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Research Article

Prediction of Weights and Percentages of Retail Cuts in Holstein Bull Carcasses [1]

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Abstract

This study was made to predict the weights and percentages of retail cuts in Holstein bull carcasses. The study material were 47 Holstein bull (mean slaughter age: 20.57±0.606 months) carcasses. Hot carcass weight (HCW, kg), ribeye area (REA, cm^2) and fat thickness (FT, cm) were used to predict weights and percentages of retail cuts. Bull carcasses were divided into 12 retail cuts and grouped as total retail cuts (TRC), first degree retail cuts (FRC) and second degree retail cuts (SRC). Regression analysis was made (stepwise method) to predict weights and percentages of TRC, FRC and SRC. Slaughter weight (SW), dressing percentage (DP), HCW, REA and FT were determined as average 544.550±6.776 kg; 55.75±0.169%; 303.600±3.948 kg; 85.538±1.978 cm^2 and 0.310±0.023 cm, respectively. All predicted models (F) were found significantly ($P<0.001$; $P<0.01$) in the analysis. As a result, it was found that HCW is most important predictor in predicting the weights and percentages of retail cuts. HCW and REA explained for 94.5% (R^2) of the variation of dependent variable (Y_{TRC}) in the predicted model for weights of total retail cuts (TRC_{kg}). REA and HCW explained for 21.7% (R^2) of the variation of dependent variable (Y_{TRC}) in the predicted model for percentages of total retail cuts ($TRC_{\%}$).

Keywords: *Holstein bull, Carcass yield, Retail cuts, Regression analysis*

Holştayn Tosun Karkaslarında Perakende Parça Ağırlık ve Oranlarının Tahmini

Özet

Bu araştırma Holştayn tosun karkaslarında perakende parça ağırlık ve oranlarını tahmin etmek amacıyla yapılmıştır. Çalışmanın materyalini 47 adet Holştayn tosun (ortalama kesim yaşı: 20.57±0.606 ay) karkasları oluşturmuştur. Sıcak karkas ağırlığı (HCW, kg), kaburga gözü alanı (REA, cm^2) ve kabuk yağı kalınlığı (FT, cm) perakende parça ağırlık ve oranlarının tahmininde kullanılmıştır. Tosun karkasları 12 parçaya ayrılmış ve bu parçalar da toplam perakende parçalar (TRC), birinci derece perakende parçalar (FRC) ve ikinci derece perakende parçalar (SRC) olarak gruplandırılmıştır. TRC, FRC ve SRC ağırlık ve oranlarının tahmininde regresyon (stepwise yöntemi) analizi yapılmıştır. Kesim ağırlığı (SW), karkas randımanı (DP), HCW, REA ve FT sırasıyla ortalama 544.550±6.776 kg; 55.75±0.169%; 303.600±3.948 kg; 85.538±1.978 cm^2 ve 0.310±0.023 cm tespit edilmiştir. Yapılan analizde tüm tahmini modellerin (F) anlamlı ($P<0.001$; $P<0.01$) olduğu belirlenmiştir. HCW'nin perakende parça ağırlık ve oranların tahmininde en önemli belirleyici olduğu tespit edilmiştir. Toplam perakende parçaların ağırlıkları (TRC_{kg}) için tahmin edilen modelde HCW ve REA bağımlı değişkendeki (Y_{TRC}) varyasyonun 94.5% (R^2)'ini açıklamaktadır. Toplam perakende parçaların oranları ($TRC_{\%}$) için tahmin edilen modelde ise REA ve HCW bağımlı değişkendeki (Y_{TRC}) varyasyonun 21.7% (R^2)'sini açıklamaktadır.

Anahtar sözcükler: *Holştayn tosun, Karkas verimi, Perakende parçalar, Regresyon analizi*

INTRODUCTION

Carcass grading systems determine the economic value of a carcass in terms of a difference in yield and flavor characteristics. Nowadays, most carcass grading systems provide a visual evaluation in moving cutting chain that can easily measure parameters of carcasses or retail cuts [1]. The primary purpose of grading is identification of important qualities as commercially and facilitate of the carcass trade [2]. There are various advantages in terms of

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producers and consumers of these applications. Sale of graded carcasses' retail cuts offers an important choice factor for many consumers. In the same way, a graded carcass means the valued sales of a product for producers [3].

