PREDICTION OF HOT CARCASS YIELD IN BEEF CATTLE USING FUZZY EXPERT SYSTEM

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ABSTRACT

The aim of this study was develop a carcass yield estimator in beef cattle. The carcass yield was estimated applying an expert fuzzy model with two input variables (age and zebu genotype) and one output variable (carcass yield). The variables predicted by the model were compared with a database created from information drawn from scientific articles, from the years 2000 to 2006, whose contemplate the same variables of study. The minor deviations between the values experimentally measured yields of carcass values predicted by fuzzy modeling were observed in animals from groups with genotype 100% or 0% zebu, which showed deviations of 0.34 and 1.02 %, respectively. The influence of age on hot carcass yield was low compared to the deviations, while the influence of the degree of zebu blood was higher. The use of fuzzy modeling for the prediction of hot carcass yield in beef cattle is reliable with low standard deviation when compared to the literature.

Keywords: decision support system, expert systems, precision livestock.

PREDIÇÃO DO RENDIMENTO DE CARCAÇA QUENTE EM BOVINOS DE CORTE POR SISTEMA ESPECIALISTA *FUZZY*

RESUMO

O objetivo deste trabalho foi estimar o rendimento de carcaça em bovinos de corte, aplicando modelagem *fuzzy*. Foram elaboradas com auxílio de um especialista, duas variáveis de entrada (idade dos animais e graus de genótipos zebuínos) e uma variável de saída (rendimento de carcaça). As variáveis previstas pelo modelo foram comparadas com um banco de dados, criado a partir de informações retiradas de artigos científicos, publicados entre os anos de 2000 a 2006, e que contemplavam as mesmas variáveis deste estudo. Os menores desvios entre os valores de rendimentos de carcaça mensurados experimentalmente e os valores preditos por meio da modelagem *fuzzy* foram observados nos animais pertencentes aos grupos de genótipo 100% zebu ou 0% zebu, os quais apresentaram desvios de 0.34 e 1.02%, respectivamente. A influência da idade sobre o rendimento de carcaça quente foi baixo em comparação com os desvios, enquanto a influência do grau de genótipo zebu foi alta. O uso de modelos *fuzzy* para a previsão de rendimento de carcaça quente em bovinos de corte é confiável, apresentando baixo desvio padrão, quando comparados com o observado na literatura.

Palavras-chave: Sistema de suporte a decisão, sistemas especialistas, pecuária de precisão.

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INTRODUCTION

In some Brazilian beef cattle production area the commercialization of cattle is no more being by live weight of the animal, to be done by the animal carcass yield. But the yield is frequent source of conflict between producer and industry, because same producers expect a good yield and has sell animals with inferior quality (PASCOAL et al., 2011), it is important to note that there are other factors that influence this aspect.

There are several factors that influence carcass yield of an animal. Sex influences due to the females have a higher reproductive and digestive tracts weight, compared to males (COUTINHO FILHO et al., 2006). Age and production system influences the yield due the differences on digestive tract content and deposition on adipose tissue (KUSS et al., 2008). The animal feeding influences the carcass yield because more fibrous foods results in changes of gastrointestinal content (PERIPOLLI et al., 2013), in this same context, fasting and transportation time are other important factors of this feature (TEKE, 2013).

Because of the importance of bovine carcass grading in the commercialization process, the use of tools that can predict the results becomes a means of great value both for producers and for the slaughterhouse. The fuzzy expert systems are one of these tools, who allow work with inaccurate information and expert knowledge, turning them into a mathematical language for easy interpretation. This system has contributed to the advancement of agricultural research, showing good results and facility make decisions (BRACARENSE et al., 2013). Researches in several areas show the application of fuzzy logic like the characterization of the productive environment for pig breeders; in obtaining thermal comfort indicative parameters of conditions in dairy cattle; for predicting the cloacal temperature of broilers, and others (PANDORFI et al., 2007; PERISSINOTTO et al., 2009; FERREIRA et al., 2012).

