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Decision-making support system for beef cattle carcass quality using fuzzy modeling

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ABSTRACT
Carcass assessment by slaughterhouses is as important as an efficient production of quality animal. The evaluation is performed subjectively by individuals although it follows delimited criteria. Therefore, an expert system should be developed to allow both reduction of subjectivity in analysis and valuation with more complex and non-continuous variables. This chapter aimed at developing a decision-making support system to assess beef cattle carcass in slaughterhouses, using a fuzzy logic modeling. The subjective knowledge of experts on beef cattle carcasses quality was used to build membership functions. Animal maturity, weight, and fatness degree were used as quality indicators, but quality itself was an output variable. The proposed fuzzy model showed 89.5% compatibility with the scores of the experts and allowed a higher specificity of the presented score, reducing differences between classifications.

PALAVRAS-CHAVE: Fuzzy Logic. Expert systems. beef cattle.

1 INTRODUCTION

The meat market expansion and increased Brazilian participation in world's production have led to the need for qualitative analysis of carcasses during slaughter by slaughterhouses. Carcass quality criteria, which were previously subjective, became measurable and later regulated by specific legislation.

Beef demand stabilization, especially in European and North American countries, has made the markets search for products with certifications, which respect environmental criteria and are of higher quality (OECD and FAO, 2021).

Brazil is the largest beef exporter, with a 17% market share, and sent 2.40 million tons of beef to international markets such as Asia and Europe in 2020 (ABIEC, 2021; XIMENES and SOARES, 2021). These markets require levels of standardization of carcass fatness, in addition to the required sanitary standards (FAO, 2018; DIAS, 2021).

The increased Brazilian beef exports to more demanding markets have led to the need to improve the typification and carcass fatness quality of the herd. Most of the animals slaughtered in Brazil still do not have their quality assessed by technical standards required by international markets, even with the evolution of beef exports (ABIEC, 2020).

The lack of information to producers has led public organizations and slaughterhouses to encourage and value animals with the highest quality perceived by the final consumer (COUTINHO FILHO et al., 2006). Therefore, producers have refined management by improving the genetic profile and feeding, leading to the possibility of reducing the age at slaughter.

Early animal slaughter allowed for inclusion of intact animals in the quality standard. This is because animal nutritional level is not influenced by castration when slaughter is performed up to 24 months of age, also presenting higher weights and weight gains and heavier carcasses, with higher yield and proportion of muscle tissue, but with a subcutaneous fat thickness similar to that of castrated animals (ITAVO et al., 2008).

The international beef industry requires a potential carcass quality index, leading producers to seek genetic and management improvements to meet the food quality demand required by these markets (MCGILCHRIST et al., 2019). Studies have explored the variability to select animals with higher potential and meat and carcass quality characteristics, which are difficult to measure in live animals, requiring the investigation of variants that influence the characteristics used to select the best animals (CARRASCO-GARCÍA et al., 2020).

Large slaughterhouses started to give bonuses, at the time of slaughter, to bovine carcasses that meet certain quality standards and can be delivered to the consumer as superior quality meat (DIAS, 2017).

The correct assessment of carcasses, even based on criteria established by the Ministry of Agriculture, Livestock and Food Supply (MAPA) Normative Instruction No. 9, of May 4, 2004, still depends on the slaughterhouse evaluator's subjective analysis at the time of slaughter for this to be effective in Brazil.

In this context, an expert system that allows both reduction of subjectivity in the analysis and the valuation with more complex and non-continuous variables is required. The mathematical model proposed in this study is based on fuzzy logic, whose application in decision support systems in the agribusiness area has been used by several researchers (GABRIEL FILHO et al., 2016; PUTTI et al., 2014; CREMASCO et al., 2010).

This chapter aimed to develop a decision-making support system to assess the carcass of beef cattle in slaughterhouses using fuzzy logic modeling (JANG, SUN, MIZUNAMI, 1997).

The subjective knowledge of experts on beef cattle carcass quality was used to construct the membership functions (SILVA et al., 2017). Afterward, animal data were inserted into the model to compare the classification used by slaughterhouses for qualitative assessment of carcasses, with the score inferred by the fuzzy model.

2 METHODOLOGY

A mathematical model based on fuzzy logic was developed to construct this study. The characteristics presented by the Brazilian Ministry of Agriculture, Livestock and Food Supply (MAPA, 2004) were used as a reference for the survey and relevance of variables. The membership functions were defined based on quality characteristics, e.g., animal maturity, final weight, and fatness degree.

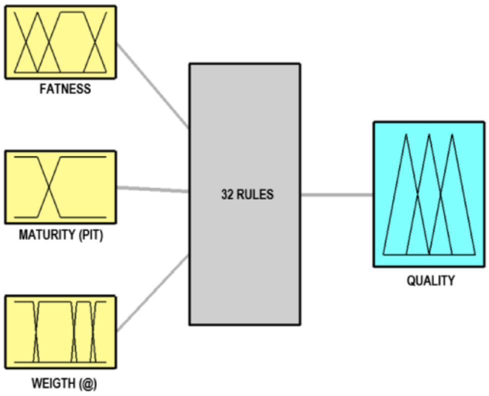
The reference values, for which the carcass presents the highest valuation in the slaughterhouse, giving a higher return to the production chain and better-quality meat to the consumer, were established based on these characteristics and the standards used by the market.

The fuzzy model was developed to assess the carcass quality of intact beef cattle and establish which standards are most desired by the market and how the carcass can be assessed with greater objectivity and precision.

2.1 FUZZY MODELING

The data presented by Silva et al. (2017) were used for the development of the model, which has a function in which $f: \mathbb{R}^3 \to \mathbb{R}$, with $(x_1, x_2, x_3) \mapsto f(x_1, x_2, x_3)$, where $\mathbb{R}$ is the set of real numbers, x_1 is the degree of fatness, x_2 is the animal maturity, x_3 is the hot carcass weight, and y is the carcass quality (Figure 1).