Carcass grading systems used around the world differ in terms of the applied techniques [4]. The method used in European Union is only based on visual evaluation and defines the carcass structure according to the 6 basic classification (S, E, U, R, O, P) and external fat level (from 1 to 5) [1]. Other grading methods include certain physical measurement and calculation in addition to the visual evaluation [4]. Example of the most established and widely known in this field is The United States Department of Agriculture (USDA) grading system. It is divided as Yield grades-YG (from 1 to 5) and Quality grades-QG (Prime, Choice, Select, Standard, Commercial, Utility, Cutter and Canner) [5]. USDA YG is based on the yield of boneless, closely trimmed, retail cuts and determined by some factors (fat thickness-FT, ribeye area-REA, hot carcass weight-HCW and percentage of kidney, pelvic and heart fat-KPH%). QG is based upon two factors: degree of marbling and degree of maturity [6].

The Japanese Meat Grading Association (JMGA), the Canadian and South Korean grading systems often have similar characteristics to the USDA grading system. It is observed the differences are in terms of some measurement and classification techniques. The classification method is used as in European Union in Australia (AUS-MEAT) and South Africa. Carcass grading method is applied with different techniques (Carcasses are classified according to yield and maturity status in the sex category) in South America countries (Brazil, Argentina, Uruguay and Chile) [5].

There are some researches about yield and quality grading of beef cattle carcasses. In these researches, FT, REA, HCW (or cold carcass weight-CCW) and KPH% were used to determine the carcass yield; marbling, meat color, fat color, texture, and maturity parameters were used in quality grading. Through these parameters, the weights and percentages of retail cuts were predicted, yield and quality characteristics of the carcasses were compared by type of animal, age and gender, and economic slaughter weight was determined [4,7-13].

There are some studies that are examined the weights and percentages of retail cuts [14] and that researched as economically in beef cattle carcasses in Turkey [15-17]. However, there are limited researches conducted on the carcass yield and quality [18-21]. At the same time, carcass weight and dressing percentage (DP) are taken into consideration in the beef market in Turkey; standard grading method is not applied. Therefore, the quality-price relationship is not established for producers.

In this study, yield of retail cuts was examined belonging to Holstein bull carcasses widely breeding in Turkey. HCW, REA and FT parameters were used to predict the weights and percentages of retail cuts.

MATERIAL and METHODS

Data Collection

Research materials are 47 (mean slaughter age: 20.57±0.606 months) Holstein bull carcasses which are fed in a private farm with the same ration (concentrated feed, alfalfa, maize silage and wheat straw) for approximately 6 months period.

Slaughter of the animals and cutting of carcasses is done in a private slaughterhouse in Ankara Province of Turkey (approved by Afyon Kocatepe University, the Local Ethics Committee on Animal Experiments, 23/05/2013, 49533702/331). Slaughter and cutting procedure was applied according to slaughter and cutting regulations of General Directorate of Meat and Dairy Board [22,23]. Slaughter weight-SW (kg) and HCW (kg) were determined. Carcasses were divided into two parts and chilled for 24 hours (between +2°C and +4°C) in cooling unit. HCW, REA and FT were used to predict weights and percentages of retail cuts. The left half of each carcass was cut between from 11-12th ribs and the REA (the longissimus muscle) and the FT (the subcutaneous fat) were measured. The longissimus muscle area was measured by plastic grid (with 1 cm x 1 cm). The carcasses are divided into 12 retail cuts at the cutting hall (between +8°C and +12°C). Total retail cuts-TRC were classified into first degree retail cuts-FRC (tenderloin, sirloin, rib roast, rump, knuckle, round eye and topside-outside flat) and second degree retail cuts-SRC (chuck, brisket, shoulder, flank and shank).

