cities surveyed, it appears that retailers may be aware of
307 local preferences and catering to these differences.

308 It would also appear, however, that there may be potential for improvement in meeting consumer
309 preferences. In a consumer preference study using pork chops, 62 % of Mexican consumers demonstrated a
310 preference for low levels of external fat cover (equivalent to 2 mm thickness) compared to 8 % of consumers who
311 preferred a fattier option (6-8 mm); the other 31 % did not use this characteristic in their choice of pork (Ngapo *et*
312 *al.*, 2007a). The average values of external fat thicknesses observed in the current study suggest that retailers are
313 meeting the preferences of the majority of consumers by trimming the subcutaneous fat to less than 3.2 mm, and
314 most often completely. However, 4 of the 26 chuleta (chop) packages had 6.2 mm of external fat cover and 16
315 had 3.2 mm fat cover. Furthermore, the low levels of apparent external fat in cuts like trozos and milanesa are
316 perhaps as much a result of the actual cut than the trimming. For example, when compared to a steak sliced from
317 one muscle, diced pork is often taken across muscles with many of the cubes having no external fat cover thereby
318 reducing the apparent external fat cover, but having a potentially higher amount of apparent seam fat which is a
319 more difficult and time consuming fat to remove. Indeed, 44 of the 101 packages with seam fat thicknesses of 3.2
320 mm were trozos, compared to only 5 of the 26 chops.

321 In contrast to the strong preference for lean fat cover, in the study by Ngapo *et al* (2007a), Mexican
322 consumers had no preference for marbling (1.5 % or absent). Verbeke *et al.* (2005) observed that Belgian

323 consumers faced difficulties when evaluating marbling in pork with marbling either not perceived, or when
324 perceived, preferences were ambiguous. These authors concluded that consumers were not aware of benefits in
325 terms of eating quality associated with marbling. Low levels of marbling, which is the visible intramuscular fat
326 (IMF) and removal of subcutaneous fat are not likely conducive to a good eating experience. Indeed, it is well
327 recognized that the pork industry is faced with the dilemma of producing meat with sufficient IMF content to
328 satisfy the eating experience of the consumer, but at the same time producing a minimal amount of visible fat in
329 order to alleviate the health concern of the same consumer (Fortin et al., 2005). In a review of factors affecting
330 the eating quality of pork, Ngapo and Gariépy (2008) illustrated that there is much discrepancy in the findings of
331 the impact of intramuscular fat on the eating quality of pork. A positive effect of IMF level on the sensory
332 attributes of pork was reported in twelve studies, while eight studies showed no influence and another three
333 showed negative effects. Among these studies, some report a minimum intramuscular fat content to achieve a
334 satisfactory eating experience, including the US National Pork Board (NPB) who set the industry target for IMF
335 at between 2 and 4 %; the minimum level reflecting the minimum eating satisfaction requirements, but at the
336 maximum level, health concerns associated with excessive fat (Meisinger, 2002). Noting that the NPB marbling
337 scores give approximate percentages of IMF, the average marbling scores for almost all cuts fall within this US
338 industry target, with the overall marbling score being 2.26 ± 1.02 and 77 % of cuts having a marbling score of 2-
339 4. However, 18 % of the cuts had a marbling score of 1 (practically devoid) and 56 % of 2 (trace), the lower end
340 of the marbling target. This is somewhat surprising when noting that leg muscles generally have higher
341 intramuscular fat content than the loin muscles (Kim et al., 2008).

342 Reports on the influence of the presence of bone and level of external fat cover on eating quality are more
343 difficult to find, but one study does show that consumers found pork loin chops from fat carcasses (15.5–16.6 mm
344 mean fat thickness measurements over longissimus dorsi at the last rib) more juicy and tender than those from
345 lean carcasses (8.4 to 8.8 mm; Kempster, Dilworth, Evans, & Fisher, 1986). In contrast, a taste panel found that
346 broiled loin chops with a fat cover of 6 mm were chewier than chops with no fat cover and that consumers
347 preferred trim loin roasts to those with 6 mm fat cover (Siemens, et al., 1990). These workers also found that the

presence of the bone did not influence the degree of liking of the pork roasts. In the current study, the presence of the bone was largely a function of the retail cuts being sold; with the chuleta being the only source of bone-in retail cuts.

