How thick do consumers' want their meat and how thick do they get it? The case of deep-fried breaded beef

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Article

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How thick do consumers' want their meat and how thick do they get it? The case of deep-fried breaded beef

Daniela C Ferraris[1], Luciano M Libertino[2], Graciela L Rodríguez[3] and Guillermo E Hough[3]

Abstract

The main objective was to estimate the optimum thickness of meat from a consumers' perspective. Breaded beef (known as "milanesa" in Spanish speaking countries and as "schnitzels" in Austria) is a food product prepared with a slice of meat that is dipped in beaten egg to then be covered in bread crumbs; thus prepared it is fried. This product was used as a case study. Breaded beef was evaluated in three different stages: raw slice of meat, appearance of meat after frying, and during mastication. Breaded beef prepared with meat of varying thicknesses were presented to consumers who evaluated if the thicknesses were too thin, ok or too thick. Survival analysis statistics were used to estimate the optimum thicknesses. Results for each stage were: raw slice of meat $= 6.7 \pm 0.2$ mm, appearance of the cut fried breaded beef $= 8.4 \pm 0.3$ mm and during mastication $= 7.6 \pm 0.3$ mm. The average thickness of the meat cut by butchers for breaded beef was 5.9 mm, not too far from the optimum. However, the average thickness of the meat in the breaded beef ready for frying sold by the same butchers 3.7 mm, clearly thinner than the optimum.

Keywords

Breaded beef, meat, optimum thickness, sensory analysis, survival analysis

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INTRODUCTION

There are few studies that have analyzed the influence of meat thickness on acceptability. Elsner et al. (1999) prepared chicken scalopini of different thicknesses (4, 8 and 12 mm) and different polyphosphate concentrations. Acceptability was influenced by the polyphosphate concentration but not by thickness. Leick et al. (2011) presented consumers with beef steaks of different thicknesses and they found that the thinner samples had higher acceptability.

Breaded beef is a food product prepared with a slice of meat of varied thickness that is dipped in beaten egg to then be covered in bread crumbs. Thus prepared it is fried, although it can also be cooked in the oven.

In Argentina, breaded beef ("milanesas") is very popular. A survey (La Nación Newspaper, January 1, 2006) on 3000 homes throughout the country showed that breaded beef and breaded chicken were consumed at least once a week in 74% of the homes. This means that for an overall population in Argentina of 41 million, there is a daily consumption of approximately 4 million units of breaded beef or breaded chicken. This product is also consumed widely in other countries such as Austria (called "schnitzels"), Mexico, Spain and Uruguay. Being such a popular and widely consumed product, it was considered adequate as a case study in determining optimum meat thickness from a consumer's perspective.

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Meat thickness used by different authors to prepare breaded beef has varied. Juárez et al. (2004, 2005) studied nutrient changes and oil deterioration during frying. In this last paper, they prepared breaded beef with meat cut to approximately 5 mm thickness, only stating that this is ''customary''. Clausen and Ovesen (2005) studied changes in fat content under different cooking conditions of schnitzels prepared with 0.5 cm, 1 cm and 2 cm thick meat; they did not consider which thickness would be preferred by consumers. Meinert et al. (2008) studied various animal effects on sensory properties of schnitzels. These were prepared with meat 15 mm thick; no reason was given for this choice.

In traditional Argentine cook books (De Pietranera, 1969; Petrona, 1992), breaded beef recipes call for ''beef fillets not too thin'' or ''beef steaks cut thin'', with no further precision on the beef thickness. An Internet search on schnitzel recipes[1] indicated thicknesses ranging from 1/8 in (0.32 cm) to 1/2 in (1.27 cm).

In an unpublished survey we conducted in August-September 2008 with 300 respondents distributed over 3 cities in Argentina, 64% answered that they consumed breaded beef more frequently than breaded chicken, 17% breaded chicken more frequently and 19% in equal proportion. Although breaded chicken is becoming more popular due the drop in chicken prices, beef is still the major choice.