The theory of fuzzy sets was introduced by Lofit Zadeh in 1965, and the biggest advantage is to assume degrees of relevance or truth among the values that define a condition or relation of a determinate domain (ZADEH, 1965).Starting with information of a specialist in characterization of bovine carcasses and the literature, is possible create association rules for estimating the carcass yield in cattle. The objective of this study is develop a decision support system from a model who applying the fuzzy logic to predict the classification of carcass yield in beef cattle, having as parameters age and genotype level of the animals.

MATERIALS AND METHODS

The study was conducted in the Department of Animal Science, of the Federal University of Santa Maria, in state of Rio Grande do Sul, Brazil.

The data used are from the scientific literature published between 2000 and 2006, with slaughtering age, degree of zebu genotype expressed in percentage, and hot carcass yield in cattle. With this information from the articles, was formed a database to the validation of modeling expert system based on fuzzy logic using MATLAB® software version 6.1 and the Fuzzy Logic Toolbox module. Using the recommendations from Amendola et al. (2005) to build the basic structure of the fuzzy system, which include four main components: fuzzifier, knowledge base, inference method, and defuzzifier.

The input variables of the model, i.e., the independent variables were age of animals in months and the percentage of zebu genotype, and the output variable, i.e., the dependent variable was the hot carcass yield in percentage. The ages of the animals were grouped follows: I1 [14-22 months], I2 [18-34 months] and I3 [32-48 months]. The percentage of zebu genotype was grouped into: G1 [0 to 35%], G2 [25 to 55%]; G3 [45 to 75%] and G4 [65 to 100% zebu genotype]. The dependent variable, hot carcass yield (HCY) was grouped into: HCY1 [53.0 to 53.6%], HCY2 [53.5 to 54.1%], HCY3 [54.0 to 54.5%], HCY4 [54.4 to 55.1%], HCY5 [55.0 to 55.5%], HCY6 [55.4 to 56.1%], HCY7 [56.0 to 56.5%], HCY8 [56.4 to 57.1%] and HCY9 [57.0 to 57.5%]. The intersections between intervals were designated to implement the method of fuzzifier and were designated by the knowledge of an expert. The expert was selected because of his experience, which should have technical training related to the production of cattle (agronomist, veterinarian or animal scientist) and have at least three years of experience. The rules defined on interviews with the expert and literature, and designed the elaboration of fuzzy modeling are described in Table 1. The inference model was MANDANI (1976) with functions of triangular pertinence.

Table 1 – Rules applied to the expert model of hot carcass yield in cattle.

	Rules[1]	
IF (S is S1)	**AND** (I is I1)	**THEN** (R is R2)
IF (S is S1)	**AND**(I is I2)	**THEN** (R is R1)
IF (S is S1)	**AND** (I is I3)	**THEN** (R is R1)
IF (S is S2)	**AND** (I is I1)	**THEN** (R is R3)
IF (S is S2)	**AND** (I is I2)	**THEN** (R is R4)
IF (S is S2)	**AND** (I is I3)	**THEN** (R is R4)
IF (S is S3)	**AND** (I is I1)	**THEN**(R is R5)
IF (S is S3)	**AND**(I is I2)	**THEN** (R is R5)
IF (S is S3)	**AND** (I is I3)	**THEN** (R is R6)
IF (S is S4)	**AND** (I is I1)	**THEN** (R is R6)
IF (S is S4)	**AND** (I is I2)	**THEN** (R is R7)
IF (S is S4)	**AND** (I is I3)	**THEN** (R is R8)

[1]Sets: Degrees of bloodS1 [0; 17.5; 35% zebu], S2 [25 to 55% zebu], S3 [45 to 75% zebu] and S4 [65 to 100% zebu]; Age at slaughter I1 [14 to 22 months], I2 [18 to 34 months] and I3 [32 to 48 months]. Hot Carcass Yield (HCY) R1 [53.0 to 53.6%], R2 [53.5 to 54.1%], R3 [54.0 to 54.5%], R4 [54.4 to 55.1%], R5 [55.0 to 55.5%], R6 [55.4 to 56.1%], R7 [56.0 to 56.5%], R8 [56.4 to 57.1%] and R9 [57.0 to 57.5%].

