Improving beef sensory quality through breeding practices management

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IMPROVING BEEF SENSORY QUALITY THROUGH BREEDING PRACTICES MANAGEMENT

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Abstract – To identify the benefic effects of breeding practices, for the fattening period, on the *Longissimus Thoracis* sensory properties, a dataset obtained from 329 young bulls (2 breed types: beef and hardy) was analyzed. Animals were classified in 2 clusters: high and low sensory quality of beef meat. Different breeding practices combinations driven to high sensory quality were highlighted with decision trees, according to breed types. A higher beef quality is possible with a forage intake ≥ 1.95 kg DM/d in the fattening diet and a fattening period duration < 178 d for young beef breed bulls. The slaughter age of young bulls had a positive impact on beef quality of hardy breeds (≥ 17.2 mo) and beef breeds (between 15.4 and 16.8 mo) if it was combined with a longer fattening period duration and a higher average daily gain, for beef breeds and in addition with a heavier weight for hardy breeds.

Key Words – breed types, fattening period, young bull

I. INTRODUCTION

In France, bovine breeds were selected according to production system. Three breed types are identified: dairy, beef and hardy breeds. Besides the breed, the bovine production used diversified breeding practices (animal type, gender, age, diet, etc.) which influence the quality of beef meat [1]. Furthermore, the principal valuable quality trait for consumers is tenderness [2]. The aim of this study was to determine which breeding practices had a positive impact on the sensory quality of beef meat. This study was carried out during the fattening period of young bulls according two breed types (beef and hardy).

II. MATERIALS AND METHODS

Dataset

This study was realized on the individual data of 329 young bulls. For each young bull, breeding practices for the fattening period and *Longissimus Thoracis* (LT) sensory properties were available. The dataset was divided according to the breed types: beef breeds (BB) with Charolaise (n = 116), Limousine (n = 74) and Blonde d'Aquitaine (n = 25) breeds and hardy breeds (HB) with Salers (n = 93) and Aubrac (n = 21) breeds.

Animals were from 6 different National Institute for Agricultural Research (INRA) published projects [3-8]. In each project, the aim was to study the characteristics of beef meat according to breeding practices for the fattening period (diet, slaughter age, slaughter live weight, period duration). In this dataset, the breeding practices for the fattening period were characterized by 13 variables: slaughter age (mo), fattening period duration (d), live weight at the beginning of fattening period (kg), final live weight before transportation for slaughterhouse (kg), final live weight before slaughter (kg), forage and concentrate intakes (kg DM/d), total dry matter intake (DMI, kg DM/d), net energy intake (Mcal/d), percentage of forage and concentrate intakes (%), average daily gain for the fattening period (ADG, kg/d) and efficiency (ADG/DMI ratio, kg/kg DM). Breeding practices for each breed type were presented in Table 1.

All animals were slaughtered at the experimental slaughterhouse of INRA, Auvergne/Rhône-Alpes Research Center (France).

Sensory analysis

LT samples taken 24h *post-mortem* were maturated during 14 d at 4°C. The samples were grilled (55-60°C), tenderness, flavor and juiciness were scored between 0 and 10 by trained taste panels (Table 1) [6].

Statistical analysis

All statistical analyses were realized with R 3.1.1 [9]. Decision trees enabled to determine breeding practices combinations to obtain a higher beef

meat quality. For sensory data from the 329 young bulls, a cluster analysis with kmeans method, was performed with linear model residuals of sensory data (tenderness, juiciness and flavor). Working with residuals allowed to take off effects of evaluation variability between sensory panels. Residual sensory data were clustered into 2 classes. Student test were realized to compare significance and breeds, breed types and projects repartition between the 2 classes. Then, the 13 breeding practices variables, for each "Beef" and "Hardy" breed types, were used to establish decision trees with the package rpart [10] in R logical witch use CART method. To evaluate decision tree, a classification error was calculated.

Table 1 Dataset description

	Breed types	
	Beef (n = 215)	**Hardy** (n = 114)
	Mean ± sd	Mean ± sd
Breeding practices		
Slaughter age (mo)	16.6 ± 2,6	17.5 ± 2.7
Beginning live weight (kg)	400 ± 63	386 ± 35
Final live weight (kg)	668 ± 107	659 ± 128
Slaughter live weight (kg)	650 ± 103	645 ± 127
Fattening period duration (d)	166 ± 63	163 ± 25
Forage intake (kg DM/d)	4.3 ± 3.1	5.7 ± 1.6
Concentrate intake (kg DM/d)	4.5 ± 2.7	2.5 ± 1.1
Dry matter intake (kg DM/d)	8.9 ± 1.2	8.2 ± 0.9
% Forage (% of the DMI)	47.4 ± 32.6	68.5 ± 14.8
% Concentrate (% of the DMI)	52.6 ± 32.6	31.5 ± 14.8
Energy intake (Mcal/d)	14.1 ± 2.3	15.0 ± 3.3
Average daily gain (kg/d)	1.7 ± 0.8	1.8 ± 1.0
Efficiency (kg/kg DM)	0.2 ± 0.1	0.2 ± 0.1
LT sensory analysis (scale: 1-10)		
Tenderness	5.4 ± 1.2	5.7 ± 1.1
Juiciness	5.3 ± 1.0	5.3 ± 1.0
Flavor	5.1 ± 1.1	5.3 ± 0.9