Meat for breaded beef is usually bought in butcher shops or from butchers within a supermarket. Some consumers ask the butcher to cut the meat thin, medium or thick; or accept the butcher's standard cut. These consumers can judge the thickness of the raw meat when preparing the breaded beef, and also when cutting the breaded beef once fried or during mastication. A common modality is to buy breaded beef already prepared at the butcher shop, ready for frying. An unpublished survey performed at our Institute indicated that 40% of housewives bought breaded beef already prepared for frying. Breaded beef is also consumed in cafeterias and restaurants. In these last cases, the thickness is only judged when cutting or during mastication. Thus, in the consumption of breaded beef there are different stages where the thickness can be judged: raw from a cook's perspective, cooked where the evaluation can be visual and/or during mastication. It is of interest to know if the optimum thicknesses vary depending on evaluation stage, as this can have practical implications for butchers, retailers and restaurants. It should be noted that the thickness of beef in raw breaded beef is rarely evaluated; to do so would mean cutting the raw breaded beef to thus judge the beef thickness. This procedure is not followed, neither by cooks nor consumers. Thus, this evaluation stage of the beef thickness was not considered.

There are no published studies on measuring the optimum thickness of meat from a consumer's point of view. Survival analysis statistics have been used to estimate the optimum color of yogurt (Garitta et al., 2006), the optimum internal cooking temperature of beef (López Osornio et al., 2007) and the optimum salt concentration in bread (Sosa et al., 2008), among other applications. An important aspect of the methodology is that experimental sensory testing is relatively simple. For example, in determining the optimum color of yogurt (Garitta et al., 2006), 60 consumers each looked at 7 yogurt samples with different red color intensities, responding to whether they found the color too light, okay or too dark. This information was sufficient to determine an optimum color with an acceptable confidence interval. Another important aspect of this methodology is that it is the consumers themselves, with their particular characteristics (Barrios and Costell, 2004), that determine the optimum of the characteristic under study. Survival analysis would be a valid approach to estimate optimum meat thickness from a consumer's perspective. Apart from breaded beef, as researched in the present study, thickness can be important to consumers in other cuts and preparations such as steaks, slices of roasted meat and slices of preserved meats.

The main objective of the present work was to estimate the optimum thickness of meat used for breaded beef evaluated in three different stages: raw slice of meat, appearance of cut breaded beef after frying and during mastication. A second objective was to compare these optimums with current market thickness of meat cut by butchers for breaded meat preparation and of the meat thickness in breaded beef ready for frying.

MATERIALS AND METHODS

Sample preparation

Breaded beef was made from *M. semitendinosus* meat bought at a local butcher shop. This is one of the most popular cuts of meat used for breaded beef and was chosen due to its uniformity and because it is easy to slice at an even thickness. The meat was sliced with a meat cutting machine (Cibeles Model A-330, Rosario, Argentina) that can be regulated to different thicknesses with an adjustable knob. This knob indicates an approximate thickness, but the actual thickness was measured using a precision ruler. Raw beef is rather soft and difficult to gauge, thus a disk of beef approximately 7 cm in diameter was cut and sandwiched between two acrylic disks of similar diameter and 0.25 mm thick. The total width was measured and the acrylic disks thicknesses were subtracted. The measured beef thicknesses were 2.0, 5.3, 6.5, 8.5, 10.0 and 12.7 mm. These values are the average over 3 disks with 3 measurements on each, that is they are the average of 9 measurements.

Breaded beef was prepared by dipping the meat in reconstituted egg powder (Sindy Argentina, Lomas del Mirador, Argentina) and then covering with bread crumbs (Mamá Cocina, Molinos Cañuelas Inc., Cañuelas, Argentina). The units of breaded beef were deep-fried in sunflower oil at an initial temperature of 180 °C (Juárez et al., 2004; Mallikarjunan et al., 2010) for 3.5 min. The oil: breaded beef relationship was approximately 10:1 by weight. Once fried, the breaded beef were placed on paper to absorb excess oil. The breaded beef was evaluated by consumers within 5 min of having been prepared.