Figure 1 – Demonstration of the expert system based on fuzzy logic for assessing carcasses of intact beef cattle.



Source: Prepared by the author.

The input variables consisted of the degree of fatness, animal maturity, and hot carcass weight. Four membership functions (3 trimf and 1 trapmf) were used for the first variable, given the complexity of using continuous data. Two membership functions (2 trapmf) were used for the second variable, while four membership functions (4 trapmf) were used for the third variable. Quality was considered as an output variable, with three membership functions (3 trimf). The membership functions were constructed as shown in Table 1.

Table 1 – Demonstration of the set of rules for the construction of membership functions of the fuzzy model.

TRAPEZOIDAL (trapmf)	TRIANGULAR (trimf)
$f\,(x,a,b,c,d) = \begin{cases} \frac{x-a}{b-a} & if\ a \leq x < b \\ 1 & if\ b \leq x \leq c \\ \frac{d-x}{d-c} & if\ c < x \leq d \\ 0 & otherwise \end{cases}$ Or $trapmf\,(x;a,b,c,d) = \max\left(\min\left(\frac{x-a}{b-a}, 1, \frac{d-x}{d-c}\right), 0\right)$	$f\,(x,a,b,c,) = \begin{cases} \frac{x-a}{b-a} & if\ a < x \leq b \\ \frac{d-x}{d-c} & if\ b < x \leq c \\ 0 & otherwise \end{cases}$ Or $trimf\,(x;a,b,c,) = \max\left(\min\left(\frac{x-a}{b-a}, \frac{c-x}{c-b}\right), 0\right)$

Source: Adapted from Putti et al. (2014) and Cremasco et al. (2010).

Considering the chosen variables (MAPA, 2004), data-based modeling was carried out (SILVA et al., 2017) to construct the membership functions of the input variables “Fatness,” “Maturity,” and “Weight” and the output variable “Quality.”

2.2 INPUT VARIABLE

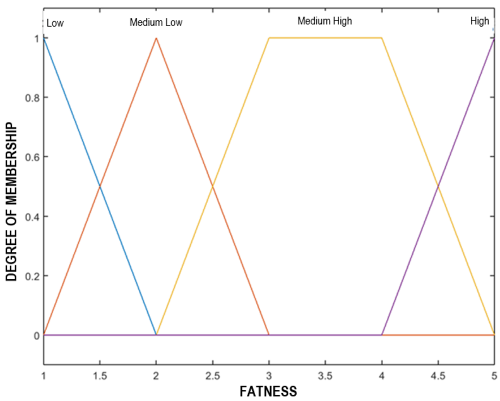
Table 2 show the membership functions of the “Fatness” variable. For its construction, the fat thickness measurement of the sirloin at the penultimate rib (12th) height, perpendicularly to the fat layer, was used as the degree of fatness.

To Variable “Maturity”, the number of permanent incisor teeth (PIT) was used as a standard for its construction, allowing the assessment of the approximate age of the animal at the time of slaughter.

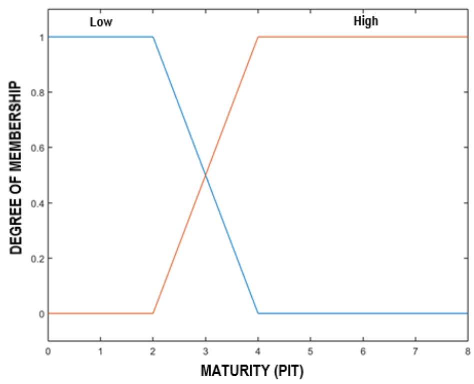
The function to the membership functions “Weight” used the hot weight after slaughter was used in the construction of this variable, with the arroba (15 kg) as the unit of measurement.

Figure 2 - Graphical representation of the membership functions for the input Variable

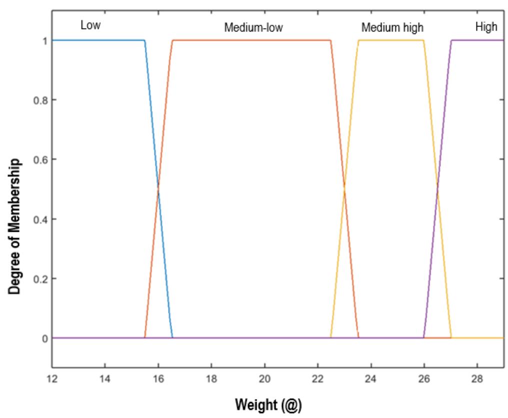
2A – “FATNESS”



2B “MATURITY (PIT)”



2C – “WEIGHT (@)”



Source: Prepared by the author.

As shown in Figure 2A, four membership functions (3 trimf and 1 trapmf) were stipulated. The linguistic functions were defined as follows: “Low” for fatness 1; “Medium low” for fatness 2; "Medium-high” for fatness 3 and 4; and “High” for fatness 5. MFs of trimf and trapmf constructions were used, considering that “Fatness” is a continuous variable and the values 3 and 4 (median and uniform) have the same qualitative valuation assigned by the expert.

The Figure 2B show two membership functions (2 trapmf) were stipulated. The linguistic functions were defined as follows: “Low” for 0 to 2 PIT and “High” for 4 to 8 permanent incisor teeth. MFs of trapmf constructions were used, considering that “Maturity” is a continuous variable.

In Figure 2C four membership functions (4 trapmf) were stipulated. The linguistic functions were defined as follows: "Low" for "Weight" between 11.5 and 15.5 arrobas; "Medium low" for "Weight" between 16.5 and 22.5 arrobas; "Medium-high" for "Weight" between 23.5 and 26 arrobas; and "High" for "Weight" above 27 arrobas. The arroba measurement unit was chosen instead of kilogram considering that the former is the most used by producers and slaughterhouses, making the fuzzy system easier to be interpreted and used.