5. Conclusions

More than two thirds of the total US pork on sale were cuts of milanesa (thin slices of pork, breaded or non-breaded) and trozos (diced pork) with both cuts being derived primarily from the leg. A majority of the cuts on sale (71 %) had no subcutaneous fat and another 23 % were trimmed to 3.2 mm. Furthermore, seam fat thickness was 3.2 mm or less in 99 % of the pork cuts surveyed. Pork of US origin appears to be merchandised predominantly as lean, low value cuts presented in small portions. This overview of the retailing of US pork imports in Mexico highlights differences in distribution and fat measures with supermarket chain, geographical location and socio-economic status indicating the potential for a targeted marketing approach in Mexico.

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Table 1. Commercial names (alternate name), U.S. equivalent name and NAMP codes for wholesale pork cuts in Mexico City.

Primal cut ^a		Subprimal cut ^a		NAMP
Mexico	USA	Mexico	USA	Code ^b
Paleta (espaldilla), cabeza de lomo de paleta, con hueso	Shoulder, Boston butt, bone-in			406
		Cabeza de lomo, recortada de grasa, sin hueso de paleta, deshuesada	Shoulder butt, cellar trimmed, boneless	407
		Barriga (tocino fresco)	Belly	408
		Costillar	Spareribs	416
Paleta (espaldilla), picnic (brazuelo)	Shoulder, picnic			405
		Maciza “cojin”, deshuesada	Cushion, boneless	405B
		Chamorros	Shoulder hocks	417
Pierna (jamon fresco), chomorro corto	Leg (fresh ham), short shank			401A
		Chomorro trasero	Hind shank	401D
		Contracara (pulpa blanca)	Outside	402D
		Pulpa negra	Inside	402F
		Punta de sirloin (pulpa bola)	Tip	402H
Lomo (chuleta natural/entrecot)	Loin, bone-in			410
		Extremo del aguayón, con hueso	Sirloin end, bone-in	410A
		Extremo del costillar, con hueso	Rib end, bone-in	410B
		Ojo de lomo (caña de lomo)	Loin eye	413C
		Filete	Tenderloin	415

^aCommercial names according to USDA (2015)

^bNAMP (2011)

26 **Table 2.** Cutting styles of retail pork cuts surveyed in Mexico City, U.S. equivalent or translation and description of the retail cutting style.

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Mexican retail cutting style	U.S. Translation ¹	NAMP code ²	Description
Milanesa	Thin slice, breaded or unbreaded		Thinly sliced (approx. 4 mm) steak for breading, maximal surface area of 12 cm x 20 cm
Trozos	Diced pork		Cubes (approx. 5 cm ³)
Trozos para brochetas	Diced pork for kabobs	435B	Cubes (from 2.54 cm ³ to 3.8 cm ³)
Trozos grandes	Big chunks		Pieces (approx. 5 cm long)
Cortadillo	Coarse chopped pork	1495	Ground (19 mm) or diced equivalent
Pieza	Piece		Irregular shaped piece, minimal thickness of 5.0 cm
Chuletas	Chop	1410, 1411, 1412, 1413	Loin chop, maximal thickness of 20 mm

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29 ¹Commercial names according to USDA (2015)

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31 ²NAMP (2011)

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Table 3. Frequency distribution of packages of US pork retail cuts, corresponding primal/sub-primal source and presence of bone, and means of marbling score, and external and seam fat thicknesses of US pork in grocery stores in Mexico.