Consumers

Consumers were recruited from the town of Nueve de Julio, a city with 40,000 inhabitants located 250 km to the west of Buenos Aires. In Nueve de Julio, the ethnic origin (majority white Caucasian), the products in supermarkets and exposure to nationwide media is similar as to the rest of Argentina.

Hough et al. (2007), for a reasonable choice of statistical parameters, recommended 120 consumers for survival analysis estimations. For the present study, 105 consumers were recruited. These consumers were women who prepared and cooked breaded beef at least once a week. Their age was between 23 and 60 years.

Experimental procedure

Thickness evaluation was in three stages:

- Raw: a raw slice of meat was evaluated by observation and manipulation with a fork.
- Cut: fried breaded beef cut in half was presented; consumers evaluated the thickness of the meat by appearance under fluorescent day-light type illumination.
- Mastication: a 2 cm × 2 cm piece of fried breaded beef pierced with a toothpick was placed in a 125-ml styrofoam cup with a lid. Consumers took the piece of breaded beef with the toothpick and evaluated its thickness during mastication. To avoid visual cues, the sensory booths were illuminated with black light.

Order of evaluation stage was balanced, that is a third of consumers evaluated *raw-cut-mastication*, a third *cut-mastication-raw* and a third *mastication-raw-cut*. Within each evaluation stage, the six thicknesses were presented to consumers in a randomized order.

For each sample consumers had to tick one of the three possible answers:

- too thin
- ok, just about right
- too thick

Consumers received a gift of food products as recognition for their time and effort.

SURVIVAL ANALYSIS CONCEPTS

The model is basically the same as that developed by Garitta et al. (2006) for determining the optimum color of yogurt. In that research, the explanatory variable was the color of the yogurt expressed by the Hunter Lab a* parameter. In the present work, the explanatory variable was beef thickness.

When a consumer buys meat to prepare breaded beef, he/she can find the slice too thin, okay or too thick. Thus, there are two events of interest: the transition from too thin to okay and the transition from okay to too thick.

Let T_{thin} be the random variable representing the thickness at which a consumer rejects a sample because it is too thin and T_{thick} the thickness at which a consumer rejects a sample because it is too thick. Assume that T_{thin} and T_{thick} are absolutely continuous with distribution functions F_{thin} and F_{thick}, then for each value of thickness t, there will be two rejection functions:

$R_{\text{thin}}(t)$ = probability of a consumer (or proportion of consumers) rejecting beef with thickness = t because it is too thin, that is $R_{\text{thin}}(t) = P(T_{\text{thin}} > t) = 1 - F(t)$

$R_{\text{thick}}(t)$ = probability of a consumer (or proportion of consumers) rejecting beef with thickness = t because it is too thick, that is $R_{\text{thick}}(t) = P(T_{\text{thick}} < t) = F(t)$.

In seeking the optimum thickness, samples with different thickness are presented to consumers. For example, t values could be 2, 4, 6, 8, 10 and 12 mm. Considering these values, the acceptance/rejection patterns of consumers will be explained.

Rejection of the meat thickness because it is too thin. If a consumer rejects the sample with thickness = 2 because it is too thin and finds thickness = 4 okay, the exact thickness where the consumer passes from "rejection because it is too thin" to "okay" could be any value between 2 and 4. This is defined as interval censoring. Left censoring occurs if a consumer finds thickness = 2 okay, thus rejection thickness is ≤ 2. If the consumer rejects all thickness because they are too thin, acceptance would occur for a thickness > 12 and the data are right censored.

Rejection of the meat thickness because it is too thick. If a consumer finds thickness = 6 okay, and rejects thickness = 8 because it is too thick, the exact thickness where the consumer passes from "okay" to "rejecting it because it is too thick" could be any value between 6 and 8. In this case, we have interval-censored data. Right and left censoring can also occur for rejection of the meat thickness because it is too thick.