2.3 OUTPUT VARIABLE QUALITY

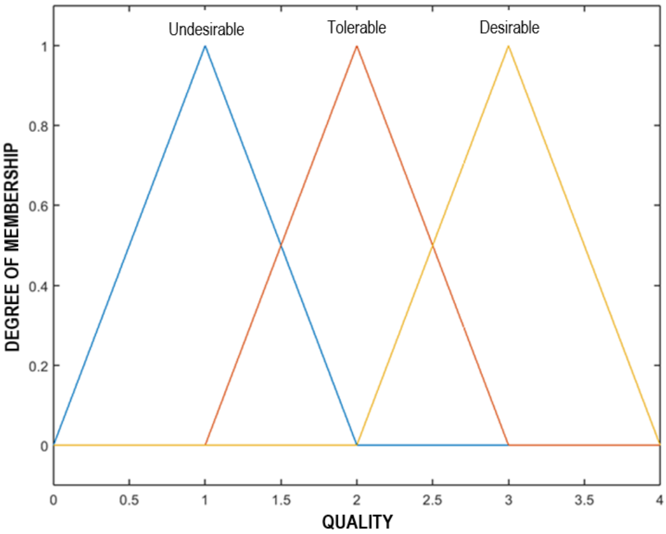
Table 2 and Figure 3 show the membership functions of the output variable “Quality”. The expected quality standard was used for its construction (undesirable, tolerable, and desirable), as proposed by Silva et al. (2017), because this is the terminology adopted by slaughterhouses to infer carcass quality characteristics.

Table 2 – Membership functions of the fuzzy model for the output variable “Quality.”

Fuzzy set	Type	Limit
Undesirable	Triangular	[0 1 2]
Tolerable	Triangular	[1 2 3]
Desirable	Triangular	[2 3 4]

Source: Prepared by the author.

Figure **3** - Graphical representation of the membership functions for the output variable “Quality.”



Source: Prepared by the author.

According to Figure 5, three membership functions (3 trimf) were stipulated. The linguistic functions were defined as follows: “Undesirable” for “Quality” equal to 1; “Tolerable” for “Quality” equal to 2; and “Desirable” for “Quality” equal to 3.

2.4 DEFUZZIFICATION PROCESS

The inference model used to calculate the numerical output value was based on the rules of Mandami's method. The center of gravity or centroid method was used for defuzzification, considering average weights as μ_A (x), in which x is the weight. The variable "Weight" was adopted as continuous, and the variables "Fatness" and "Maturity" were adopted as discrete. The formulas shown in Table 3 were used.

Table **3** - Método de defuzzificação para variáveis contínuas (1) e para variáveis discretas (2).

Continuous variable	Discrete variable
$\bar{z} = \frac{\int \mu_A(x) x dx}{\int \mu_A(x) dx}$	$\bar{z} = \frac{\sum_x \mu_A(x) x}{\sum_x \mu_A(x)}$

Source: Adapted from Putti et al. (2014) and Cremasco et al. (2010).

The MATLAB 15th software was used through the Fuzzy Logic Toolbox to perform the numerical simulations of the developed fuzzy controller.

3 RESULTS AND DISCUSSION

The fuzzy model rule base was carried out based on the crossing of information obtained from expert opinions (SILVA et al., 2017), literature review, and MAPA Normative Instructions (2004). Subsequently, the base was tested, and simulations were performed, allowing reaching a higher level of precision. Thus, carcass "$Quality$" was accurately classified considering the variation of the factors of "$Fatness$," "$Maturity$," and "$Weight$" of the hot carcass of uncastrated males or intact males.

3.1 RULE BASE

A conditional linguistic pattern "IF," with the causal delimiter "$THEN$," was used to construct the rules. As an example, the first rule consisted of:

$$if\ "Fatness"\ is\ LOW;\ if\ "Maturity"\ is\ LOW;\ if\ "Weight"\ is\ LOW,$$
$$THEN\ "Quality"\ is\ \text{UNDESIRABLE}.$$

The sistem shows 32 rules for the fuzzy model for assessing the carcass quality, with 26 rules returning the output "$Quality$" as $undesirable$, seven rules returning "$Quality$" as $Tolerable$, and one rule returning "$Quality$" as $Desirable$.

Figure 6 exemplifies the modeling of rules, with inference by Mandami's method. The inputs $Fatness = 3\ (median)$, $\text{Maturity} = 2\ (\text{2 permanent incisors})$, and $\text{Weight} = 20.5\ (307.5\ \text{kg})$ led to a fuzzy output score of $\text{Quality} = 3\ (\text{Desirable quality})$.

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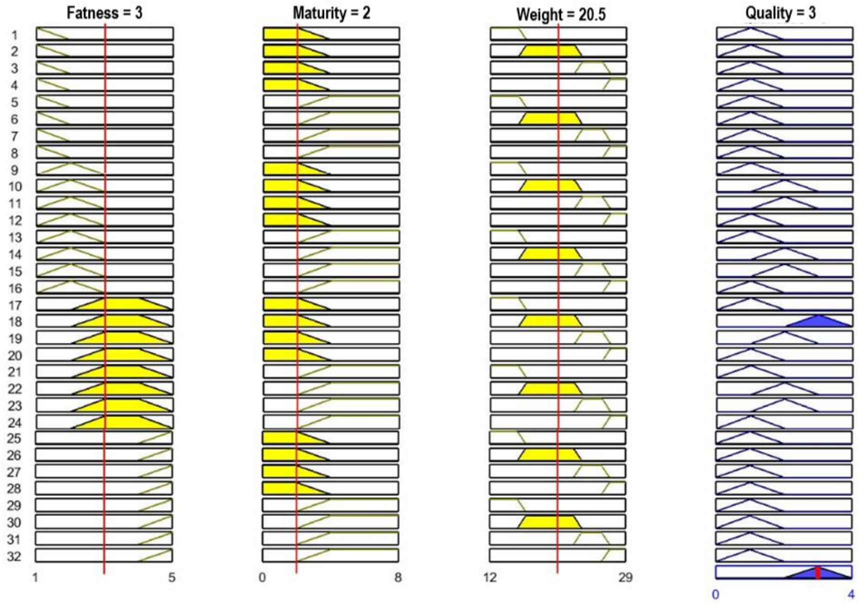
Figura 4 - Inference by Mandami's method – MATLAB 15th.