Retail cut and primal/ sub-primal source	NAMP ¹ code	Packages (n)	Packages (%) ^{2,3}	External fat (mean ± SD, mm)	Seam fat (mean ± SD, mm)	Marbling score (mean ± SD)	Packages with bone present (n)	Packages with bone present (%) ²
Milanesa		121	35	0.34 ± 1.07	0.66 ± 1.42	2.08 ± 0.88	1	<1
Leg	401	75	62	0.30 ± 1.07	0.68 ± 1.31	2.04 ± 0.78	1	100
Outside	402D	1	1	0.00	0.00	2.00	-	-
Unknown		45	37	0.42 ± 1.09	0.64 ± 1.6	2.16 ± 1.04	-	-
Trozos		113	33	0.73 ± 1.47	1.24 ± 1.56	2.10 ± 0.84	1	<1
Leg	401	80	71	0.75 ± 1.54	1.35 ± 1.58	2.04 ± 0.77	1	100
Shoulder, picnic	405	3	3	2.12 ± 1.83	1.06 ± 1.83	3.67 ± 0.58	-	-
Outside	402D	2	2	1.59	0.00	2.00	-	-
Unknown		28	25	0.45 ± 1.13	1.02 ± 1.51	2.11 ± 0.96	-	-
Chuleta	1410, 1411, 1412, 1413	26	8	2.93 ± 1.91	0.61 ± 1.28	2.23 ± 1.11	26	8
Loin	410	26	100	2.93 ± 1.91	0.61 ± 1.28	2.23 ± 1.11	26	100
Brocheta		3	<1	2.12 ± 1.83	1.06 ± 1.83	5.00 ± 1.00	0	0
Leg	401	1	33	3.18	3.18	6.00	-	-
Loin	410	1	33	0.00	3.18	4.00	-	-
Unknown		1	33	3.18	3.18	5.00	-	-
Cortadillo	1495	3	<1	1.06 ± 1.83	1.06 ± 1.83	3.00 ± 1.00	0	0
Leg	401	1	33	0.00	0.00	4.00	-	-
Loin	410	1	33	0.00	3.18	2.00	-	-
Unknown		1	33	3.18	0.00	3.00	-	-
Trozo grande		2	<1	1.59	3.18	4.00	1	<1
Leg	401	1	50	3.18	3.18	6.00	-	-
Shoulder, picnic	405	1	50	0.00	3.18	2.00	1	100
Unidentifiable		74	21	1.42 ± 1.91	1.50 ± 1.91	2.62 ± 1.14	37	11
Leg	401	43	58	1.44 ± 1.87	1.55 ± 2.00	2.51 ± 1.10	23	62
Spare ribs	416	12	16	1.85 ± 2.12	1.85 ± 1.63	3.00 ± 1.48	12	32
Loin	410	10	14	0.87 ± 1.53	0.58 ± 1.00	2.20 ± 0.92	-	-
Shoulder, picnic	405	4	5	0.00 ± 0.00	3.97 ± 1.59	3.50 ± 0.58	-	-
Belly	408	2	3	3.18	0.00	2.00	-	-
Shoulder hocks	417	2	3	1.59	0.00	3.50 ± 0.71	2	5
Shoulder	403	1	1	3.18	3.18	3.00	-	-
Total retail cuts		342	100	0.93 ± 1.66	1.05 ± 1.91	2.26 ± 1.02	66	19
Leg	401	201	59	0.74 ± 1.52	1.15 ± 1.63	2.19 ± 0.96	25	38
Loin	410	38	11	2.26 ± 2.08	0.58 ± 1.25	2.26 ± 1.06	26	39
Spare ribs	416	12	4	1.85 ± 2.12	1.85 ± 1.63	3.00 ± 1.48	12	18

Shoulder, picnic	405	8	2	0.79 ± 1.47	2.78 ± 2.03	3.38 ± 0.74	1	2
Outside	402D	3	1	1.06 ± 1.83	0.00 ± 0.00	2.00 ± 0.00	-	-
Belly	408	2	1	3.18	0.00	2.00	-	-
Shoulder hocks	417	2	1	1.59	0.00	3.50	2	3
Shoulder	403	1	<1	3.18	3.18	3.00	-	-
Unknown		75	22	0.51 ± 1.17	0.76 ± 1.55	2.19 ± 1.05	-	-

¹ NAMP (2011)

²Frequency (%) when referring to the retail cut is expressed as a percentage of all retail cuts (n=342) whereas when referring to the retails cut by primal/sub-primal source is expressed as a percentage of the given retail cut.