The likelihood function, which is used to estimate the failure function, is the joint probability of the given observations of the n consumers (Klein and

Moeschberger, 1997). In our study, there are two likelihood functions: L_{thin} (too-thin) and L_{thick} (too thick):

$$L_{thin} = \prod_{i\varepsilon R} R_{thin}(l_i) \prod_{i\varepsilon L}(1 - R_{thin}(l_i)) \prod \Pi_{i\varepsilon I}(R_{thin}(l_i) - R_{thin}(r_i)) \quad (1a)$$

$$L_{thick} = \prod \Pi_{i\varepsilon R}(1 - R_{thick}(r_i)) \prod_{i\varepsilon L} R_{thick}(l_i) \times \prod_{i\varepsilon I}(R_{thick}(r_i) - R_{thick}(l_i)) \quad (1b)$$

Both in Equation (1a) and (1b), R is the set of right-censored observations, L the set of left-censored observations and I is the set of interval-censored observations. Equation (1a) and (1b) show how each type of censoring contributes differently to the likelihood functions.

Usually, failure values are not normally distributed; instead their distribution is often right skewed. In this case, a log-linear model is chosen:

$$Y = \ln(T) = \mu + \sigma W$$

where W is the error term distribution. That is, instead of the optimum thickness, its logarithmic transformation is modeled. In Klein and Moeschberger (1997) or Meeker and Escobar (1998) different possible distributions for T are presented, for example the log-normal or the Weibull distribution. If the log-normal distribution were chosen, the rejection functions are

$$R_{thin}(t) = 1 - \Phi\left[\frac{\ln(t) - \mu_{thin}}{\sigma_{thin}}\right] \quad (2a)$$

$$R_{thick}(t) = \Phi\left[\frac{\ln(t) - \mu_{thick}}{\sigma_{thick}}\right] \quad (2b)$$

Both in Equation (2a) and Equation (2b), Φ is the normal cumulative distribution function and μ_{thin}, μ_{thick} and σ_{thin}, σ_{thick} are the model's parameters. The values of μ are parameters of equation (2a) and (2b); we do not consider that interpretation of each one of the values would be fully necessary.

The parameters of the log-linear model are obtained by maximizing the likelihood functions (equation (1a) and (1b)). The likelihood function is a mathematical expression that describes the joint probability of obtaining the data actually observed on the subjects in the study as a function of the unknown parameters of the model being considered. To estimate μ and σ for the log-normal distribution, the likelihood function is maximized by substituting R_{thin} (t) and R_{thick} (t) in equation (1a) and (1b) by the expressions given in equation (2a) and (2b), respectively.

In order to establish whether stage of evaluation (raw, cut or mastication; see above) and order of thickness evaluation influenced rejection thicknesses, the following log-linear regression model with inclusion of covariates was applied (Meeker and Escobar, 1998):

Too-thin rejection model

$$\ln(T_{thin}) = \mu_{thin} + \sigma_{thin} W = \beta_{0thin} + \beta_{1thin} Z_{CUT} + \beta_{2thin} Z_{MASTICATION} + \beta_{3thin} Z_{SECOND} + \beta_{4thin} Z_{THIRD} + [\text{two} - \text{way interaction}] + \sigma_{thin} W \quad (3)$$

where

- T_{thin} is the thickness at which a consumer rejects a sample because it is too thin,
- $\beta_{0\text{-}4thin}$ are the regression coefficients,
- Z_{CUT}: 1 if the evaluation stage is appearance after cutting, 0 if otherwise.
- $Z_{MASTICATION}$: 1 if the evaluation stage is appearance after cutting, 0 if otherwise.
- Z_{SECOND}: 1 if the evaluation was done in second place, 0 if otherwise.
- Z_{THIRD}: 1 if the evaluation was done in third place, 0 if otherwise.
- σ_{thin} is the shape parameter, which does not depend on the covariates,
- W is the error distribution.

The too-thick rejection model is analogous to equation (3), substituting the *thin* subtext for *thick*.

Once the likelihood is formed for a given model, specialized software can be used to estimate the parameters (β coefficients and σ) that maximize the likelihood function for the given experimental data. The CensorReg procedure from S+ (Tibco Software Inc., Palo Alto, California) was used to estimate the models' parameters, quantiles and corresponding standard deviations. In all, 5% or less was considered for significance. The "survreg" function from the freely distributed *R*-Statistical package (http://www.r-project.org/, accessed May 26 2009) can also be used for these calculations

When processing the data from the appearance of the cut breaded beef and the mastication of the bread beef, the thicknesses were those of the raw slice of meat used to prepare the breaded beef.