The model, after construction, was validated simulating conditions observed in articles published in scientific journals, who has similar information to those used to input and output in this model.

RESULTS AND DISCUSSION

The building of the model allowed to obtain predictions of hot carcass yield (HCY) were simulated as shown in Table 2 using as input variable the percentage of zebu genotype and age of cattle. The smallest deviations between the estimated and predicted values by fuzzy modeling HCY were measured experimentally observed in animals belonging to groups of genotype 100 or 0% Zebu, which showed mean standard errors of 0.34 and 1.02, respectively (Table 2). This performance model should be associated with homogeneity within the herds that comprised these groups of animals, since, as it is defined breeds of animals, the variability is lower than in herds of animals from crossing systems.

Table 2 – Hot Carcass Yield (%; HCY) measured experimentally and simulated by through a fuzzy expert system.

Author	Age at slaughter (months)	Zebu genotype (%)	HCY (%)	Fuzzy Predict	Standard error
Brondani et al. (2004)	14	0	54.95	53.80	1.15
Brondani et al. (2004)	14	0	53.75	53.80	-0.05
Ferreira et al. (2006)	16	0	55.84	53.80	2.04
Menezes et al. (2005a)	24	0	54.40	53.20	1.20
Restle et al. (2000)	24	0	54.20	53.20	1.00
Menezes et al. (2005b)	22	0	54.00	53.30	0.70
				Mean	1.02
Menezes et al. (2005a)	24	25.00	57.30	53.20	4.10
Restle et al. (2000)	24	25.00	55.30	53.20	2.10
Ferreira et al. (2006)	16	31.25	56.07	54.10	1.97
Menezes et al. (2005a)	24	31.25	56.80	54.40	2.40
Ferreira et al. (2006)	16	37.50	56.76	54.30	2.46
Menezes et al. (2005a)	24	37.50	57.50	54.80	2.70
Pacheco et al. (2005)	15	37.50	56.30	54.30	20
Pacheco et al. (2005)	22	37.50	54.10	54.80	-0.70
Ferreira et al. (2006)	24	37.50	54.98	54.80	0.18
				Mean	2.06
Restle et al. (2000)	24	50.00	56.70	55.00	1.70
Restle et al. (2000)	24	50.00	57.20	55.00	2.20
Jaeger et al. (2004)	24	50.00	55.99	55.00	0.99
Jaeger et al. (2004)	24	50.00	56.29	55.00	1.29
				Mean	1.54
Menezes et al. (2005a)	24	62.50	56.70	55.30	1.40
Pacheco et al. (2005)	15	62.50	54.56	55.30	-0.74
Pacheco et al. (2005)	22	62.50	57.51	55.30	2.21
Ferreira et al. (2006)	24	62.50	56.32	54.40	1.92
Menezes et al. (2005a)	24	68.75	57.40	55.50	1.90
Menezes et al. (2005a)	24	75.00	56.60	56.20	0.40
Restle et al. (2000)	24	75.00	56.40	56.20	0.20
				Mean	1.25
Menezes et al. (2005a)	24	100	56.20	56.20	0.00
Restle et al. (2000)	24	100	56.10	56.20	-0.10
Jaeger et al. (2004)	24	100	55.96	56.20	-0.24
Menezes et al. (2005b)	22	100	55.30	56.30	-1.00
				Mean	0.34
				General Mean	1.24

The HCY found in different studies that were used in comparison with the group of zebu genotype 0%, mean 54.52% of HCY, is close to the values reported by BIANCHINI et al. (2007) for yearly Simmental steers, with yield of 53.9% and RESTLE & VAZ (1997), with values of 53.2% for the Hereford cattle.

The average HCY was 56.5% of animals with zebu racial predominance, close to the value reported by ARBOITTE et al. (2004) that report an average yield of 55.9% for steers with 62.5% of zebu genotype.