Each retail cut was weighed on precision scale and weights of retail cuts were determined. The percentages of TRC, FRC and SRC weights were calculated according to HCW [9].

Statistical Analysis

Descriptive statistics (mean, minimum and maximum values) were determined belonging to all variables. HCW, REA and FT parameters (independent variables) were used and multiple linear regression analysis was used to predict the weights and percentages belonging to TRC, FRC and SRC (dependent variables). Stepwise method was used in choosing the independent variables. Correlation analysis of all the variables that included in the model was done.

RESULTS

Descriptive statistics of Holstein bull carcasses are presented in *Table 1*. Approximately 56% of dressing percentage was obtained from animals, which are about 21 months old. Approximately 61% of total retail cuts (TRC) are provided from these carcasses (according to HCW).

Percentage of bones and crumbs (according to HCW) was detected 18.75% and 17.08%, respectively.

Predicted regression models for the weights and percentages of TRC, FRC and SRC are given in *Table 2* and *Table 3*. It was determined that all predicted models (*F*) are significant (*P*<0.001; *P*<0.01) which are using stepwise method in analysis.

It was determined that HCW and REA are the best predictor in predicted model (Y_{TRC}) for TRC_{kg} *(Table 2)*. HCW and REA explained for 94.5% (R^2) of the total variation in Y_{TRC}. According to the partial correlation coefficient (pr^2), HCW (94.3%) is most explanatory variable to REA (11.6%). HCW, FT and REA are predictor in predicted model (Y_{FRC}) for FRC_{kg}. These variables explained for 83.5% (R^2) of the total variation in Y_{FRC}. HCW has most explanatory power (pr^2: 81.2%) than other two variables. This was followed by the FT (16.4%) and REA (11.8%), respectively. It was found that FT's effect is significantly negative on Y_{FRC} in this model. It was determined that HCW was single explanatory variable in the Y_{SRC} model (R^2: 89.2).

It was found that REA and HCW are predictor (R^2: 21.7) in predicted model for $TRC_{\%}$ and it was determined that their variations explanatory power is in Y_{TRC} 11.6% and 10.8%, respectively *(Table 3)*. FT, HCW and REA explained for 44.5% of the total variation in $FRC_{\%}$ and HCW has higher partial correlation coefficient (pr^2: 16.2) according to other two variables. HCW (34.4%) was found single explanatory variable for $SRC_{\%}$.

Table 4 is seen that HCW effects positively to TRC_{kg}, FRC_{kg}, SRC_{kg}, $SRC_{\%}$ (*P*<0.01) and $TRC_{\%}$ (*P*<0.05). REA has only positive effect on the $TRC_{\%}$ (*P*<0.05). FT effects positively to TRC_{kg}, SRC_{kg} (*P*<0.01) and $SRC_{\%}$ (*P*<0.05).

DISCUSSION

In this study, HCW, REA and FT parameters were used to predict the weights and percentages of retail cuts of carcasses. There are some studies, which used by similar methods [7,9,10,12]. CCW was used instead of HCW in other research except Chen et al.[9]. REA and FT measurements

Table 1. *Descriptive statistics of the carcass traits*
Tablo 1. *Karkas özelliklerinin tanımlayıcı istatistikleri*

Parameters	n	Mean	S.E.	Min.	Max.
Slaughter age (month)	47	20.57	0.606	15	37
Slaughter weight-SW (kg)	47	544.550	6.776	420.069	685.114
Hot carcass weight-HCW (kg)	47	303.596	3.948	241.101	391.027
Dressing percentage-DP (%)	47	55.75	0.169	53.74	58.26
Rib eye area-REA (cm^2)	47	85.538	1.978	46.365	119.328
Fat tickness-FT (cm)	47	0.310	0.023	0.113	0.889
Total retail cuts-TRC (kg)	47	186.372	2.785	146.727	246.857
First degree retail cuts-FRC (kg)	47	73.958	0.823	61.502	88.841
Second degree retail cuts-SRC (kg)	47	112.413	2.088	80.902	158.016
Total retail cuts-TRC (%)	47	61.34	0.242	57.32	65.20
First degree retail cuts-FRC (%)	47	24.41	0.153	21.91	27.31
Second degree retail cuts-SRC (%)	47	36.93	0.272	33.57	41.66