Thickness cut by butchers

In order to compare the optimum thickness estimated from consumer evaluations with the thickness of meat cut by butchers, authors of this article went to six butcher shops located in different areas of nine de Julio (the town where the consumers measured the optimum thicknesses). There are a total of 36 butcher shops in 9 de Julio, thus 6 could be considered representative. In the butcher shop they bought ¼ kg of *M. semitendinosus* beef asking the butcher to cut the meat for breaded beef, leaving the thickness up to the butcher's criterion. Of the six butchers, one used a meat-cutting machine and the rest used a knife. In the same butcher shops breaded beef ready for frying was also bought. The outer layer (egg mixed with bread-crumbs) of the breaded beef ready for frying was removed with a knife to thus measure the thickness of the meat with which they had been prepared. Thickness of the meat was measured as indicated above (Sample preparation). The data were averaged and compared with estimated optimums obtained from consumer evaluations.

RESULTS

As stated above, the probability of a consumer rejecting a certain thickness as too thick or too thin (equations (2a) and (2b)) can follow different distributions. S+ software offers the possibility of producing a graph that compares the fit of different distributions with the experimental data, and this criteria has been used in previous survival analysis applications to food quality (Garitta et al., 2006; Hough et al., 2003, 2004). Garitta et al. (2006) disregarded covariates in the choice of the most adequate distribution. An alternative is to choose the distribution that gives the lowest log-likelihood (Hough, 2010). The model with covariates (equation (3)) was tested for the Weibull, log-normal and normal distributions (Hough, 2010). For the three distributions, the log-likelihood tests showed that the only significant factor in the model was the stage of evaluation; order of evaluation and the stage X order interaction were not significant. Comparing the log-likelihoods of the Weibull, log-normal and normal distributions, each with stage of evaluation as covariate, showed that the log-normal distribution was the most adequate, both for too-thin and two-thick rejection models.

The β and σ values of equation (3) (and corresponding too-thick equation) with their 95% confidence intervals are in Table 1. With these parameters, the μ values of the log-normal distribution (Equations 2(a) and 2(b)) can be calculated. For the too-thin to ok event, the μ values corresponding to each one of the evaluation stages are

– Raw: $\mu_{\text{RAWthin}} = 1.659 + 0.300 \times 0 + 0.098 \times 0 = 1.659$
– Cut: $\mu_{\text{CUTthin}} = 1.659 + 0.300 \times 1 + 0.098 \times 0 = 1.959$
– Mastication: $\mu_{\text{MASTICATIONthin}} = 1.659 + 0.300 \times 0 + 0.098 \times 1 = 1.757$

Table 1. Log-normal parameters corresponding to the too-thin and too-thick rejection probabilities (equation (3)), with their 95% confidence intervals

	Rejection event	
Parameter	Too thin to ok	Ok to too thick
β_0	1.659 (0.050)	2.153 (0.042)
β_1	0.300 (0.070)	0.154 (0.060)
β_2	0.098 (0.070)	0.147 (0.060)
Σ	0.198 (0.022)	0.191 (0.018)

For the ok to too-thick event, the μ values corresponding to each one of the evaluation stages are:

– Raw: $\mu_{\text{RAWthick}} = 2.153 + 0.154 \times 0 + 0.147 \times 0 = 2.153$
– Cut: $\mu_{\text{CUTthick}} = 2.153 + 0.154 \times 1 + 0.147 \times 0 = 2.307$
– Mastication: $\mu_{\text{MASTICATIONthick}} = 2.153 + 0.154 \times 0 + 0.147 \times 1 = 2.300$

