FOOD FOR COLLECTIVES
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Temperatures and cooking indexes of grilled meats on a *Parrilla* grill in a commercial restaurant

Temperaturas e índices de cocção de carnes grelhadas na parrilla de um restaurante comercial

Abstract

Objective: The purpose of this study was to evaluate the cooking indexes and surface temperatures of grilled meats on a commercial restaurant grill in Fortaleza. ***Methods*:** Characterized as descriptive-exploratory and quantitative research, the selected cuts (all beef) were Sirloin, Filet Mignon, and Top Sirloin Cap (*picanha*), grilled to the following cooking points: rare, medium, and well-done. During the months of September through November 2020, thirty-eight samples were collected. Net weight, cooked weight, cooking index (CI), and average temperatures were measured, in addition to average grill temperatures. Statistical analysis involved Shapiro-Wilk and ANOVA tests. ***Results:*** For Sirloin, the CIs ranged from 0.76 to 0.92; for Filet Mignon, from 0.69 to 0.92; and for Top Sirloin Cap, from 0.66 to 0.85. There was a reduction in Filet Mignon weight when cooking from rare to medium. The CI range (0.65 to 0.90) in the Ornelas study corroborated our findings. According to the WHO classifications, *Sirloin* (rare) would be classified as potentially safe. According to the Prill et al. Model, the Top Sirloin Cap classified as rare. The *Sirloin* followed a decreasing temperature trend, which was contrary to the anticipated standard. ***Conclusion:*** Appropriate temperature control is essential in obtaining ideal models, and this detailed investigation provides an important reference for the use of CIs.

Keywords: Collective Feeding. Food services. Temperature. Meat.

Resumo

***Objetivo*:** O propósito deste estudo foi avaliar os índices de cocção e as temperaturas da superfície de carnes grelhadas na *parrilla* de um restaurante comercial de Fortaleza. ***Métodos*:** Caracterizou-se como uma pesquisa descritivo-exploratória e quantitativa. Os cortes de carne bovina selecionados foram *chorizo* (contrafilé), lombo (filé mignon) e tira (picanha) nos seguintes pontos de cozimento: malpassado, ao ponto e bem-passado. Foram coletadas 38 amostras entre os meses de setembro e novembro de 2020. Aferiram-se os pesos líquidos, pesos dos alimentos cozidos, índices de cocção (IC) e temperaturas médias, além de avaliação da temperatura média da grelha da *parrilla*. A análise estatística foi constituída dos testes de Shapiro-Wilk e ANOVA. ***Resultados*:** Os ICs resultantes variaram de 0,76 a 0,92 para o chorizo, 0,69 a 0,92 para o lombo e 0,66 a 0,85 para a tira. Houve redução do peso do lombo malpassado para ao ponto. O intervalo de IC de 0,65 a 0,90 do estudo de Ornelas convergiu com o presente estudo. O *chorizo* malpassado se enquadrou como possivelmente seguro pela classificação da OMS e a tira, classificada como malpassada pelo modelo de Prill et al. O *chorizo* seguiu uma tendência decrescente de temperatura, contrariando o padrão prévio. ***Conclusão*:** É fundamental haver um controle de temperatura apropriado na busca por uma temperatura compatível às

exigências para se chegar a um modelo ideal. Além disso, a investigação detalhada tornou o estudo uma importante referência para a utilização dos ICs descritos.

Palavras-chave: Alimentação Coletiva. Serviços de alimentação. Temperatura. Carne.

INTRODUCTION

The *parrilla*, in its primary form is a slanted grill that comes from the Gauchos, who were nomadic natives of the Argentine and Uruguayan pampas region. In the mid-19th century, they explored the idea of making iron grills to avoid direct contact with fire during the preparation of beef.[1,2]

Currently, *parrilla* is a way of grilling meats, usually with selected cuts marinated to preserve tenderness, over a source of dry heat at high temperatures. Despite its traditionally being used with red meats and chicken, seafood and vegetable grilling also regularly occurs in restaurants concentrated in Uruguay, Brazil, and principally Argentina. [3]

