TOTAL SCORE AS A GENETIC INDEX OF MEAT QUALITY TRAITS IN CHIANINA BEEF CATTLE

IL TOTAL SCORE QUALE INDICE GENETICO DELLA QUALITÀ DELLA CARNE DELLA RAZZA CHIANINA

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SUMMARY

The aim of this research was to study a Total Score Index, capable to resume the meat quality traits, and useful for improvement programs. The quality of meat from the *Longissimus dorsi* muscle, of 82 Chianina bulls, was analysed. The animals, reared in two Tuscan farms with different feeding-programs, were slaughtered at about 19 months of age. Colour traits, observed before and after 48 h of storage, tenderness traits, water-holding capacity and chemical composition were considered. Three sub-indexes (Appearance Index "A_I", Quality Index "Q_I" and Chemical Composition Index "CC_I") were defined and they contributed, after weighing, to the Total Score and to the relative Total Selection Index "TS_I". All indexes allowed us to determine differences due to environmental variability (breeding farm), biological factors (age at slaughter) and genetic factors, such as the family and the place of origin of the sires. A methodological model is proposed in this study, that did not pretend to resolve the issue of evaluating meat quality for the purpose of genetic improvement. In addition, since the consumer has the irreplaceable task of evaluating the complex set of his sensation when buying, cooking and eating a particular cut of meat, it is, therefore, obvious that the relative influence of single parameters may change over time according to the changing tastes.

Keywords: Total Score Index; meat quality; Chianina breed.

RIASSUNTO

La ricerca ha avuto l'obbiettivo di tentare la definizione di un indice di selezione globale semplificato di caratteri multipli e complessi quali quelli della qualità della carne. A tale

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scopo è stata analizzata la qualità della carne proveniente dal muscolo Longissimus dorsi di 82 soggetti di razza Chianina, suddivisi in famiglie di mezzi fratelli di padre. Gli animali, appartenenti a due allevamenti della Toscana che adottavano differenti piani alimentari, sono stati macellati ad un'età di circa 19 mesi. Sono stati presi in considerazione i parametri di colore, prima e dopo conservazione in frigo per 48 ore (L*, a*, b*, C* e H*), di tenerezza, la capacità di ritenzione idrica e la composizione chimica. Scelti opportunamente i parametri da utilizzare all'interno di ogni categoria, sono stati elaborati tre sotto-indici (Indice di Aspetto "I_A", Indice di Qualità "I_Q" e Indice di Composizione Chimica "I_{CC}"), che hanno contribuito, dopo successiva ponderazione, alla formazione del Total Score e del relativo Indice (I_{TS}).

L'indice così elaborato ha permesso di evidenziare differenze dovute a fattori di variabilità ambientale (allevamento), biologica (età alla macellazione) e genetica quale la famiglia e l'area di origine dei padri. In particolare, per l'aspetto genetico, il TS si è dimostrato l'indice selettivo più efficace per ottenere un miglioramento equilibrato di tutti i parametri di qualità e l'unico in grado di evitare indesiderati effetti negativi. Considerati i positivi risultati ottenuti, la ricerca proseguirà per recepire nel modello TS, possibilmente semplificato, i suggerimenti degli operatori di filiera (produttori, commercializzatori e consumatori) per rendere il TS adottabile quale indice genetico integrativo dei riproduttori chianini.

Parole chiave: Total Score Indice; qualità della carne; Razza Chianina.

INTRODUCTION

The knowledge of meat quality traits is of great importance for the Chianina breed, in order to preserve its well-known qualitative attributes. The breed shows, however, a high degree of variability for many qualitative parameters requiring attention on both managerial as well as genetic factors. In addition to the choice of the most significant and heritable parameters (Cecchi et al., 2004), it would be, therefore, interesting to define a composite index representing all parameters, properly arranged according to the consumer's point of view.

The consumer is inclined to assess meat quality from its appearance, but even more from its rheological properties (tenderness, juiciness), usually neglecting nutritional characteristics, which are less easy to estimate. The present study attempted to define a composite selection index according to the outline proposed by Robinson (1990), capable of summarising the complex trait defining meat quality in a single estimate.