Figure 1 shows the too-thin and too-thick rejection curves for the raw slice of meat evaluation stage. The optimum thickness can be determined from the minimum of the sum of both these curves as illustrated in Figure 1 (Garitta et al., 2006). The confidence intervals of the optimum thickness for an α significance level can be calculated by the following equation (Garitta et al., 2006):

$$\text{optimum thickness} \pm Z_{1-\alpha/2} \times \frac{1}{2}\sqrt{\text{se}^2_{\text{thin}} + \text{se}^2_{\text{thick}}} \quad (4)$$

where $Z_{1-\alpha/2}$ is the $1-\alpha/2$ coordinate of the standard normal distribution and se_{thin} and se_{thick} are the standard errors of the optimum thickness calculated from the rejection due to too-thin and rejection due to too-thick curves, respectively. Estimated optimum thicknesses and their confidence intervals are in Table 2. As mentioned above, when processing the data from the appearance of the cut breaded beef and the mastication of the breaded beef, the thicknesses were those of the raw slice of meat used to prepare the breaded beef. Thus, the optimums in Table 2 are all expressed in terms of the thickness of the raw meat.

The average thickness of the beef cut by butchers for breaded beef was 5.9 mm with a range between 4.2 mm and 8.4 mm over the six butcher shops. The thickness of the meat in the breaded beef ready for frying sold by

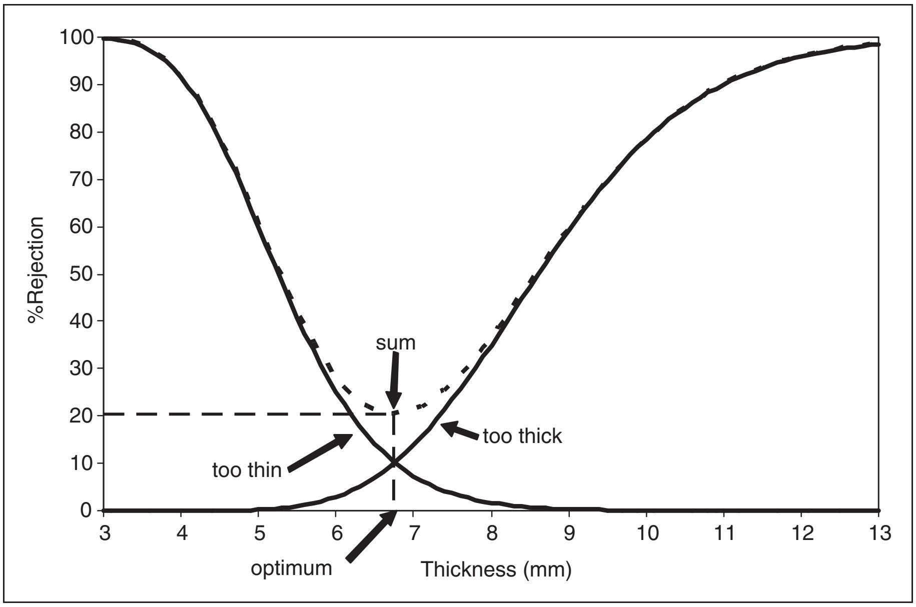

Figure 1. Percentage rejection versus thickness of beef used to prepare breaded beef evaluated on the raw slice of meat.

Table 2. Optimum thicknesses in mm (95% confidence interval in parenthesis) and percentage rejections at the optimum corresponding to different stages of evaluation

Evaluation stage	Optimum thickness	% Rejection due to too-thin	% Rejection due to too-thick
Raw slice	6.7 (0.2)	10	9
Appearance of the cut breaded beef	8.4 (0.3)	19	18
Mastication the breaded beef	7.6 (0.3)	8	7

the same butchers had an average of 3.7 mm with a range between 2.8 mm and 4.3 mm.

DISCUSSION

During the frying process, the meat thickness shrinks and this explains the difference in optimums between the raw slice (6.7 mm) and the appearance of the cut breaded beef (8.4 mm). This last value of 8.4 mm is actually the thickness of the meat used to prepare the breaded beef, not the actual thickness that is seen once the breaded beef has been cooked.