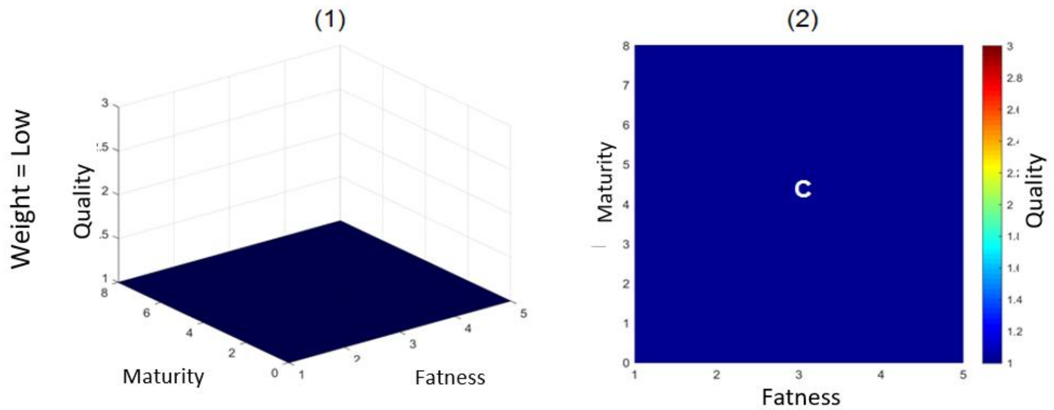


Source: Prepared by the author.

3.2 FUZZY MODELING FOR CATTLE CARCASS ASSESSMENT

Figure 5 shows the surfaces and contour map of the fuzzy model. They allow analyzing the used variables and their regions, considering that the surface plotted with MATLAB 15th allows only the visualization of two input variables and their interference in the output variables. One of the variables was fixed to construct the graphs. The surfaces were plotted because the model had three input variables.

Figure 5 - Surface (1, 3, 5, and 7) and contour map (2, 4, 6, and 8) for the variables "Fatness" × "Maturity" and their interactions on the Quality in the fuzzy model.



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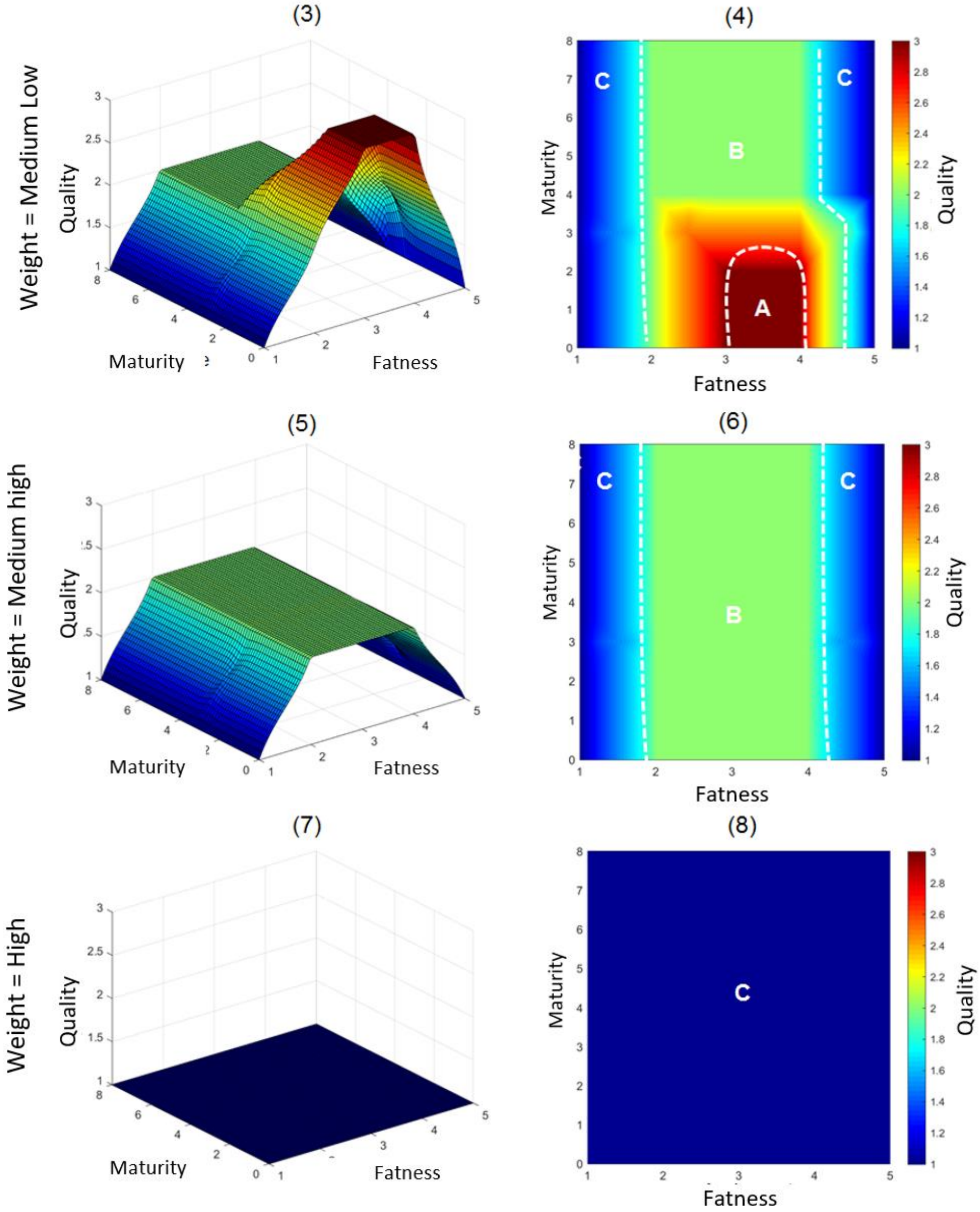