Table 4. Frequency distribution of external and seam fat thicknesses and marbling scores of US pork in grocery stores in Mexico.

Characteristic	Packages of retail cuts (n)	US pork on sale (%)
External fat thickness (mm)		
0.0	243	71
3.2	78	23
6.4	11	3
Seam fat thickness (mm)		
0.0	235	69
3.2	101	30
6.4	6	2
Marbling score		
1 (Practically devoid)	63	18
2 (Trace)	190	56
3 (Slight)	42	12
4 (Small)	32	9
5 (Modest)	11	3
6 (Moderate)	3	1

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Table 5. Frequency distribution of packages of retail cuts, and retail cuts by primal/sub-primal source, presence of bone and targeted clientele, mean external fat, seam fat and marbling scores, and numbers of stores and supermarket chains surveyed across the five Mexican cities

	Mexico City		Monterrey		Guadalajara		Queretaro		León		Total	
Retail cut (packages; n, %) ¹	177	52	82	24	49	14	20	6	14	4	342	100
Milanesa	81	46	4	5	19	39	10	50	7	50	121	35
Trozos	77	44	12	15	7	14	10	50	7	50	113	33
Unidentifiable	10	6	43	52	21	43	-	-	-	-	74	22
Chuleta	5	3	20	24	1	2	-	-	-	-	26	8
Brocheta	3	2	-	-	-	-	-	-	-	-	3	1
Cortadillo	-	-	2	2	1	2	-	-	-	-	3	1
Trozos grandes	1	1	1	1	-	-	-	-	-	-	2	1
Retail cut per primal/sub-primal source (packages; n, %) ¹												
Leg	131	74	27	33	18	37	11	55	14	100	201	59
Unknown	31	18	12	15	26	53	6	30	-	-	75	22
Loin	8	5	27	33	3	6	-	-	-	-	38	11
Spare ribs	5	3	5	6	2	4	-	-	-	-	12	4
Shoulder, picnic	1	1	7	9	-	-	-	-	-	-	8	2
Outside	-	-	-	-	-	-	3	15	-	-	3	1
Belly	-	-	2	2	-	-	-	-	-	-	2	1
Shoulder hocks	-	-	2	2	-	-	-	-	-	-	2	1
Shoulder	1	1	-	-	-	-	-	-	-	-	1	<1
Presence of bone in retail cut (packages; n, %) ^{1,2}												
Boneless	167	94	35	43	39	80	20	100	14	100	275	81
Bone-in	10	6	46	56	10	20	-	-	-	-	66	19
Targeted clientele (packages; n, %) ¹												
High socio-economic status	30	17	36	44	19	39	4	20	8	57	97	28
Medium socio-economic status	124	70	31	38	25	51	16	80	6	43	202	59
Low socioeconomic status	23	13	15	18	5	10	-	-	-	-	43	13
Stores surveyed (n, %) ³	82	57	26	18	20	14	10	7	7	5	145	100
High socio-economic status	14	16	12	46	7	35	2	20	4	57	39	27
Medium socio-economic status	59	68	9	35	11	55	8	80	3	43	90	62
Low socioeconomic status	9	10	5	20	2	10	-	-	-	-	16	11
Supermarket chains surveyed (n)	6		6		6		3		4		10	
High socio-economic status	6		6		5		2		4		18	
Medium socio-economic status	5		3		2		5		3		7	
Low socioeconomic status	4		2		1		-		-		5	
External fat (mean ± SD, mm)	0.75 ± 1.51		1.82 ± 2.00		0.52 ± 1.35		0.48 ± 1.16		0.00 ± 0.00		0.93 ± 1.66	
Seam fat (mean ± SD, mm)	1.22 ± 1.62		1.12 ± 1.82		0.84 ± 1.42		1.30 ± 1.16		0.00 ± 0.00		1.05 ± 1.91	
Marbling score (mean ± s.d.)	2.25 ± 0.94		2.52 ± 1.08		1.82 ± 0.88		2.15 ± 0.93		2.57 ± 1.65		2.26 ± 1.02	