The thicknesses in Table 2 are "optimum" not "perfect". This means that not all subjects were satisfied with the optimum thicknesses and this is expressed in the last two columns of Table 2 which indicate how the consumer population was segmented. For example, if a subject is evaluating the thickness of a raw slice of meat for breaded beef and is presented with a slice 6.7 mm thick, there is an estimated 19% probability that he/she will reject the sample, either because he/she finds it too thin (10% probability) or too thick (9% probability). Another interpretation is that if 100 subjects are presented with a slice of raw meat for breaded beef 6.7 mm thick, it is probable that 19 of them will reject the sample, 10 because they find it too thin and 9 because they find it too thick. Previous studies using survival analysis in different systems have given varied percent rejections at the estimated optimums:

- Color in yogurt (Garitta et al., 2006): 26%–28%
- Internal beef cooking temperature (López Osornio et al., 2007): 17%–53%
- Ripening time of tomatoes (Garitta et al., 2008): 3%–5%
- Salt in bread (Sosa et al., 2008): 23%

The values obtained in the present study are within these ranges.

Butchers could well do with the information of the estimated optimum of 6.7 mm for the raw slice

(Table 2) to thus adjust the thickness with which they cut meat for breaded beef. To do this, they would have to use meat-cutting machines as adjusting a thickness by knife-cutting is not easy.

From values shown in Table 2, recommending an optimum thickness is not straightforward. If the raw slice optimum of 6.7 mm is adopted, the person who buys and prepares the breaded beef will be satisfied. However, if another person who did not participate in the preparation cuts the breaded beef and evaluates its thickness, the survival analysis model predicts a 61% rejection probability due to the person finding the breaded beef too thin. Alternatively, if the optimum of 8.4 mm is adopted, the person who receives the fried breaded beef and evaluates its thickness by appearance will be satisfied. However, there is a 45% probability that a person who prepares breaded beef from raw slices of meat cut this thickness will consider them too thick.

From the data collected at local butcher shops, on average the slice of meat sold to consumers for breaded beef preparation (5.9 mm average) is not as thick as the raw slice optimum (6.7 mm optimum). This 0.8 mm difference is probably not detected by consumers. What is definitely thinner is the meat included in the breaded beef ready for frying: 3.7 mm average. The choice of this thinner slice of beef by the butchers is clearly economical: beef is more costly than the covering of egg and bread crumbs; and the price they sell the raw beef is approximately equal to the price they sell the breaded beef ready for frying. Considering the optimum thickness of 6.7 mm: why do consumers tolerate these thin slices of meat in the breaded beef ready for frying? Clearly for the convenience of buying a ready-to-cook product.

From the above discussion, the recommendations for the optimum thicknesses of meat for breaded beef would be:

a. For consumers buying the raw meat slices to prepare breaded beef, the optimum of 6.7 mm would seem adequate. Their experience has shown them that their families or they themselves will find this thickness satisfactory. Very probably, the appearance of the cut breaded beef is rarely evaluated. The model predicts that at 6.7 mm thickness there is a 23% probability of the breaded beef being rejected during mastication due to being too thin, this probability is not high enough to justify thicker slices of raw beef. An additional argument to recommend the 6.7 mm thickness is that it is close to the average thickness of 5.9 mm that butchers use in commercial practice. Also, people who prepare breaded beef are aware of the fact that thicker raw slices lead to a reduced number of breaded beef per kg of beef and thus end up being less economical than thinner slices.
b. There would be a market for premium breaded beef served at restaurants made from meat approximately 8 mm thick. If consumers are made aware of the fact that they are receiving breaded beef made from ''extra thick'' slices of meat, they will pay attention to the appearance of the cut breaded beef and/or evaluate the thickness while mastication. Considering the optimums for these stages of evaluation (Table 2), there will be a high degree of satisfaction.

As discussed in the Introduction, there are few studies analyzing the influence of thickness on meat acceptability and there are no published studies on measuring the optimum thickness of meat from a consumer's point of view. The survival analysis methodology used in the present research can be a valuable tool to estimate optimum thicknesses for cuts of meat other than breaded beef, such as steaks, slices of roasted meat and slices of preserved meats. An interesting point to be pursued in further research is the influence of consumer demographics on optimum meat thickness. For example, as low-income consumers tend to consume breaded beef made with relatively thin meat to thus obtain higher yield, it could be hypothesized that their optimum thickness is lower than higher income consumers. Other demographic variables of interest would be age, gender and geographical location.