sd: standard deviation, LT: *Longissimus Thoracis*,
n: number of animals

III. RESULTS AND DISCUSSION

Sensory data were classified in 2 clusters "high sensory quality" (HSQ) and "low sensory quality" (LSQ) of respectively 163 and 166 young bulls. The 2 clusters were significantly different ($p < 0.001$) for each sensory properties (Table 2). Each breed and project were represented in each cluster. The HSQ cluster contained 102 BB and 61 HB young bulls. The LSQ cluster contained 113 BB and 53 HB young bulls.

Table 2 Sensory clusters description on all animals

	Sensory quality	
	High (n = 163)	**Low** (n = 166)
	Mean ± sd	Mean ± sd
Sensory (scale: 1-10)		
Tenderness	6.1^{a} ± 1.0	4.9^{b} ± 0.9
Juiciness	5.7^{a} ± 1.0	4.9^{b} ± 0.8
Flavor	5.4^{a} ± 1.1	5.0^{b} ± 1.0

n: number of animals, a,b ($p < 0.001$)

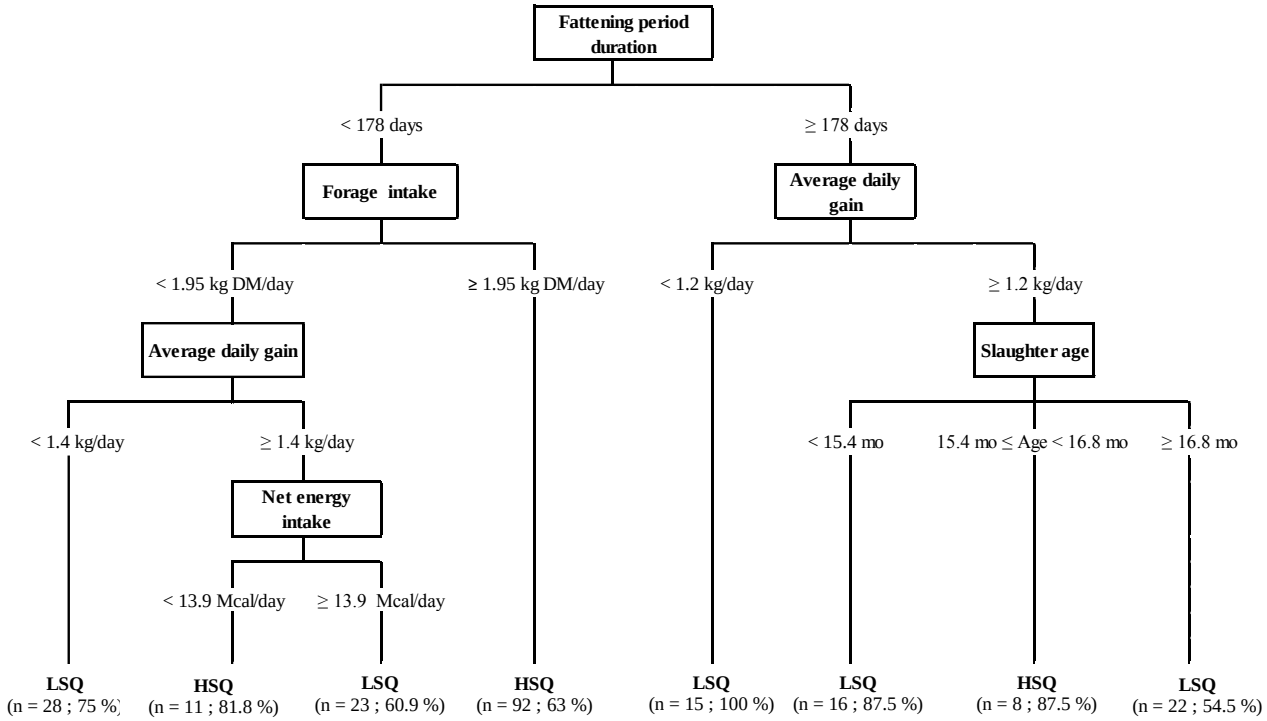
The decision tree, obtained on all BB young bulls (n = 215), retained 5 breeding practices variables: fattening period duration, forage quantities intake, ADG, slaughter age and net energy intake (Fig. 1) to allocate young bulls in 8 terminal sheets divided into 3 HSQ and 5 LSQ. The classification error of this tree was 30.2%. Three breeding practices combinations drive to a high sensory quality:

1: A fattening period duration < 178 d and a forage intake ≥ 1.95 kg DM/d.
2: A fattening period duration < 178 d, a forage intake < 1.95 kg DM/d, an ADG ≥ 1.4 kg/d and a net energy intake < 13.9 MCal/d.
3: A fattening period duration ≥ 178 d, an ADG ≥ 1.2 kg/d and slaughter between 15.4 and 16.8 mo.

