Effect of environment, feed, management, load, transport, unloading and slaughter on carcass pH and health of veal calves

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Abstract—**A study was conducted to evaluate the influence of different aspects of animal welfare on animal health, carcass weight and meat pH. A total of 41 variables related to animal, nutrition, housing system and transport were checked on 17 farms. 514 calves (51% Fresian breed, 48% crossbreed, 1% others), were observed. Data regarding these calves were collected at slaughter. Animal age and hot carcass weight were recorded. At 60 minutes post-mortem pH within *longissimus thoracis* was measured. Frequency analysis indicated: chronic or acute lung disease in about 15% of animals; a very high level of gastric lesions (ranging from 68% to 100%; average 84.9%). Correlation analysis showed that larger livestock facilities correlated to higher lung disease frequency; high density of animals in breeding pens confirmed a slower growth tendency; prolonged loading of the animals lowered meat pH. Analysis of variance showed: no statistical differences on use of whole, soaked or micronized maize on the pathology of abomasum. Short-term stress affects the meat quality of veal calves and the health problems are correlated with defects in animal housing. Stress management in the short term should be more carefully managed.**

Keywords— **veal calves, welfare, carcass pH.**

I. INTRODUCTION

Worldwide, surplus male dairy calves are mainly used for veal production in specialized fattening units under intensive rearing conditions. Italy is one of the main producing countries with a yearly production of more than 0.5 million of veal calves [1]. However veal calf production has been strongly criticized for poor animal welfare [2]. To fulfil the physiological and behavioural demands of the calf, a specific European legislation for their protection set a ban on the individual cage and added the provision of solid feed in addition to the all-liquid diet [3]. The farmers achieved relevant improvements of calf behaviour and productive performance after the introduction of the group housing [4, 5, 6]. Moreover, the compulsory provision of increasing amounts of solid feed in addition to the all-liquid diet reduced abnormal oral behaviours [7] and promoted rumen development [8].

However veal calves breeding involves short-term stress that influences quantity and quality of products and long-term stress that affects animal health. Although the level of stress cannot be measured directly, it can be estimated using physiological responses that are reflected in different parameters [9].

Despite recent advances in veal production, calf welfare is still compromised by gastrointestinal disorders such as rumen mucosal alterations and abomasal lesions [10].

Various factors have been reported as responsible for glycogen depletion [11]: time and handling during transportation from farm to slaughterhouse, waiting time at slaughterhouse, climatic factors, social disruption, and the novelty of pre-slaughter environment. The influence of the post mortem decrease in pH and temperature on meat quality characteristics is widely demonstrated.

These correlations are very important both for farmers and consumers in order to improve ethical, economic and quality aspects of veal calves welfare.

Therefore, the aim of this study was to evaluate the influence of several factors on veal calves welfare, as well as their relationship with animal health (expression of long-term stress) and carcass pH (expression of short-term stress)

II. MATERIALS AND METHODS

A sample of 17 farms, rearing veal calves, was chosen to study feeding plans, breeding conditions, housing system and transport to slaughterhouse. A randomized group of 514 male veal calves, belonging

to the same batch of farms, were followed at the slaughterhouse at the end of their cycle.

Specific data by our own protocol, regarding veal calves breeding, housing, feeding treatment, structural and managerial aspects of loading, unloading and transport to slaughterhouse were gathered from an interview and measurements carried out on each farm.

At the abattoir abomasa and lungs belonging to 514 calves were checked during the post mortem examination.

Meat pH and temperature of 514 carcasses were measured 60 minutes *post mortem* in the *Longissimus thoracis* at 12th rib, on right side with a portable pH meter PH 25 with a penetration probe 50 T (Crison, Spain). Age of animals and hot carcass weight were also recorded.

Data analysis was performed by SAS/ STAT in SAS 9.2 [12] using one-way analysis of variance (GLM) and treatment as independent variable. Results are expressed as LSmeans and MSE. A Pearson correlation analysis was performed among continuous variables.

Table 1Farm means and standard deviation (SD) values for variables (N=17)

Item		Mean	SD
Animal			
Age	d	223.4	23.53
Farm			
Animals/pen	n	4.7	0.98
Loading			
Length	m	18.7	8.49
Duration	min	37.2	13.29
Ramp slope	%	24	17.6
Noise	0:low-6:high	4.6	1.02
Animal management	0:poor-6:good	3.6	1.41
Transport			
Distance	km	84.6	46.40
Estimated speed	km/h	70.6	15.08
Health			
Respiratory diseases	%	14.3	18.42
Abomasal diseases	%	84.9	10.63
Carcass characteristics			
Carcass weight	kg	172.4	29.07
pH_1 *Longissimus thoracis*		6.49	0.08
Temperature 1h	°C	35.8	1.95
$6.0 \geq pH_1 \leq 6.8$	%	90.0	7.90
$pH_1 < 6.0$	%	2.7	3.40
$pH_1 > 6.8$	%	7.3	9.10