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REFERENCES

Barrios EX and Costell E. (2004). Review: use of methods of research into consumers opinions and attitudes in food research. *Food Science and Technology International* 10(6): 359–371.

Clausen I and Ovesen L. (2005). Changes in fat content of pork and beef after pan-frying under different conditions. *Journal of Food Composition and Analysis* 18(2–3): 201–211.

De Pietranera LP. (1969). *Recetario de Doña Lola*. Buenos Aires: Editorial y Librería Concourt, p. 407.

Elsner RJF, McWatters KH and Resurreccion AVA. (1999). Consumer preference optimization of scallopini made from boneless, skinless chicken thighs. *International Journal of Food Sciences and Nutrition* 50(6): 399–405.

Garitta L, Hough G and Hulshof E. (2008). Determining optimum ripening time of fruits by applying survival analysis statistics to consumer data. *Food Quality and Preference* 19(8): 747–752.

Garitta L, Serrat C, Hough G and Curia A. (2006). Determination of optimum concentrations of a food ingredient using survival analysis statistics. *Journal of Food Science* 71(7): 526–532.

Hough G. (2010). *Sensory Shelf Life Estimation of Food Products*. Boca Raton, FL: Taylor & Francis Group.

Hough G, Calle ML, Serrat C and Curia A. (2007). Number of consumers necessary for shelf life estimations based on survival analysis statistics. *Food Quality and Preference* 18(5): 771–775.

Hough G, Garitta L and Sánchez A. (2004). Determination of consumer acceptance limits to sensory defects using survival analysis. *Food Quality and Preference* 15(7–8): 729–734.

Hough G, Langohr K, Gómez G and Curia A. (2003). Survival analysis applied to sensory shelf-life of foods. *Journal of Food Science* 68(1): 359–362.

Juárez MD, Alfaro ME and Sammán N. (2004). Nutrient retention factors of deep-fried milanesas. *Journal Food Composition and Analysis* 17(1): 119–124.

Juárez MD, Masson L and Sammán N. (2005). Deterioration of partially hydrogenated soybean oil used in deep fat frying of a meat food. *Grasas y Aceites* 56(1): 53–58.

Klein JP and Moeschberger ML. (1997). *Survival Analysis, Techniques for Censored and Truncated Data*. New York, NY: Springer-Verlag.

Leick CM, Behrends JM, Schmidt TB and Schilling MW. (2011). Consumer selection of constant-weight ribeye, top loin, and sirloin steaks. *Meat Science* 87(1): 66–72.

López Osornio MM, Hough G, Salvador A, Chambers IE, Mcgraw S and Fiszman S. (2007). Beef's optimum internal cooking temperature as seen by consumers from different countries using survival analysis statistics. *Food Quality and Preference* 19(1): 12–20.

Mallikarjunan K, Ngadi M and Chinnan M. (2010). *Breaded Fried Foods*. Boca Raton, FL: CRC Press Taylor and Francis Group, p. 7.

Meeker WQ and Escobar LA. (1998). *Statistical Methods for Reliability Data*. New York, NY: John Wiley & Sons.

Meinert L, Tikk K, Tikk M, Brockhoff P, Bejerholm C and Aaslyng M. (2008). Flavour formation in pork semimembranosus: combination of pan-temperature and raw meat quality. *Meat Science* 80(2): 249–258.

Petrona C. (1992). *El libro de Doña Petrona*, 81° edicion. Buenos Aires: Sainte Claire Editora S.R.L., p. 420.

Sosa MP, Flores A, Hough G, Apro N, Ferreyra V and Orbea M. (2008). Optimum level of salt in French-type bread. Influence of income status, salt level in daily bread consumption, and test location. *Journal of Food Science* 73(8): S392–S397.