**A=Desirable; B=Tolerable; C=Undesirable.*
Source: Prepared by the author.

Figure 5 (1) and (2) illustrates the regions of the output variable $Quality$ by fixing the variable $Weight = LOW\ being\ \{11.5 \leq x \leq 15.5\}$, varying the inputs $Maturity$ and $Fatness$, the response consists of $Quality$ as $Undesirable\ (\boldsymbol{C})$. The variable $Weight = LOW$ leads to the response variable $Quality$ as the absolute response $Undesirable\ (C)$, regardless of the other variables.

Figure 5 (3) and (4) shows the regions of the output variable $Quality$ by fixing the variable $Weight = MEDIUM\ LOW\ being\ \{16.5 \leq x \leq 22.5\}$, the response consists of $Quality$ as $Desirable\ (\boldsymbol{A})$, when $\overline{X} \times \overline{Y}$, where $\overline{X} = \{x \in \Re/2 \leq x \leq 4\}$ of the variable $Fatness$ and $\overline{Y} = \{y \in \Re/0 \leq x \leq 2\}$ of the variable $Maturity$, considered the best possible result for the producer. Also, the $Tolerable\ (\boldsymbol{B})$ region is found in the interval $[1.5; 2.5] \cap [4.2; 4.8]$ on the $x - axis\ (Fatness)$ and $[0.8]$ on the $y - axis\ (Maturity)$. Furthermore, the

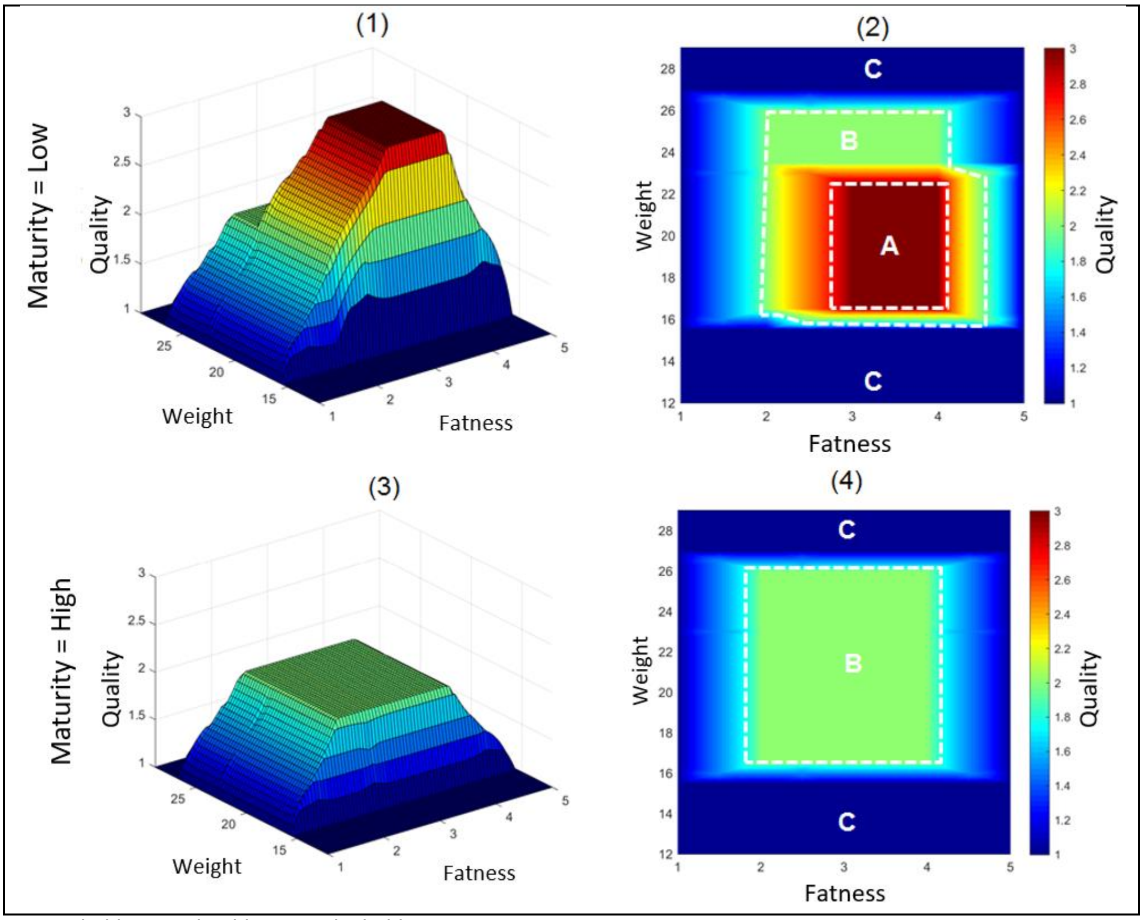
$Undesirable$ ($\boldsymbol{C}$) region occurs when $Fatness$ varies between $[1, 1.5] \cap [4.8, and\ 5]$, while it varies between [0,8] on the $y\ axis$ ($Maturity$).

Items (5) and (6) of Figure 5 show the output variable $Quality$ fixing the variable $Weight = MEDIUM\ HIGH\ being\ \{23.5 \leq x \leq 26.0\}$ in the $Tolerable$ ($\boldsymbol{B}$) region, which is in the $Fatness$ [2.0; 4.0] interval, regardless of the value assigned to the variable $Maturity$. The response of $Quality$ as $Undesirable$ ($\boldsymbol{C}$) appears when the values [1.0; 2.0] and [4.0; 5.0]are given to the input variable $Fatness$.