As with other cooking techniques, temperature control is important, since the meat's organoleptic quality characteristics are greatly influenced by heat. When in an oven set at 288°C for 30 minutes, both odor and flavor in meats improve as internal temperature reaches 82°C. Further, as the meat reaches its internal cooking temperature, an outer layer is formed (especially at temperatures of around 70°C) that prevents liquid losses. Finally, for softness, from 57 to 60°C, is the ideal temperature range for softening connective tissue without compromising myofibrillar proteins, although the amount of collagen and the use of artificial softening products can also be also important.[4]

The Brazilian National Health Surveillance Agency - ANVISA (*Agência Nacional de Vigilância Sanitária*), Resolution nº 216/2004 standardizes food safety, and heat treatments applied to food, and delineates that cooked foods must at least 70°C in their geometric centers, and also contemplates the expected changes in both color and texture.[5] The World Health Organization (WHO) recommends the same temperature (70°C) as a safety parameter for food.[6] It is important to emphasize that foods of animal origin are often parasite reservoirs, and if cooking is improper it can cause considerable damage to the population through zoonoses.[7] In addition to microbial pathogen contamination of meats, other agents can act acting with deleterious effects on nutritional quality.[8] Further, this concept extends to the current COVID-19 pandemic, since the virus can be eliminated at this cooking temperature.[9]

While Brazilian legislation and the WHO provide an identical minimum ideal temperature for safe cooking of any type of food, the American Public Health Agency: Food Safety and Inspection Service (FSIS), of the United States Department of Agriculture (USDA), is more exhaustive in its guidelines when differentiating foods. For beef, pork, and sheep, it is 71°C. For all bird species, it is 74°C. For steaks, roasts and chops, it's 63°C, with a 3-minute rest requirement. For fish, cooking must continue until opaque.[10] These values vary by country according to the recommendations of each government, and even involve regional legislation, such as that proposed by the São Paulo Health Surveillance Center, which assigns a minimum temperature of 74°C for heat treatment of food.[11-13]

In addition to sanitary control, cooking performance is vital for a restaurant to avoid both excess and/or insufficient weights of the prepared food. The commonly known cooking conversion factor (CCF), conversion index, or the cooking index (CI), is an indicator of the relationship between the cooked or ready to eat weight, and that of clean raw food.[14,15]

There are few studies in the Brazilian literature involving cooking indexes, fully validated methods are not commonly used, the number of foods studied is restricted, and methodologies and tools used often lack standardization, causing difficulties when placed in other experimental environments.[16,17]

Yet since precision remains essential, the cooking index measurement remains relevant to gauge the end service to the customer. Furthermore, using the cooking index, the nutritionist can provide a more appropriate food plan as well as protect against food waste.[18]

Given that commercial restaurants lack data concerning appropriate values for use with the cooking index, and also since food must be kept at desirably pleasant and safe temperatures for the consumer, the objective of this work was to evaluate cooking indices and surface temperatures for different types of cuts and cooking points of grilled meats in a commercial restaurant, located in Fortaleza-CE.

METHODS

The present descriptive-exploratory-quantitative study was applied in a commercial restaurant specializing in meat cuts cooked on a *Parrilla* grill with an intermediate/luxury menu and (*à la carte service*) in the city of Fortaleza.

The restaurant offers lunch and dinner respectively from 12:00 to 16:00 and 18:00 to 23:00, every day. up to 38 types of cuts and fractions of beef (mainly), sheep, pork, chicken and fish are *grilled* , being produced with their weights previously standardized by portioning, which like the grill area is a Basic Management Unit (BMU) of the establishment. Specifically in this company, BMU is the name of each work area, in order to make it more autonomous. In addition, the meat is cooked to 5 cooking points: rare, medium rare, medium, medium well, and well -done.

For analysis, we selected the 3 types of cuts most often sold: *Sirloin* (central portion of the sirloin), *serving* at 200g *per capita*; Filet Mignon, *serving* at 180g *per capita;* and Top Sirloin Cap (picanha), *serving* at 200g *per capita*. *Per capita* denotes the amount of raw food per person.[19] As for meat cooking points, the most requested are: rare, medium, and well-done.