The Total Score here proposed is a simplified form of the total (or aggregate) Economic Genetic Index (EGI), also known as Overall Economic Value or Total Genetic Index (TGI), used for the selection of multiple traits (Nicholas, 1988; Minvielle, 1990; Falconer & Mackay, 1996; Lynch & Walsh, 1998; Pagnacco, 2004).

MATERIALS AND METHODS

Animals

Meat quality traits from 82 young Chianina bulls raised in two farms in Tuscany were analysed. Animals were slaughtered at approximately 19 months of age, after reaching a live weight of about 770 kg. The farms supplying the animals followed different feeding plans: the first farm using corn-silage as basic fodder, while the second providing hay.

The animals were chosen according to their genealogical data and to areas of origin of their fathers, in order to form groups of paternal half-sibs and to distinguish three breeding (Pisa and Livorno composing the first area, Arezzo and Florence the second, Siena the third), based on the genetic similarities among provinces detected in previous studies carried out on the same breed (Cecchi et al., 2001a; Ciampolini et al., 2003).

Meat instrumental measurements and chemical analysis

According to the commercial ageing periods for Chianina carcasses, approximately 19 days after slaughtering, the *Longissimus dorsi* (*Ld*) muscle was taken and analysed instrumentally (ASPA, 1991) as follows:

Meat colour

Using a Minolta CR300 colourmeter (illuminant C), calibrated against a standard white tile in the CIE L*a*b* system, which measures the value of lightness (L*), redness (a*), yellowness (b*), saturation (C*) and Hue (H*) co-ordinates (Renerre, 1982); three different measures were made on each sample, consisting of a 2.5-cm thick slice of meat covered with a polyethylene film and refrigerated for 45 min at 4°C.

Meat colour after 48 h

On the same samples as above kept at 4°C for 48 h to show possible alteration of colour during meat storage (L*48, a*48, b*48, C*48 and H*48).

Water-holding capacity (WHC)

Water-holding capacity (WHC) determined using two different methods:

- *Drip loss*, as the weight loss of the meat sample used for colour determination, kept at 4°C for 48 h in a plastic container with a double bottom (Lundström and Malmfors, 1985);
- *Cooking loss* on the meat sample used for drip loss, as the percentage of weight loss during cooking in a ventilated oven at 180°C to an internal temperature of 75°C; the sample temperature was detected using a thermocouple thermometer HANNA H192704C (Hanna Instruments, Padua, Italy).

Tenderness, measured as shear force, using Warner Bratzler Shear applied to an Instron 1011, on 1-inch-diameter cylinders of raw and cooked meat.

Chemical analysis

Dry matter, ether extract, crude protein and ash (A.O.A.C., 1990).

All data were corrected for the time of aging of meat, when significant, and the average values and standard deviations of each parameter were then calculated.

Definition of sub-indexes

To develop the sub-indexes and the Total Score Index, the choice of parameters to be considered was based on the demand of the average Italian consumer who tends to prefer meat with a clear Hue (H*), a high value of lightness (L*), which loses little weight and maintains its clear Hue (H*48) and brightness (L*48) during its domestic storage. Consumers also prefer nice tasting meat that is more tender after cooking and has limited moisture loss.

The results were then stratified in two classes:

- class 1 = positive: above the average values for crude protein, ether extract, dry matter, L*, L*48, H*, H*48; below average values for drip loss, cooking loss, and shear forces, that are more appreciated if they present low values;

- class 2 = negative: all the others

The analysis of variance between the two classes of each parameter showed highly significant differences so that the establishing of other stratification of the characteristics was not considered necessary. The index of each subject was calculated by assigning each group of variables a chosen subjectively score considering its relative importance.