Table 2. *Predicted regression models for weight of retail cuts (stepwise method)*
Tablo 2. *Karkas perakende parça ağırlıklarının tahmini regresyon modelleri (stepwise yöntemi)*

Models	Independent Variable	Intercept	Regression Coefficient	*SE*	*t*	*Sig.*	*F*	*Sig.*	*R²*	*pr²*
1 ($Y_{TRC, kg}$)		-29.714		8.408	-3.534	**0.001	378.965	*0.000	94.5	
	HCW		0.678	0.025	27.116	*0.000				94.3
	REA		0.120	0.050	2.397	***0.021				11.6
2 ($Y_{FRC, kg}$)		9.727		4.531	2.147	***0.037	72.405	*0.000	83.5	
	HCW		0.201	0.015	13.601	*0.000				81.2
	FT		-7.277	2.505	-2.905	**0.006				16.4
	REA		0.062	0.026	2.397	***0.021				11.8
3 ($Y_{SRC, kg}$)		-39.261		7.909	-4.964	*0.000	370.628	*0.000	89.2	
	HCW		0.500	0.026	19.252	*0.000				

n: 47, * *P*<0.001, ** *P*<0.01, *** *P*<0.05

Table 3. *Predicted regression models for percentages of retail cuts (stepwise method)*
Tablo 3. *Karkas perakende parça oranlarının tahmini regresyon modelleri (stepwise yöntemi)*

Models	Independent Variable	Intercept	Regression Coefficient	*SE*	*t*	*Sig.*	*F*	*Sig.*	R^2	pr^2
1 ($Y_{TRC,\%}$)		52.181		2.764	18.877	*0.000	6.109	**0.005	21.7	
	REA		0.040	0.016	2.410	***0.020				11.6
	HCW		0.019	0.008	2.314	***0.025				10.8
2 ($Y_{FRC,\%}$)		27.482		1.542	17.818	*0.000	11.483	*0.000	44.5	
	FT		-2.168	0.853	-2.542	***0.015				13.0
	HCW		-0.015	0.005	-2.879	**0.006				16.2
	REA		0.023	0.009	2.648	***0.011				14.0
3 ($Y_{SRC,\%}$)		24.683		2.532	9.747	*0.000	23.582	*0.000	34.4	
	HCW		0.040	0.008	4.856	*0.000				

n: 47, * *P*<0.001, ** *P*<0.01, *** *P*<0.05

Table 4. *Pearson correlation coefficients of the carcass variables*
Tablo 4. *Karkas değişkenlerinin Pearson korelasyon katsayıları*

Variables	HCW	REA	FT	TRC_{kg}	FRC_{kg}	SRC_{kg}	$TRC_{\%}$	$FRC_{\%}$	$SRC_{\%}$
HCW	1.00								
REA	0.09	1.00							
FT	0.48**	-0.03	1.00						
TRC_{kg}	0.97**	0.17	0.45**	1.00					
FRC_{kg}	0.88**	0.24	0.25	0.89**	1.00				
SRC_{kg}	0.94**	0.13	0.49**	0.98**	0.79**	1.00			
$TRC_{\%}$	0.34*	0.35*	0.08	0.56**	0.44**	0.57**	1.00		
$FRC_{\%}$	-0.51**	0.28	-0.52**	-0.42**	-0.04	-0.54**	0.11	1.00	
$SRC_{\%}$	0.59**	0.16	0.36*	0.74**	0.42**	0.82**	0.83**	-0.46**	1.00

** *P*<0.01, * *P*<0.05

are usually carried out on between 12-13th ribs especially the USDA grading system in the world. In Turkey, in particular General Directorate of Meat and Dairy Board slaughterhouses, beef carcasses are quartered from between 11-12th ribs [16]. Thus, REA and FT measurements were made from between 11-12th ribs. In JMGA grading system, the measurement of these parameters is carried out from between 6-7th ribs [5].