Figure 5 (7) and (8) illustrates the regions of the output variable $Quality$ by fixing the variable $Weight = HIGH\ being\ \{27.0 \leq x \leq 29.5\}$, with the input variables $Maturity$ and $Fatness$, the response consists of $Quality$ as $Undesirable$ ($\boldsymbol{C}$), when the variable $Weight = HIGH$, the response variable $Quality$ will also present as an absolute response $Undesirable$ ($\boldsymbol{C}$), regardless of the other variables.

Also, $Quality$ is $Desirable$ ($\boldsymbol{A}$) to the producer if the variable $Fatness$ is at [2.5; 4.0] and $Maturity$ at [0.2] but $Quality$ is $Tolerable$ ($\boldsymbol{B}$) if $Maturity$ is at [2.8], that is, $Quality$ can be determined as $Tolerable$ ($\boldsymbol{B}$) or $Desirable$ ($\boldsymbol{A}$) if $Maturity$ is at [0.8] with a variation in $Fatness$ at [1.5; 4.8].

Figura 6 - Surface (1 and 3) and contour map (2 and 4) for the variables "Maturity" × "Weight" and their interactions on Quality in the fuzzy model.

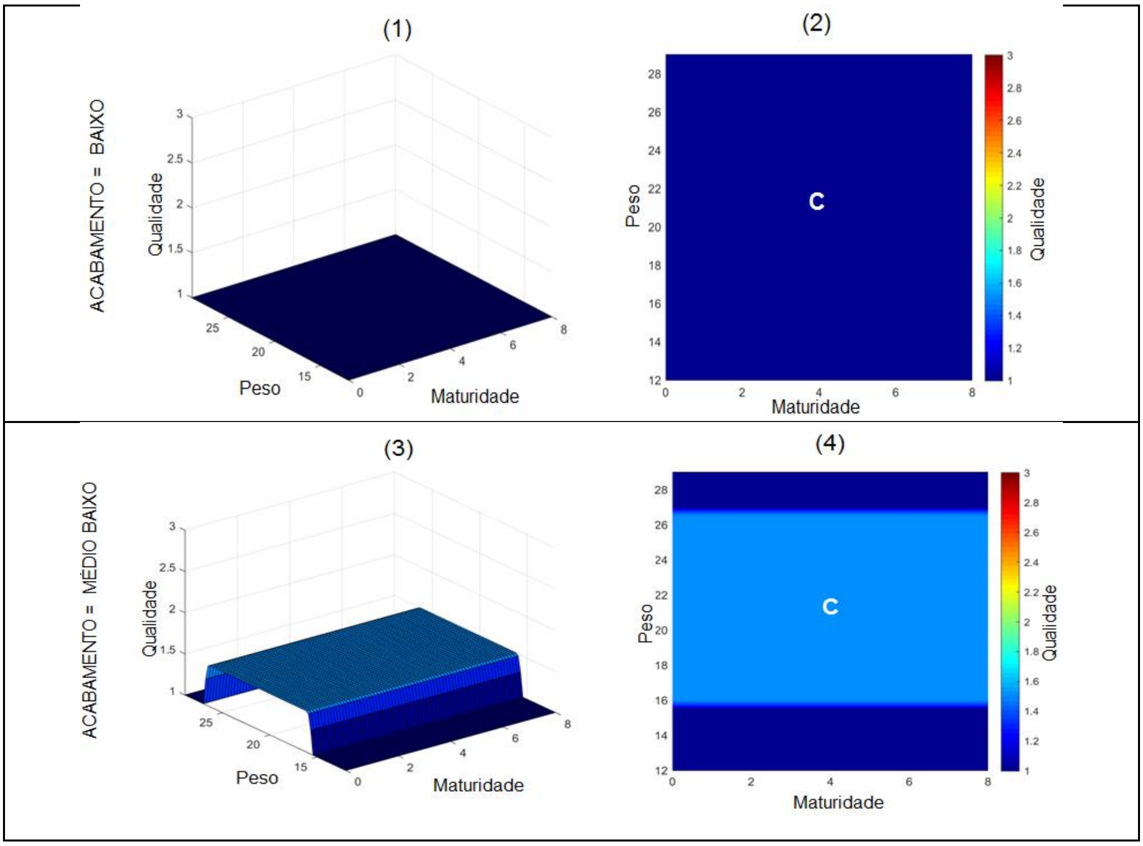


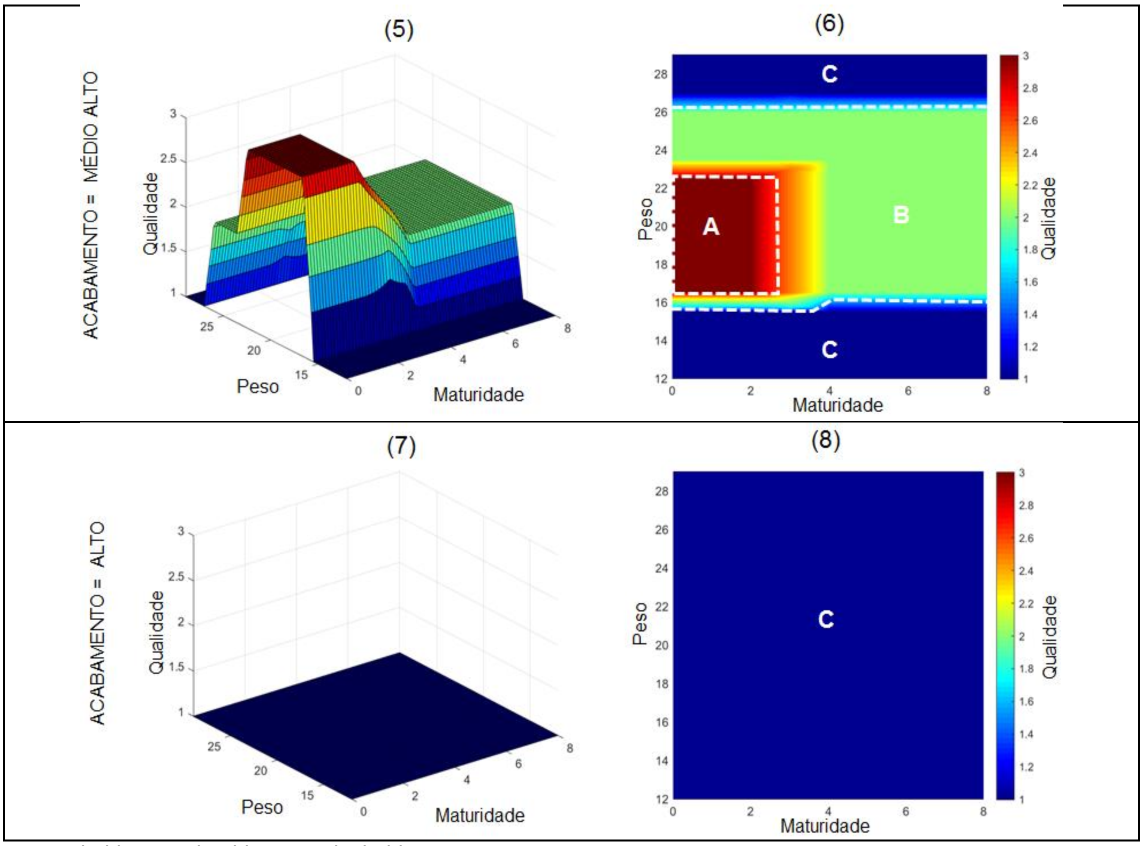
**A=Desirable; B=Tolerable; C=Undesirable.*
Source: Prepared by the author.

Figure 6 (1) and (2) illustrates the regions of the output variable $Quality$ by fixing the variable $Maturity = LOW\ being\ \{0 \leq x \leq 2\}$, with the response consisting of $Quality$ as $Desirable\ (\boldsymbol{A})$, when $\overline{X} \times \overline{Y}$, where $\overline{X} = \{x \in \Re/3 \leq x \leq 4\}$ of the variable $Fatness$ and $\overline{Y} = \{y \in \Re/17 \leq x \leq 22\}$ of the variable $Weight$, considered the best possible result for the producer. Also, the $Tolerable\ (\boldsymbol{B})$ region, which is at the interval $[2.0; 3.0] \cap [4.0; 4.5]$ of the $x - axis\ (Fatness)$ and $[16.0; 26.0]\ where\ (\boldsymbol{B}) \not\subset (\boldsymbol{A})$ of the $y\ axis\ (Weight)$. In addition, the variable $Undesirable\ (C)$ occurs when $Fatness$ varies between $[1.0; 2.0] \cap [4.8, and\ 5]$, while it varies between $[12.0; 15.5] \cap [26.5; 29.5]$ on the $y\ axis\ (Weight)$.