1) *Quality Index* (Q_I) - Lightness and Hue after 48 h of storage (L*48 and H*48 respectively), cooking loss and shear force on cooked meat (variables classified as being the most important) were considered, assigning the following points: $Q_I = 0$ if all variables belong to class 2; $Q_I = 1$ if shear force on cooked meat belongs to class 2 and one or two other variables belong to class 1; $Q_I = 2$ if shear force on cooked meat belongs to class 1 and the other variables to class 2; $Q_I = 3$ if shear force on cooked meat and another variable belongs to class 1; $Q_I = 4$ if shear force on cooked meat and two other variables belong to class 1; $Q_I = 5$ if all variables belong to class 1.

2) *Appearance Index* (A_I) - The drip loss was accepted as being of the greatest importance compared to L* and L*48, H* and H*48 and the following points were then assigned: $A_I = 0$ if all variables belong to class 2; $A_I = 1$ if drip loss belongs to class 2 and all other four variables belong to class 1; $A_I = 2$ if drip loss belongs to class 2 and all other variables belong to class 1, or else drip loss and another variable belong to class 1; $A_I = 3$ if drip loss and two or three other variables belong to class 1; $A_I = 4$ if all variables belong to class 1.

3) *Chemical Composition Index* (CC_I). For this evaluation, the percentages of crude protein, ether extract and dry matter were considered and the protein percentage was considered to be the most important variable: $CC_I = 0$ if all variables belong to class 2; $CC_I = 1$ if ether extract and dry matter belong to class 1 and crude protein to class 2; $CC_I = 2$ if crude protein belongs to class 1 and all other parameters belong to class 2; $CC_I = 3$ if all parameters belong to class 1.

Definition of the Total Score Index

The Total Score method consists of the following steps:

- the relative importance of each index was considered and the coefficient 1 assigned to the least important group and higher coefficients to the other indexes. Considering that consumers cannot appreciate nutritive parameters while color is the most important as first impression at buying, for this investigation, the following coefficients were assigned: Chemical Composition Index = 1, Appearance Index = 3, Quality Index = 4.

The Total Score for each animal was therefore: $TS = 4Q_I + 3A_I + 1CC_I$.

The Selection Index was obtained by dividing the Total Score of each individual by the maximum possible value of TS and multiplying by 100. It gives an estimate of the worth of the individual on a percentage scale, with $TS_I = (TS/35)*100$ where 35 is the maximum score an animal could attain [$TS_{max} = 4(5) + 3(4) + 1(3) = 20 + 12 + 3 = 35$]. It is obvious that high selection index scores represent excellent meat quality.

Statistical analysis.

TS_I was divided into 5 classes each with class ranges of 20 score (from <20 to >80); the number of animals in each class interval and the relative frequency within the source of variability (age at slaughter, sires area of origin, breeding farm and family) were calculated. The differences between the values of each trait and of each index within the sources of variability were tested using the following models:

model 1: data concerning age at slaughter, sires area of origin and breeding farm:

$Y_{ijkl} = \mu + H_i + D_j + SA_k + \varepsilon_{ijkl}$, where Y_{ijkl} = considered parameters; μ = overall mean; H_i = fixed effect of the ith herd (I = 1,2); D_j = fixed effect of the jth class of age at slaughtering (class1< 19 months and class 2 > 19 months); SA_k = fixed effect of the kth sires area of origin (k = 1, 2, 3); ε_{ijkl} = residual error. For the comparison of traits and indexes on different families but belonging to the same rearing methods and then submitted to the same managerial treatment and feeding plans, only two families of rearing 1 were considered.

model 2: data concerning the two families of farm 1:

$Y_{ij} = \mu + F_i + bX_{ij} + \varepsilon_{ij}$, where Y_{ij}= considered parameters; μ = overall mean; F_i = fixed effect of the ith family (i=1,2); b = regression coefficient on the age at slaughter in days (X_{ij}); X_{ij}= age at slaughter in days; ε_{ij} = residual error. The experimental data obtained were analysed by SAS (2002).