In the study, regression analysis with stepwise method was used to examine the quantity and the direction of the relationship between the HCW, REA and FT (independent variables) and the weights and percentages of TRC, FRC and SRC (dependent variables). It is reported long of decades that this method is most popular method used to determine carcass composition [7].

It was found that HCW is most important predictor to predict of the weights and percentages of retail cuts of the carcasses. In addition, HCW affects positive all variables except the $FRC_{\%}$. High correlation was found between HCW and the weights of TRC (0.97), FRC (0.88) and SRC (0.94) *(Table 4)*. In a previous study, it was reported that high correlation between (0.96) HCW and weights of total retail cuts [9]. In another study, it was detected high correlation (0.94) between CCW and weights of total retail cuts [10]. It was determined that increase in HCW or CCW, increases REA and FT linearly [13].

REA is most important predictor after HCW in prediction of weights and percentages of the TRC and FRC. REA was found insignificant prediction of weights and percentages of SRC. REA affects positively all variables except the FT. Chen et al.[9] found a similar situation in their research. Carcass weight, sex, nutritional status and measurement location (11-12th rib section) may have been affected the average value determined for the REA (85.538±1.978 cm^2) which differ from some research results. In some research, REA was reported between 68.13-84.3 cm^2 [9-12]. In studies from Turkey, REA values belonging to Brown Swiss, Charolais x Brown Swiss, Charolais and Eastern Anatolian Red steers, Friesian and Friesian Crossbreeds were measured between 64.73-101.15 cm^2 [18-21].

FT has only been predictor in the prediction of weights and percentages of FRC. FT explained alone (pr^2) for 16.4%

and 13.0% of the variation of $Y_{FRC, kg}$ and $Y_{FRC, \%}$ respectively. However, FT has negative impact both on the weights and percentages of FRC. The determined average values for FT (0.301±0.023 cm), as in the REA which can be expected to differ depending on the results of other research depending on carcass weight, sex, nutritional status and place of measurement (11-12th ribs section). In studies which done with carcasses belonging to different animal breeds, FT was reported between 0.58 - 0.96 cm [9,10,12]. In the study conducted in Turkey FT was measured between 0.29 - 0.93 cm [18-20].

In Japanese Black steers carcasses, which measurements carried out in the 6-7th ribs, REA and FT were determined 42.7 cm^2 and 2.6 cm, respectively. In the same study, age, slaughter weight and CCW were reported 27.3 months, 635.5 kg and 402.6 kg, respectively [7].

As a result; in this study, regression models were predicted for weights of TRC ($Y_{TRC, kg}$ = -29.714 + 0.678HCW + 0.120REA), and percentages of TRC ($Y_{TRC, \%}$ = 52.181 + 0.040REA + 0.019HCW) in Holstein bull carcasses. Total yield of retail cuts can be predicted for Holstein bull carcasses by these models which using HCW and REA values. Likewise, regression models were predicted for weights of FRC ($Y_{FRC, kg}$ = 9.727 + 0.201HCW - 7.277FT + 0.062REA), and percentages of FRC ($Y_{FRC, \%}$ = 27.482 - 2.168FT - 0.015HCW + 0.023REA). First degree retail cuts yield can be calculated which using HCW, REA and FT values. HCW is just enough to know for second degree retail cuts yield. It should be noted that predicted regression coefficients changed if there is a difference in the number of carcass, animal breed, slaughter age, sex, nutrition, carcass weight (HCW or CCW) and measurement techniques (for REA and FT).

The regression coefficients can be determined for HCW, REA and FT in beef carcasses belonging to different breeds in Turkey. More research needs to be done on the subject in the future. In this study, a survey was conducted for the yield level of the beef carcasses. Carcass grading methods has been improved both for yield and quality in the world. Turkey is located in a major shortcoming in this subject; meat standards should be improved at the national level for the different breed of cattle carcasses with future studies.

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