The single grating was divided into 3 areas, "upper", "central", and "lower". These were sectioned into 9 areas (3 areas each), and the temperatures of each section were obtained using an average of 3 samples at the center of the grilling area using a laser thermometer. The grilling procedure practiced in the restaurant followed the following protocol: initially, meats are placed in the "upper" portion of the grill, where they are arranged transversally, and as they pass cooking points, from rare to medium, and from medium to well-done, they are usually transferred to lower area of the grill. When the meats are located towards the back of the grill, they are often rare, since they are higher up, these are often redistributed before going to the lower cooking area. However, when they are to be medium or well-done cuts, they can spend a relatively significant amount of time in the central or lower grill areas.

The net weight (NW) is the weight of the food while still raw and obtained after discarding all unusable parts, such as trimmings and husks. The cooked weight (CW) is the weight of the food after cooking or preparation, and is necessary for the calculation of both the cooking index (CI) and the energy value of the food. The cooking index is responsible for predicting the loss or increase of NW due to the actions to which the food will be subjected by physical, chemical and (or) biological agents. Other factors can also impact the CI, such as heat intensity, cooking time, the utensils and equipment used, the preparation technique and the qualification of the workforce. A result greater than 1 means that there was weight gain of the food during cooking and less than 1, that the weight was reduced.[19]

Then, with the CW and NW available, the CI is calculated using the following relationship:[17]

$$\mathrm{CI} = \frac{\text{Cooked Weight (CW)}}{\text{Net Weight (NW)}}$$

The purpose of the work was to identify the cooking indexes of the aforementioned pieces of meat and present the comparatives and temperature adjustments in the grilling *process.* Data collection was carried out during the lunch period between September and November 2020. The weights of the cooked foods were measured using an SF-400 digital scale with an accuracy of 1g to 10 kg, and the surface temperatures were measured using a Minipa MT 302-A infrared thermometer with a measurement range of -50 to 580°C. During the period of data collection, 38 samples of cuts were collected in total, with at least 3 samples for each piece at a certain cooking point, so that it was possible to reach a satisfactory average for analysis of the items.

The results of the ICs were evaluated to compare them with the standards in the literature already available, being Bernardes, Ornelas, and Silva, while for the temperatures, the temperatures measured were compared with the those recommended by the WHO and FSIS, the sensory standards used were by Embrapa, and the cooking points used were by an adaptation of the model proposed by Prill et al. from Kansas State University.[4,6,17,18,20-23]

For statistical analysis, IBM SPSS Statistics 20 software was used. The Shapiro-Wilk normality test was applied to the quantitative variables, and all data were satisfactory in terms of normal distribution correspondence. One-way analysis of variance (ANOVA) was also applied to compare the means between the groups of meat cooking points, both IC, and temperature for each cut, and a significance level of $p < 0.05$ was adopted.

RESULTS AND DISCUSSION

Table 1 presents the meat cuts and cooking points and their respective values of net weights, average cooked food weights, and average CIs, with CIs from the literature. The CIs of the *Sirloin* in its well done, medium, and rare cooking points ranged from 0.76 to 0.92. For Filet Mignon, they ranged from 0.69 to 0.92. For the Top Sirloin Cap (picanha), they ranged from 0.66 to 0.85. These intervals denote yields in terms of cooking time and the grilling/cooking point of the meat, facilitating the pre-cooking prognosis. The differences between each of the ICs of the cooking points of each cut were statistically significant.

Table 1. Net weight, cooked weight, and cooking index for meat cooking points on a grill in a Fortaleza-CE commercial restaurant (2020).

Cut	Cooking Point	NW (grams)	Average CW (grams)	CI			Literature CI		
				Average	P	F	Bernardes (1999) [18]	Ornelas (2013) [17]	Silva et al. (2012) [23]
Sirloin	Rare	200	184	0.92	0.463	36.21	0.60 to 0.70	0.65 to 0.90	0.59
	Medium	200	168	0.84	0.406				
	Well done	200	152	0.76	0.780				
Filet Mignon	Rare	180	166	0.92	0.316	40.32			
	Medium	180	131	0.73	0.637				
	Well done	180	124	0.69	0.463				
Top Sirloin Cap	Rare	200	170	0.85	0.505	10.29			
	Medium	200	156	0.78	0.223				
	Well done	200	132	0.66	0.911				

*NW – Net weight; CW – Cooked Weight; CI – Cooking Index.
** p – Shapiro-Wilk test p-value.
*** F – ANOVA F statistic.