A verification process has been developed to evaluate if the selection applied on tenderness (the most important parameter for the consumer), could select also the other quality parameters. It has been choosen the 25% of subjects with the best values of shear force on raw and cooked meat and of Total Score Index. For these parameters we evaluated the average values of quality traits, and compared them with the average values of other individuals, by applying the following model:

model 3: $Y_{ijklm} = \mu + H_i + D_j + SA_k + B_l + \varepsilon_{ijklm}$ where Y_{ijklm} = considered parameters; μ = overall mean; H_i = fixed effect of the ith herd (i = 1, 2); D_j = fixed effect of the jth class of age at slaughter (class1< 19 months and class 2 > 19 months);

SA_k = fixed effect of the k[th] sires area of origin (k = 1, 2, 3); B_l = fixed effect of the l[th] group of selection for shear force on raw meat or shear force on cooked meat or for Total Score Index (l=1 the best 25%; 2= the other 75% of the population); ε_{ijklm} = residual error.

RESULTS AND DISCUSSION

Parameters and Indexes variability

Table I reports differences in meat quality traits and in the indexes for the two farms: as regards meat colour, Farm 2 showed a significant higher value of H* and

Tab. I. Meat quality traits and indexes: differences among farms.

	Farm 1 (n = 33)	Farm 2 (n = 49)	Error Mean Square
Chemical composition:			
Dry matter	25.34	25.72	1.03
Ether extract	1.68 B	2.37 A	0.86
Ash	1.00	1.01	0.01
Crude protein	22.66	22.35	0.98
Meat colour:			
L*	42.07 b	43.45 a	2.23
a*	25.88	25.74	2.26
b*	12.43	12.77	1.64
C*	28.66	28.73	2.70
H*	25.39 B	26.32 A	1.49
After 48 h of storage:			
L*	41.93 B	43.41 A	2.14
a*	25.82	26.71	3.05
b*	12.68 b	14.21 a	1.75
C*	28.69	29.85	2.54
H*	26.10 B	26.95 A	1.42
Shear force:			
on raw meat	10.58	10.81	9.64
on cooked meat	7.63	7.38	2.38
Water-holding capacity:			
Drip loss	1.97 a	1.52 b	0.57
Cooking loss	28.75	30.36	20.63
Index:			
Appearance "A_I"	1.33 B	2.31 A	1.24
Quality "Q_I"	2.00	2.55	1.59
Chemical Composition "CC_I"	1.28	1.39	1.07
Total Score "TS_I"	28.56 B	52.59 A	16.80

On row: a, b: P≤0.05; A, B: P≤0.01.

L* both before and after 48 h of storage and of b* after storage, and consequently meat was more agreeable as to colour characteristics. The two farms considered recorded also a significant higher ether extract percentage and a lower drip loss for farm 2 compared to farm 1; so it showed a significantly higher Appearance Index (2.31 vs. 1.33 of farm 1; P≤0.01) and a significantly higher TS_I (52.59 vs. 28.56 respectively; P≤0.01). Quality Index and Chemical Composition Index were similar in the two farms. In farm 2 there is a higher percentage of animals (Tab. II) with a total score of more than 60 (40.82% vs. 18.18%) and a lower percentage of subjects with a score of less than 40 (28.57 % vs. 54.54%).

Between the two families from farm 1 (Tab. III), family B while presenting better values in all chemical composition traits and consequently in CC_I (1.80 vs. 0.93; P≤0.01), obtained a significantly lower A_I (0.87 vs. 1.87; P≤0.01) even if drip loss, L* and H* both before than after storage were similar; instead, a*, b* and C* both after than before storage were resulted significantly lower then in family A. Bulls of family B gave very tender meat, as shown by lowest shear force before and after the cooking process; drip loss was similar in the two family even if higher in family B, while cooking loss was better in this last family which consequently obtained also a significantly higher Q_I (2.67 vs. 1.94; P≤0.05) and a significantly higher TS_I (44.76 compared to 23.23 of family A; P<0.01). In fact, family A (Table 2) presents a higher percentage of subjects with a score of less than 20 (18.75% vs. 13.33%), and no subject with a total score of more than 80 (compared to 13.33% in the other family).

There were not many significant differences in meat quality between bulls divided by different sires area of origin (Tab. IV); only dry matter percentage and drip

Tab. II. Percentage distribution of the subjects divided according their Total Score Index within different variability factors.