Figure 6 (3) and (4) demonstrates the regions of the output variable $Quality$ by fixing the variable $Maturity = HIGH\ being\ \{4.0 \leq x \leq 8.0\}$, with the input variables $Weight$ and $Fatness$, the response consisting of $Quality$ as $Tolerable\ (\boldsymbol{B})$, which is at the interval $Fatness[2.0; 4.0]$ if the variable $Weight\ [16.5; 26; 0]$.

Figure 7 - Surface (1, 3, 5, and 7) and contour map (2, 4, 6, and 8) for the variables “Finish” × “Weight” and their interactions on Quality in the fuzzy model.





A=Desirable; B=Tolerable; C=Undesirable.
Source: Prepared by the author.

Figure 7 (1) and (2) illustrates the regions of the output variable $Quality$ by fixing the variable $Fatness = LOW\ being\ \{1 \leq x \leq 2\}$, varying the inputs $Weight$ and $Maturity$, and the response consisting of $Quality$ as $Undesirable\ (\boldsymbol{C})$. The response variable $Quality$ will be $Undesirable\ (\boldsymbol{C})$ as an absolute response when the variable $Fatness = LOW$, regardless of the other variables.

Figure 7 (3) and (4) shows the output variable $Quality$ by fixing the variable $Fatness = MEDIUM\ LOW\ being\ \{2 \leq x \leq 3\}$, with the input variables $Weight$ and $Maturity$, the response consisting of $Quality$ as $Undesirable\ (\boldsymbol{C})$. The response variable $Quality$ will be $Undesirable\ (\boldsymbol{C})$ when the variable $Fatness = LOW$, with a score variation $[1.0; 1.5]$ when $Weight$ $[15.5; 27.0]$.

Figure 7 (5) and (6) illustrates the regions of the output variable $Quality$ by fixing the variable $Fatness = MEDIUM\ HIGH\ being\ \{3 \leq x \leq 4\}$, the response consisting of $Quality$ as $Desirable\ (\boldsymbol{A})$ when the $\overline{X} \times \overline{Y}$, where $\overline{X} = \{x \in \Re/16.5 \leq x \leq 26.5\}$ of the variable $Weight$ and $\overline{Y} = \{y \in \Re/0 \leq x \leq 2\}$ of the variable $Maturity$, the best possible result for the producer. Furthermore, the $Tolerable\ (\boldsymbol{B})$ region is found as $[16.0; 26.0]\ where\ (\boldsymbol{B}) \not\subset (\boldsymbol{A})$ of the $x-axis\ (Weight)$ and $[0; 8.0]\ where\ (\boldsymbol{B}) \not\subset (\boldsymbol{A})$ of the $y-axis\ (Maturity)$. In addition, the variable $Undesirable\ (\boldsymbol{C})$ occurs when $Weight$ varies between $[12.0; 16.0] \cap [26.0; 29.0]$, whereas it varies between $[0; 8]$ on the $y\ axis\ (Maturity)$.