¹The frequency (%) of the total packages of retail cuts for a given city is expressed as a percentage of all retail cuts (n=342); the frequency (%) of the individual retail cuts, primal/sub-primal sources, presence of bone or targeted clientele, is expressed as a percentage of the total packages for the given city.

²One observation from Monterrey did not have data for presence or absence of bone.

³The frequency (%) of the total stores surveyed is expressed as a percentage of all stores (n=145); the frequency of the stores surveyed for a given socio-economic status is expressed as a percentage of the stores surveyed in a given city.

Table 6. Frequency distribution of most common retail cuts and primal/sub-primal sources, and presence of bone, and averages of external fat, seam fat and marbling score by socio-economic status of targeted clientele as reported by the store managers.

	Socio-economic status of targeted clientele					
	High		Medium		Low	
Retail cut (packages; n, %) ^{1,2}	97	28	202	59	43	13
Milanesa	28	29	83	41	10	23
Trozos	26	27	75	37	14	33
Unidentifiable	28	29	36	18	11	26
Chuleta	12	12	7	4	7	16
Retail cuts per primal/sub-primal source (packages; n, %) ^{1,2}						
Leg	41	42	147	73	13	30
Loin	22	23	8	4	8	19
Unknown	23	24	35	17	17	40
Presence of bone in retail cut (packages; n, %) ^{2,3}						
Boneless	25	26	27	13	14	33
Bone-in	72	74	174	86	28	65
External fat (mean ± SD, mm)	1.18 ± 1.73		0.75 ± 1.56		1.23 ± 1.84	
Seam fat (mean ± SD, mm)	0.69 ± 1.31		1.16 ± 0.69		1.30 ± 1.72	
Marbling score (mean ± SD)	2.21 ± 1.19		2.23 ± 0.94		2.51 ± 0.98	

¹Only the retail cuts and primal/sub-primal sources with more than 25 meat trays on sale are reported

²Frequency (%) of packages of total retail cuts for a given socio-economic status is expressed as a percentage of all retail cuts (n=342); the frequency (%) of individual retail cuts, primal/sub-primal sources or presence of bone is expressed as a percentage of the total retail cuts for the given socio-economic status .

³One observation in the medium socio-economic status did not have data for presence or absence of bone.

Table 7. Distribution of the most common retail cuts and primal/sub-primal source, and the average marbling score and reported socio-economic level by supermarket chain¹.

	Supermarket chain A		Supermarket chain B		Supermarket chain C		Supermarket chain D		Supermarket chain E	
Retail cut (packages; n, %) ^{2,3}	146	43	29	8	46	13	36	11	41	12
Milanesa	45	31	14	48	23	50	16	44	20	49
Trozos	41	28	13	45	23	50	14	39	19	46
Unidentifiable	41	29	1	3	-	-	6	17	1	2
Chuleta	16	11	-	-	-	-	-	-	1	2
Retail cuts per primal/sub-primal source (packages; n, %) ^{2,3}										
Leg	69	47	24	83	34	74	29	81	33	81
Loin	17	12	2	7	-	-	-	-	2	5
Unknown	48	33	3	10	11	24	2	6	6	15
Retail cuts per socio-economic status (packages; n, %) ³										
High	38	26	7	24	10	22	9	25	8	20
Medium	79	54	18	62	32	70	27	75	29	78
Low	29	20	4	14	4	9	-	-	4	10
Presence of bone in retail cut (packages; n, %) ^{2,3}										
Boneless	107	73	29	100	46	100	35	97	36	88
Bone-in	38	26	0	-	0	-	1	3	5	12
External fat (mean ± SD, mm)	0.87 ± 1.52		0.22 ± 0.82		0.76 ± 1.66		0.70 ± 1.33		0.53 ± 1.20	
Seam fat (mean ± SD, mm)	1.13 ± 1.57		0.77 ± 1.38		1.10 ± 1.67		0.77 ± 1.38		0.88 ± 1.44	
Marbling score (mean ± SD)	2.12 ± 0.97		2.24 ± 1.15		2.09 ± 0.76		2.21 ± 1.19		2.17 ± 1.16	
Stores surveyed (n, %)	57	39	14	10	23	16	15	10	19	13