	Total Score Index classes				
	<20	20-40	40-60	60-80	>80
Farms:					
1	15.15	39.39	27.27	12.12	6.06
2	8.16	20.41	30.61	20.41	20.41
Families of farm 1:					
A	18.75	50.00	18.75	12.50	0.00
B	13.33	26.67	33.34	13.33	13.33
Sire origin areas:					
1 (PI; LI)	15.75	42.11	21.05	10.53	10.53
2 (AR; FI)	10.81	24.32	32.43	18.92	13.51
3 (SI)	8.00	24.00	28.00	20.00	20.00
Age at slaughter:					
<19 month	8.16	34.69	30.61	14.29	12.25
>19 month	15.15	18.18	27.27	21.21	18.18

Tab. III. Meat quality traits and indexes: differences among the two families of farm 1.

	Family A (n = 16)	Family B (n = 17)	Error Mean Square
Chemical composition:			
Dry matter	22.93	24.02	0.26
Ether extract	0.96 b	1.65 a	0.72
Ash	1.02	1.02	0.03
Crude protein	20.96	21.35	0.97
Meat colour:			
L*	41.68	42.55	1.89
a*	28.65 A	26.46 B	1.67
b*	13.47 a	12.41b	1.25
C*	31.67 A	29.24 B	2.03
14*	25.04	24.95	1.08
After 48 h of storage:			
L*	42.32	41.47	1.85
a*	28.57 A	23.65 B	2.65
b*	13.79 A	11.36 B	1.58
CI'	31.72 A	26.09 B	3.03
H*	25.67	25.72	1.62
Shear force:			
on raw meat	28.58 A	16.22 B	13.98
on cooked meat	10.53 A	7.90 B	1.44
Waterholding capacity:			
Drip loss	1.60	1.98	0.17
Cooking loss	32.37 A	27.62 B	19.76
Index:			
Appearance "A1"	1.87 A	0.87 B	1.03
Quality "Q"	1.94 b	2.67 a	1.48
Chemical Composition "CC_I"	0.93 B	1.80 A	0.79
Total Score "TS_I"	23.23 B	44.76 A	21.21

On row: a, b: P≤0.05; A, B: P≤0.0l.

loss were different and the province of Pisa and Livorno showed the worst values so they had lower score in Appearance Index (P≤0.01), as opposed to that of the other provinces. On the contrary, Siena recorded the highest score for A_I and TS_I. As reported in Tab. II, Siena showed a lower percentage of subjects with scores lower than 40 (32.00% vs. 57.86% from the area including Pisa and Livorno) and a higher percentage of subjects with scores higher than 60 (40.00% vs. 21.06%). The geographic area comprising Arezzo and Florence occupies an intermediate position. Siena, which has a great number of sires approved for reproduction since the beginning of performance tests (Cecchi et al., 2001b), and which offers a wide genetic variability

Tab. IV. Meat quality traits and indexes: differences between bulls divided for sires area of origin.

	Area 1 (n = 20)	Area 2 (n = 37)	Area 3 (n = 25)	Error Mean Square
Chemical composition:				
Dry matter	25.17 b	25.80 a	25.57 a	0.98
Ether extract	1.85	2.16	2.18	0.69
Ash	1.00	1.01	0.01	0.01
Crude protein	22.31	22.63	22.38	0.98
Meat colour:				
L*	41.85	43.13	43.13	3.42
a*	25.05	26.17	25.85	2.79
b*	12.08	12.76	12.82	2.25
C*	27.80	29.06	28.86	3.42
H*	25.41	25.96	26.24	1.99
After 48 h of storage:				
L*	41.67	43.12	42.94	3.19
a*	25.48	26.63	26.68	2.92
b*	12.58	14.19	13.50	1.83
C*	28.30	29.82	29.63	3.37
H*	26.23	26.66	26.76	1.36
Shear force:				
on raw meat	10.23	11.16	10.52	7.74
on cooked meat	7.90	7.29	7.41	2.32
Water-holding capacity:				
Drip loss	2.41 A	1.48 B	1.53 B	0.21
Cooking loss	28.85	29.67	30.32	15.29
Index:				
Appearance “A_I”	1.16 B	1.97 A	2.32 A	1.11
Quality “Q_I”	2.26	2.30	2.48	1.52
Chemical Composition “CC_I”	0.89	1.49	1.44	0.79
Total Score “TS_I”	32.34 b	47.41 ab	52.34 a	16.22

On row: a, b: P≤0.05; A, B: P≤0.01.