Figure 7 (5) and (6) shows that the animals weighing less than 16 arrobas and above 26 arrobas have $Undesirable\ Quality\ (\boldsymbol{C})$, regardless of the $Fatness$. However, the producer with animals weighing 16 arrobas in the range $Fatness$ $[2.0; 4.0]$, for example, is recommended to supplement up to a maximum of 24 arrobas to generate $Quality$ with a score, optimizing profit.

Figures 5, 6, and 7 corroborate the standard assessment proposed by Silva et al. (2017) on the classification of cattle carcasses of intact males and allow the observation of the $Desirable$ ($\boldsymbol{A}$), $Tolerable$ ($\boldsymbol{B}$), and $Undesirable$ ($\boldsymbol{C}$) classification regions.

The transition regions between classifications and the mathematical modeling that generated the surfaces shown in Figures 5, 6, and 7 generalize the tabulated concept of the literature through the mathematical function that considers the characteristics of animals and uses actual values of more gradual classification.

The main advance of the fuzzy model regarding the expert analysis is to allow an intermediate valuation between two classifications ($A\ and\ B$) or ($B\ and\ C$), and the carcass score can present an intermediate value x, with $\{A \leq x \leq B\}$ or $\{B \leq x \leq C\}$, which allows the allocation of an intermediate carcass bonus.

The carcass quality assessment model met the need for an animal classification system, with materialized information in the cattle raising to assess the cattle carcass quality considering the conditions in which the animals were.

Table 4 shows the model application in the data of animals that were the objects of this study, as described in Chapter 2, considering the score obtained by the developed fuzzy model compared to the given score, using the standards define d by SILVA et al. (2017).

Table 4 - Comparison between expert score × fuzzy score.

Animal	PIT	Weight (@)	Fatness	Expert score	Fuzzy score
1	2	22.8	Median	2.0	2.7
2	2	21.5	Median	3.0	3.0
3	2	22.0	Median	3.0	3.0
4	2	23.9	Median	2.0	2.0
5	2	24.1	Median	2.0	2.0
6	2	20.6	Scarce	2.0	2.0
7	2	21.3	Median	3.0	3.0
8	2	20.8	Median	3.0	3.0
9	2	21.6	Median	3.0	3.0
10	2	22.3	Median	3.0	3.0
11	2	20.4	Median	3.0	3.0
12	2	23.0	Median	2.0	2.5
13	2	20.5	Median	3.0	3.0
14	2	22.9	Scarce	2.0	2.0
15	2	20.4	Median	3.0	3.0
16	2	21.8	Median	3.0	3.0
17	2	22.4	Scarce	2.0	2.0
18	2	18.7	Scarce	2.0	2.0
19	2	21.0	Scarce	2.0	2.0

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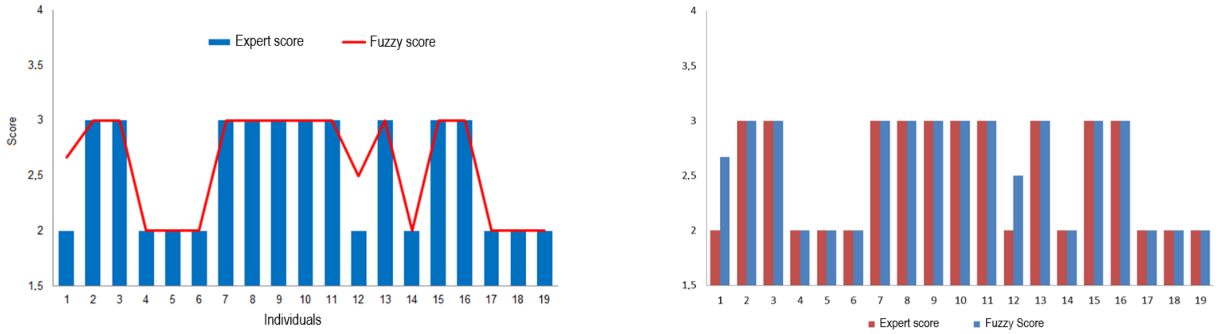
Figure 8 shows the difference between the score presented by the expert (DIAS, 2017) and the fuzzy model.

Figure 8 - Comparison between expert score × fuzzy score.



Source: Prepared by the author.

The fuzzy score was assertive in most animals, with two discordant values. Table 4 shows that the score of the first and the twelfth values have differences because the expert score is based on a table with fixed values, with no gradual transition between classifications, that is, in some cases the expert score verifies that Fatness is inadequate when considering "1" with the variables Weight and Maturity fixed and the variable "Fatness" is at "2" and the other variables are similarly fixed. The transitions between scores with the fuzzy model are gradual between classifications, as shown in Table 4.

Furthermore, 89.5% of compatibility was observed with the analyzed data. Also, the data with discordant values (individuals 1 and 12) in the fuzzy model showed a higher score because they are located at the intersection of sets.

4 CONCLUSIONS

This study sought to develop a decision-making support system for the qualification of intact cattle carcasses. The model based on fuzzy logic sought to model the thought pattern for objective carcass classification.

The proposed fuzzy model had 89.5% compatibility with the expert scores and allowed a higher specificity of the presented score, reducing the difference between classifications. The model would have a higher specificity if the expert presented the variables "Maturity" and "Fatness" as discrete, with a higher degree of objectivity.

Enabling objective modeling based on an expert system can lead slaughterhouses to increase the evaluation criteria, allowing carcasses to have more specific scores. It can generate a differentiation of the produced meats, seeking a higher appreciation in the consumer market, resulting in better remuneration to the producer.

Therefore, the mathematical modeling presented behavior analysis and the influence of characteristics on "Quality," according to the objectives of this study, leading to a new method of meat classification seeking to generalize those existing in the literature.

In future studies, we suggest the creation of an expert model to allow producers to value animals before sending for slaughter. It would provide an estimate of gain for producers, reducing information asymmetry between expectation and results indicated by slaughterhouse.

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