For animals with genotype 100% zebu, the carcass yield measured experimentally was 55.9%, close to that obtained by fuzzy modeling of 56.2%. Evaluating different diets on feeding Nellore confined steers, Ezequiel et al. (2006) observed HCY mean of 54.9%. In general, the fuzzy model simulated the increase in HCY as the increment of zebu cattle, which is consistent with the observations of RESTLE et al. (1999) who found an increase in cold carcass yield with the increase of degree of zebu genotype on steers.

Age had less influence than HCY in the percentage of zebu genotype (Figure 1). This is explained by the fact that with the increased deposition of adipose tissue with advancing age, there is also greater bone tissue growth (greater weight of legs and head) and increases the deposition of visceral fat, penalized with the toilet in fridge.

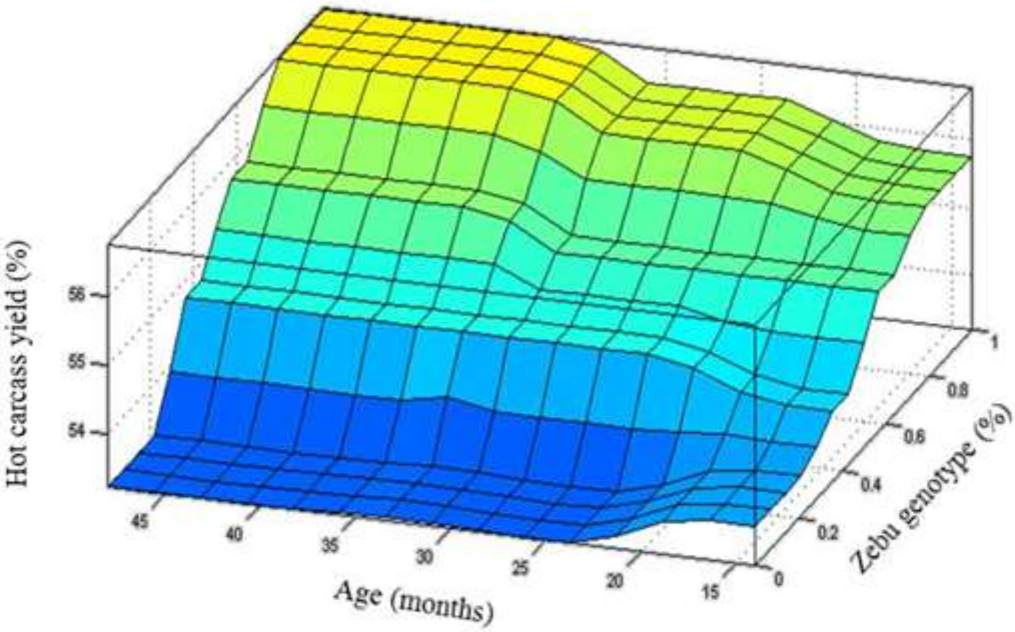

Figure 1 - Hot carcass yield of cattle due to age and degree of zebu blood.

Regarding the influence of genotype on the HCY, there is shown that the major contribution to increased yield. Several authors (CRUZ et al., 2004; KUSS et al., 2005; BIANCHINI et al., 2007; RUBIANO et al., 2009) who studied the HCY of cattle on different genetic groups, reported that animals of zebu genotype have more thin bone and skin, therefore more lighter and less head weight.

The fuzzy expert system presented in this study can be easily implemented in mobile applications with programming Android®. This type of application allows a different user applies it in negotiations for the sale of animals, making them less conflictual when shipping animals for slaughter.

CONCLUSION

The use of expert fuzzy model for prediction of hot carcass yield in cattle is reliable to be possible and generate a predictive model with standard error from the observed relatively low, which may be a help in a time when the industry buy the animals to slaughter. Among the input variables of the model, the genotype of the animal shown to have greater influence, and the model performed better genetically more homogeneous herds.

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