(Cecchi et al., 2001a; Ciampolini et al., 2003), justifies the great demand for its male breeding stock with its higher TS_I, and its superiority in meat quality as well.

There were no differences in water-holding capacity, in shear force and in meat colour before storage among bulls slaughtered at different ages (Tab. V), but there were significant differences in some colour parameters revealed after storage (a*, b* and C*; P≤0.05), and in ether extract percentage (P≤0.01) higher in the bulls slaughtered after 19 months (Preziuso & Russo, 2004). All Indexes tended to be superior in the sires slaughtered at an age of more than 19 months, especially with regard to the CC_I (1.91 vs. 0.94; P≤0.01).

Tab. V. Meat quality traits and indexes: differences among bulls slaughtered at different ages.

	Age at slaughtering		
	<19 months (n = 49)	>19 months (n = 33)	Error Mean Square
Chemical composition:			
Dry matter	25.43	25.78	1.36
Ether extract	1.86 B	2.42 A	1.24
Ash	1.00	1.01	0.02
Crude protein	22.56	22.34	0.91
Meat colour:			
L*	42.99	42.75	2.75
a*	25.63	26.04	2.24
b*	12.54	12.76	1.69
C*	28.51	28.97	2.69
H*	25.95	25.94	1.42
After 48 h of storage:			
L*	42.75	42.91	2.45
a*	25.83 a	27.12 b	2.28
b*	12.95 b	14.55 a	5.22
C*	28.72 b	30.37 a	2.50
H*	26.55	26.70	0.93
Shear force:			
on raw meat	10.49	11.05	7.96
on cooked meat	7.39	7.62	1.71
Water-holding capacity:			
Drip loss	1.74	1.64	0.84
Cooking loss	29.08	30.65	12.62
Index:			
Appearance "A_I"	1.84	2.03	1.33
Quality "Q_I"	2.31	2.36	1.72
Chemical Composition "CC_I"	0.94 B	1.91 A	1.01
Total Score "TS_I"	44.76	49.87	18.98

On row: a, b: P≤0.05; A, B: P≤0.01.

The applicability to selective aims

The verification process has confirmed the utility of the Total Score Index, because it has pointed out that the selection for tenderness, evaluated before cooking doesn't involve any other quality traits (Tab. VI). Nothworthly, better results could be obtained with the selection based on shear force measured on cooked meat because it is linked to a lower cooking loss and to a significantly higher Quality Index (P<0.01); yet it would have a significantly worst Appearence Index determined from lower colour traits. Such meat could be less attractive for the consumer

Tab. VI. Meat quality traits and indexes: differences among the 25% of subjects with the best value and the others.