III. RESULTS AND DISCUSSION

Main descriptive statistics for the studied variables are in Table 1. Friesian calves were the prevalent breeds of veal calves in 51% of the farms, followed by crossbreed (48%). Farms adopted small groups, varying between 3÷6 calves/pen. Considering the feeding plan, calves received commercial milk replacers, substituted by powder milk in finishing period. In addition calves were supplemented with soaked or micronized or whole maize up to 110-120 days until slaughtered (6-7 months). 70% of farms interviewed employed whole maize, 18% soaked maize, 12% micronized maize and 47%provided also fibre feeds. Veal calves were quickly loaded (37 min) through rather difficult paths with different slope. However loading animals from different pens and mixed them was very common. This could produce social disturbances that lead to biological costs for the animals and potential negative implications for productivity [9]. Distance of transport was 85 km average, but on different flow roads with speed of transport between 50 and 97 km/h. Calves waited before being slaughtered 3 hours and the temperature at the slaughterhouse, detected during the summer, was under 25°C. The age and weight of veal calves, respectively between 7 and 10 months and 125-211 kg, showed high variability and this fact affected the carcass quality. The frequency of abomasal lesions per farm was very widespread (between 69% and 100%, average 84.9%) and respiratory diseases showed a very variable rate, ranging between 0 and 54%. of animals per farm. Carcass pH at 1 hour *post mortem* was regular in 90% of animals/farm ($6.0 \geq pH_1 \leq 6.8$). One farm had 33.3% of animals with pH_1 greater than 6.8.

Nutritionally, supplementation with maize provided low iron concentration, constant chemical composition and high nutritive and stimulated growth performance [6]. The different type of maize supplementation was not significant (Table 2) except for a higher frequency of carcass pH_1 above 6.8. The frequency of abomasal lesions was always high in all the three groups. Farmers supplemented animals with whole maize and fibre to reduce the problem, but they occurred most frequently with very high frequencies, according to the

literature [2]. The causes of abomasal lesions are still unclear, but different factors are believed to be associated with the pathogenesis of abomasal ulceration. Predisposing factors include environmental and physical stress, mineral deficiencies, lowering of the abomasal pH and dietary factor including overfeeding [13]. In particular, abomasal ulcers are suggested to be associated with the overloading of the stomach with high volumes of milk replacer delivered in a small number of meals per day [5], as well as to the mechanical damage caused by roughage with high fibre content [14]. Bähler et al. [10] associates lesions with coarse solid feed. Our results indicate a trend, even if not statistically significant, in animals supplemented with whole maize to have higher percentage of abomasal lesions than animals supplemented with soaked and micronized maize. However other predisposing factors or stressors have also been reported as potential risk factors for the occurrence of this disease. Recent findings from Bähler et al. [10] suggested that the high prevalence of abomasal lesions might be associated with cleaning frequency or the ventilation model in the farm (manual *vs* mechanical).

Table 2 Maize type effects on health and carcass quality expressed as farm LSmean (N=17)

Parameters		Soaked	Whole	Micro-nized	MSE
Carcass weight	kg	199.3	165.5	178.0	852.86
pH_1		6.58	6.47	6.49	0.007
T_1	°C	36.3	35.6	36.7	4.490
pH_1 frequency< 6.0	%	0.0	3.4	2.8	12.14
pH_1 frequency> 6.8	%	23.8^{A}	4.5^{B}	11.1^{AB}	46.24
Abomasal diseases	%	75.0	87.3	68.8	93.32
Respiratory diseases	%	0.0	14.6	25.0	375.10

A, B P<0.01; a, b P<0.05

Farmer's practices related to calf-management are critical for calves' well being. Authors [15] hypothesized that the farmers' attitudes are strongly related to their practices. Regarding to the housing system a statistically significant correlation between high density of animals per pen and slow growth tendency was found (r=-0.56; P=0.024). In general lighter animals resulted more susceptible to stress as confirmed by carcass weight, pH_1 and T_1 correlation (Table 3). A significant correlation between respiratory diseases, carcass weight and loading corridor length was found. This last factor represents an indirect measure of barn dimensions (loading length=barn length/2). This relationship suggests that larger barns have more ventilation problems, that means a lowering in air turnover per hour, an increase in temperature difference between the inside and the outside of the barn, the rise of relative humidity and air temperature, factors related to stocking density, etc. Calf barns frequently become microenvironments of poor hygiene with high bacterial counts that could be associated with a higher prevalence of respiratory diseases. [16]. The other examined variables, such as transportation distance and speed of transport partially affect the pH_1 in agreement to Mach [11] and disagreement with Mounier [17]. These results suggest that psychological stress could be an important cause of economic loss for farmers.

IV. CONCLUSIONS

The results of the present study show that 10% of animals/farm have a carcass pH_1 out of normal range, with a possible and important economic loss especially

Table 3 Correlations among farm management, animal health and carcass quality parameters

Parameters	pH_1	T_1	pH_1 frequency < 6.0	pH_1 frequency > 6.8	Respiratory diseases	Abomasal diseases
N. of animals/pen	NS	-0.63**	NS	NS	0.48	NS
Loading length	NS	NS	NS	NS	0.70**	NS
Loading duration	-0.45	NS	0.47	-0.47	NS	NS
Transport speed	NS	-0.45	NS	NS	NS	NS
Carcass weight	0.53*	0.69**	NS	0.44	-0.62*	NS

** P<0.01; * P<0.05; P<0.10

regarding meat quality. pH_1 measurement allowed us to identify managerial problems at farm, during loading, transportation, unloading and slaughtering, even if we couldn't determine a relationship between these issues and short-term stress.

In intensive veal calves production respiratory and abomasal diseases resulted the most important indicators of animal poor welfare, due to the long-term stress. Our results suggest that abomasal diseases were not only related with the feeding plan but may also be associated with other stressors during the rearing cycle. In conclusion our study should encourage the development and application of on-farm solutions with the aim of improving calf welfare.

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