¹Only the supermarket chains with more than 25 US retail cuts on sale are reported

²Only the retail cuts and primal/sub-primal sources with more than 25 meat trays on sale are reported

³The frequency (%) of packages of total retail cuts for a given city is expressed as a percentage of all retail cuts (n=342); the frequency (%) of the individual retail cuts, primal/sub-primal sources or presence of bone is expressed as a percentage of the total retail cut for a given city.

Table 8. Selected risk ratios (RR) and confidence intervals (CI) for the presence of retail cuts, primal/sub-primal source and marbling scores based on geographic location, socio-economic status or supermarket chain.

	Mexico City vs. all other locations			Mexico City vs. Monterrey			High vs. medium socio-economic status			Chain A vs. chains B, C and D		
	RR	CI ²	<i>P-value</i>	RR	CI	<i>P-value</i>	RR	CI	<i>P-value</i>	RR	CI	<i>P-value</i>
Retail cut ¹												
Milanesa	1.92	1.40-2.63	< 0.01	9.21	3.49-24.3	< 0.01	0.68	0.47-0.97	0.03	0.65	0.45-0.89	0.01
Trozos	2.05	1.47-2.87	< 0.01	2.95	1.71-5.11	< 0.01	0.67	0.45-0.98	0.04	0.61	0.44-0.85	0.01
Unidentifiable	0.15	0.08-0.28	< 0.01	0.10	0.06-0.20	< 0.01	1.65	1.06-2.58	0.04	4.49	2.10-9.61	< 0.01
Chuleta	0.23	0.09-0.59	< 0.01	0.12	0.04-0.30	< 0.01	3.57	1.45-8.78	0.01	-	-	-
Retail cuts per primal/sub-primal source												
Leg	1.64	1.35-1.98	< 0.01	2.14	1.56-2.92	< 0.01	0.62	0.49-0.79	< 0.01	0.60	0.50-0.73	< 0.01
Loin	0.26	0.12-0.54	< 0.01	0.14	0.06-0.29	< 0.01	5.73	2.65-12.4	< 0.01	7.11	1.69-29.9	< 0.01
Unknown	0.68	0.45-1.02	0.06	1.19	0.64-2.19	0.60	1.37	0.86-2.18	0.20	2.25	1.35-3.74	< 0.01
Presence of bone												
Bone-in	0.25	0.14-0.45	< 0.01	0.22	0.12-0.38	< 0.01	1.64	1.17-2.31	< 0.01	2.04	1.70-2.46	< 0.01
Marbling score												
1	0.42	0.26-0.70	< 0.01	0.49	0.27-0.88	0.02	1.58	1.00-2.50	0.08	1.09	0.67-1.77	0.85
2	1.76	1.43-2.17	< 0.01	2.57	1.78-3.72	< 0.01	0.85	0.67-1.07	0.18	0.91	0.74-1.12	0.46
3	0.34	0.18-0.66	< 0.01	0.20	0.11-0.39	< 0.01	0.95	0.49-1.87	0.91	1.50	0.66-3.37	0.44
4	0.90	0.46-1.76	0.76	0.46	0.24-0.90	0.04	0.58	0.22-1.51	0.37	1.80	0.65-4.95	0.37

¹Only the retail cuts and primal/sub-primal sources with more than 25 samples on sale are reported

²Confidence intervals that include 1.0 indicate prevalence of cut, source, presence of bone or marbling score was not different between variables