	Shear force								
	On raw meat			On cooked meat			Total Score Index		
	The best ones (n = 20)	The others (n = 67)	Error Mean Square	The best ones 20	The others 67	Error Mean Square	The best ones 20	The others 67	Error Mean Square
Chemical composition:									
Dry matter	25.84	25.48	1.13	26.00	25.43	1.12	25.32	25.65	1.04
Ether extract	2.22	2.05	1.08	2.17	2.06	1.07	2.06	2.10	0.97
Ash	1.00	1.01	0.02	1.01a	1.00b	0.02	1.01	1.00	0.02
Crude protein	22.62	22.43	0.84	22.81a	22.36b	0.82	22.24	22.55	0.90
Meat colour:									
L*	43.75	42.62	2.82	42.04	43.17	2.72	44.43A	42.40B	2.65
a*	25.57	25.87	2.46	25.42	25.92	2.45	26.06	25.71	2.41
b*	12.75	12.59	1.73	12.18	12.78	1.24	13.24	12.43	1.51
C*	28.50	28.76	2.96	28.08	28.89	2.57	29.14	28.56	2.76
H*	26.37	25.81	1.49	25.46	26.10	1.61	26.75A	25.69B	1.52
After 48 h of storage:									
L*	43.69	42.53	2.74	41.97	43.08	2.60	44.73A	42.19B	2.44
a*	25.65	26.57	2.55	26.15	26.41	2.75	27.03	26.13	2.37
b*	13.02	13.78	3.61	14.38	13.34	3.51	14.04	13.45	3.09
C*	28.77	29.58	2.96	29.18	29.45	2.91	30.41	29.05	2.86
H*	26.81	26.55	1.15	26.26	26.72	1.08	27.47A	26.34B	1.11
Shear force:									
on raw meat	7.93B	11.62A	1.96	11.11	10.59	2.53	10.91	10.65	2.48
on cooked meat	7.09	7.60	1.58	5.88B	5.88A	1.30	6.56B	7.78A	1.50
Waterholding capacity:									
Drip loss	1.67	1.71	0.98	1.66	1.72	0.98	1.55	1.75	1.70
Cooking loss	29.65	29.73	5.62	27.44b	30.44a	5.46	27.73b	30.35a	5.50
Index:									
Appearance “A_I”	2.25	1.28	1.91	1.40b	2.08a	1.30	2.95A	1.58B	1.19
Quality “Q_I”	2.80	2.18	1.59	3.40A	1.98B	1.49	4.45A	1.64B	1.05
Chemical Composition “CC_I”	1.55	1.26	1.11	1.70	1.21	1.10	1.25	1.35	1.12
Total Score “TS_I”	55.71	43.96	23.38	55.71	43.96	21.47	79.71A	36.22B	14.67

On row, for the same trait; a, b; P≤0.05; A, B; P≤0.01.

that initially chooses meat above all for the colour. Instead the subjects with the higher Total Score Index presented at the same time a more tender meat with reduced cooking loss and the best colour traits and also the best Indices with the exception of the Composition one that however didn't show differences in comparison with the Index of the other subjects.

CONCLUSION

The different feeding plans of the two farms resulted in significant differences mainly in colours and water-holding capacity after storage and consequently in Appearance Index. Significant difference in ether extract percentage was also found between the farms, but the CC_I index did not attain to evidence. Between the two families of farm 1 and among areas of origin of the fathers, significant differences in Appearance Index were evidenced. The single parameters (drip loss, L*, L*48, H*, H*48) resulted in a non-significant difference (except for drip loss between different sires areas of origin). The only index with significant differences between animals slaughtered at different age was CC_I, reflecting the scenario observed for single traits.

The study did not pretend to resolve the issue of evaluating Chianina meat quality for the purpose of genetic improvement, but aimed at proposing a methodological model. The consumer has the irreplaceable task of evaluating the complex set of his sensations when buying, cooking and eating a particular cut of meat (Poli, 1997). Therefore, it is obvious that these parameters may change over time according to the changing tastes of the consumer.

Nevertheless, the Total Score Index of meat from the *Longissimus dorsi* muscle, calculated by considering a wide range of attributes, even chosen and weighted in a subjective manner, provided satisfactory indications to be a suitable method to evaluation of a complex trait like meat quality.

The Total Score Index has in fact enabled us to demonstrate how the qualitative differences of meat were due to environmental factors (such as the breeding farm), biological factors (such as age at time of slaughter), and those of genetic nature such as the family and the place of origin of fathers.

Besides, it has been pointed out that a selection conducted exclusively on tenderness, before and after cooking is completely unable to improve the meat quality in all the aspects requested from the consumer, while the Total Score Index seems useful and effective in representing a high quality meat.

The research will proceed amplifying the number of tested animal, trying to semplify the procedures by reducing the quality parameters needed for the TS_I and estimating its heritability. The aim is to evaluate if the meat quality selection index, calculated according to the Total Score, could be adopted as an integrative index for Chianina progeny tests. Besides, it is necessary to improve the efficacy of selection by controlling more carefully extragenetic factors

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