When the fattening period duration was shorter, the forage intake had a positive impact on the beef meat quality.

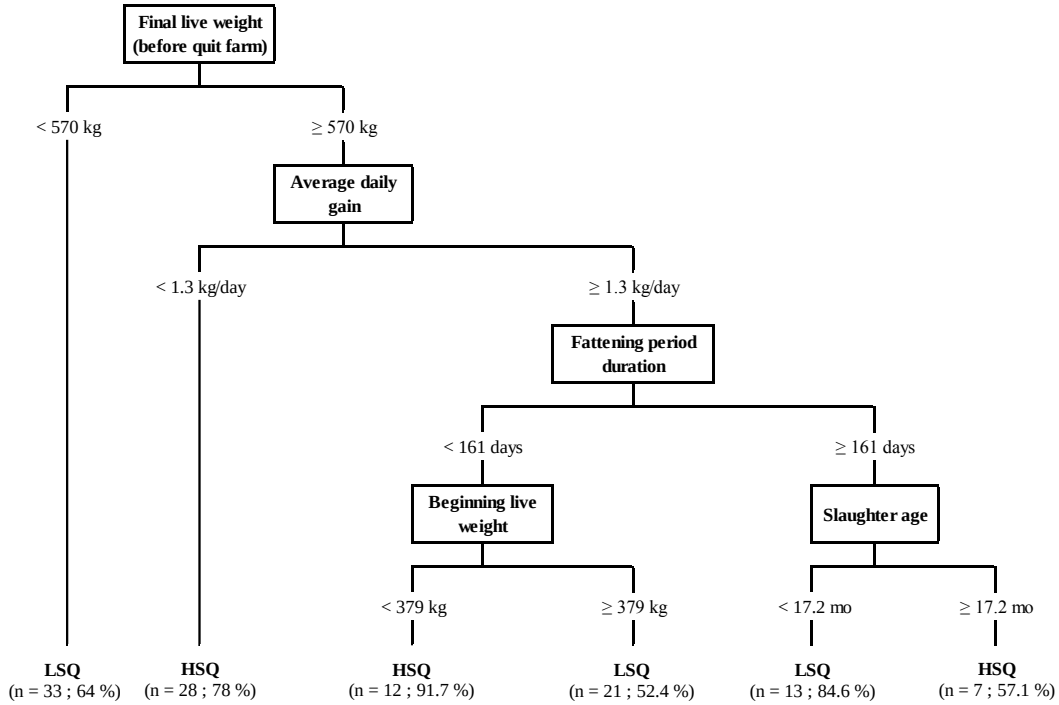
The decision tree obtained on all HB young bulls (n = 114), retained 5 breeding practices variables: final live weight before animal quit farm, ADG, fattening period duration, beginning live weight and slaughter age (Fig. 2) to allocate young bulls in 6 terminal sheets divided into 3 HSQ and 3 LSQ. The classification error of this tree was 42.5%.Three breeding practices combinations drive to a high sensory quality:

Figure 1. Decision tree for Beef Breeds



n: number of animal in the terminal sheet, %: animal percentage in the good cluster, **HSQ**: high sensory quality, **LSQ**: low sensory quality

Figure 2. Decision tree for Hardy Breeds



n: number of animal in the terminal sheet, %: animal percentage in the good cluster, **HSQ**: high sensory quality, **LSQ**: low sensory quality

1: A final live weight before transportation for slaughterhouse ≥ 570 kg and an ADG < 1.3 kg/d.
2: A final live weight before transportation for slaughterhouse ≥ 570 kg, ADG ≥ 1.3 kg/d, a fattening period duration < 161 d and a start live fattening weight < 379 kg.
3: A final live weight before transportation for slaughterhouse ≥ 570 kg, an ADG ≥ 1.3 kg/d, a fattening period duration ≥ 161 d and a slaughter age ≥ 17.2 mo.

Despite, relatively high classification errors of trees, the percentage of good animals classified in the terminal HSQ sheets was high.
Data highlight different breeding practices combinations to manage meat quality of young bulls. Some practices were common among these combinations for both breed types (fattening period duration, ADG, slaughter age) but with different levels of intervention within the decision trees. Other practices impact only one breed type (forage intake and net energy for BB, and live weights at the beginning and the end of the fattening period for HB). The implication of some dietary variables in the BB decision tree can be explained by more variability among the diets for the BB than the HB.
In the literature, few studies, concerning the breeding practices of young bulls, showed a link with the sensory properties of LT [1].

IV. CONCLUSION

The breeding practices combinations to manage the sensory quality of beef meat need to be adapted according to the breed types. The HB young bulls can be slaughtered older than the BB, if they had a final weight ≥ 570 kg, an ADG ≥ 1.3 kg/d and a fattening period ≥ 161 d. Further studies with numerous animals must be conducted to confirm the identified combinations.

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