Low-fat or noble meats have a CI of 0.60 to 0.70, according to Bernardes.[18] The evaluated cuts reached or were close to this range of values when they were at the well-done cooking point. However, Ornelas points out that the CI range for beef is 0.65 to 0.90.[17] In this case, almost all the cuts were in the indicated range, with the exception of the *Sirloin* and the *Filet Mignon*. As for rare, we have *Sirloin* and *Filet Mignon* with a CI of 0.92, while the *Top Sirloin Cap* was 0.85.

We note that according to Table 1, that as expected, the averages of all the cooking indexes suffered decreases with more cooking and change of cooking point. It was also observed that there was a more accentuated reduction between the Filet Mignon rare and medium points, with a respective weight decrease of 8% and 27%.

Certain studies have sought to reproduce beef ICs to investigate the yield of these foods in their institutions. Santos et al., and Araujo et al. evaluated beef in the food production area of their research hospitals and found respective CI values of 0.90 and 0.79; being that Santos et al. used dry heat to cook the meat, and Araujo et al., use humid heat. Silva et al. analyzed beef using many ways of preparation, emphasizing grilled meat with a CI of 0.59, which did not corroborate the CIs found in the present study. Of all the studies investigated, Santos et al. alone specified the cut, opting for chuck steak. [21-23.]

Table 2. Meat cooking point temperatures; meats on commercial grill restaurant in Fortaleza-CE (2020).

Cut	Cooking Point	Temperature (°C)			Temperature Prill et al. [20] (°C)	Temperature WHO [6] (°C)	Temperature FSIS [10] (°C)
		Average	P	F			
Sirloin	Rare	78.33	0.317	16.02	54 to 60	70	63
	Medium	58.00	0.577		63 to 71		
	Well done	52.67	0.843		77 to 82		
Filet Mignon	Rare	67.00	0.588	2.47	54 to 60		
	Medium	62.67	0.637		63 to 71		
	Well done	55.00	0.274		77 to 82		
Top Sirloin Cap	Rare	54.83	0.454	1.39	54 to 60		
	Medium	54.43	0.148		63 to 71		
	Well done	63.00	0.492		77 to 82		

* WHO – World Health Organization ; FSIS – *Food Safety and Inspection Service.*
** The FSIS recommendation requires a further 3 minute meat rest.
*** p – Shapiro-Wilk test p-value.
**** F – ANOVA F statistic.

Table 2 presents the average temperatures of the meat cuts with their respective cooking points, and the temperatures recommended by the literature. Only the *Sirloin* presented significant temperature differences between the averages in its cooking points (p = 0.002), though the individual analyses of the Filet Mignon and Top Sirloin Cap cooking points were also appropriate.

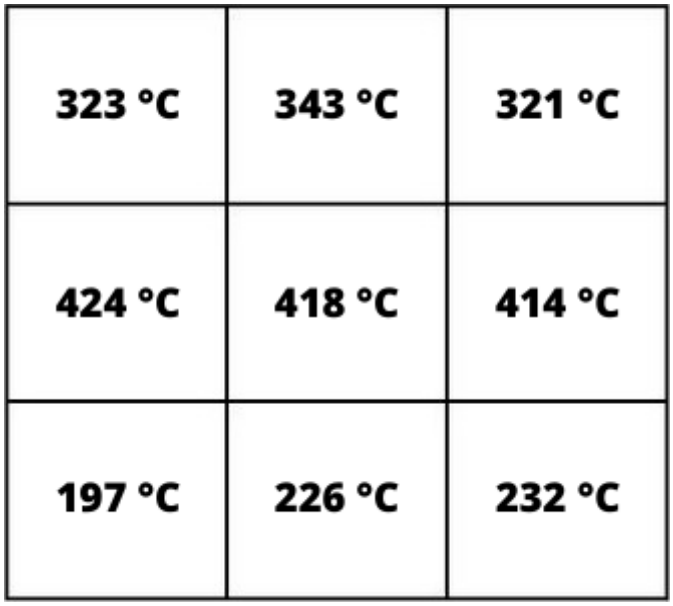
As mentioned above, to achieve certain characteristics (depending on the type of meat cut and the cooking point requested by customer), temperatures possess ideal values. Although no sensory analysis was performed as recommended in the literature for preserving the flavor and odor of the preparations, no cut exceeded the known limit of 82°C. A temperature below 70°C is also recommended to obtain succulent meat, but, on the other hand, the WHO recommendation would not be fulfilled. Regarding tenderness, one cut met the recommended range of 57 to 60°C, that of *Sirloin* at the "medium" cooking point.

One cut was above 70°C, for rare *Sirloin*, fitting as possibly safe by the WHO. Cuts equal to or above 63°C, which is the ideal temperature for steaks according to FSIS, would protect rare *Sirloin*, rare Filet Mignon, medium-rare Filet Mignon, and well-done Top Sirloin Cap. However the 3-minute rest time before delivery to the customer was not respected.

The geometric center temperatures for the cooking points, in the Prill model et al., are divided into 6 levels: *very rare* (54°C), *rare* (60°C), *medium rare* (63°C), *medium* (71°C), *well done* (77°C) and *very well done* (82°C).[20] For the analysis, the cooking points were set to 3 levels: rare (54 to 60°C), medium (63 to 71°C), and well-done (77 to 82°C). Only one cut from Table 2 fit this temperature classification claim, the rare Top Sirloin Cap. With regard to palatability, the idea that there is a consumer preference for medium, that is, between 63°C and 71°C given the mentioned values, was reinforced.[24,25] Both Filet Mignon (*rare*) and Top Sirloin Cap (*well-done*) fell within this range, despite not being the exact cooking points requested.

Sirloin followed a decreasing trend in temperature with a higher cooking point, revealing a variance from the expected pattern found in the Prill et al. model[20] The justification for this is in the average temperatures of the portions of the grill, as shown in Figure 1. In theory, all cuts that spent more time in the central areas should have the highest temperatures, and cuts that spent more time in the the lower areas should present lower temperatures. However, exchanges between sections occur during cooking, making it difficult to determine the area of greatest influence. Furthermore, the cooking technique is not clearly defined as to the time required in each section, nor is it strictly followed in cases of high demand. Therefore, though grill temperatures are important, knowing the food preparation methodology and applying it correctly with proper temperature control is even more important. The average grill temperatures are shown in Figure 1.

Figure 1 Average grill temperatures at the front of the *Parilla.*



Meat temperature control, when properly executed, can reduce risks to consumer health and confer palatability to the food. In a broader context, the adversities arising from immoderation of this control in food preparation affect the community, bringing economic loss to individuals, organizations and the health system.[26,27] Inspection and compliance with correct temperature and cooking index prerequisites, bring a

margin of safety in theory and in practice towards preservation of desired nutritional and sensory food properties, being also a beneficial preventive health measure in promoting well-being.[17,23]

The lack of literature that raises discussions on the issues addressed was a notable limitation of this study. In addition, although there have been promising findings regarding cooking indexes and temperatures, A further limitation regarding the use of the thermometer on the surface of the iron grill, occurs since the grill is affected by the exchange of heat with the meats, which could be in contact with the grill just before measurements. The embers below, which can affect grill temperature depending on area usage. The temperature measurements suffered significant variations according to the location and time of measurement. For the measurements to be more reliable, it would be necessary to have a schematic of grill operation, with a plan that would cover variables such as the sequencing of the production order, and the heat transfer coefficients.[28] Further, the methodology of the meat preparation technique and its cooking time was left to the grill handler.

CONCLUSION

This study reflects the need for appropriate temperature control in the roasting process. As discussed above, to achieve an ideal model for meat temperatures, issues such as quality, quantity, health, customer preference, grill handling, preparation techniques, and equipment are essential cooking parameters to be considered.

Few studies point to cooking indexes and most fail to specify food preparation methods. On the other hand, the detailed investigation into the method, and the measures adopted in this research were successful, making the study database a reference to guide for use in future works, especially in Nutrition and Gastronomy.

To better reliability and to further enhance the subject, whether with the same cuts presented or in other food studies, the CIs described both here and in complementary research are suggested for use in future studies

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Contributors

Danziato Neto MA and Carioca AAF participated in the conception, design of the study, with analysis, and interpretation of data, and review and approval of the final version; Oliveira KP participated in the review and approval of the final version; and Antunes LO participated in the conception and design of the study.

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