Detection of Ketosis in dairy cattle by determining infrared milk ketone bodies amount

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Abstract

Ketosis is a disease caused by negative energy balance. This disease affects more than 50% of dairy farms (Fourichon et al, 2010) and causes economic losses. The current method of detection of ketosis, based on the milk fat/protein ratio, is limited: sensitivity of 58 % and specificity of 69 % (Duffield, 2003). FCEL has developed a model for detecting ketosis in dairy cows from milk composition and zootechnical criteria. The model was built from 184 individual milk samples from 70 dairy herds. The milk components were measured by chemical reference method (Scalar method) (De Ross, 2007) and by infrared method in order to determine the cows' status (healthy or suffering from ketosis). The model was then validated by a first dataset of 2,500 cows (within 100 days of lactation) and by a 2nd dataset including 60 selected dairy cows with the status of suffering from ketosis (according to the model). Blood analysis were performed on the 60th dairy cows in order to compare the statutes predicted by the model with blood tests (Enjalbert et al, 2001). This indicator (CetoDetect®) can detect animals (within 120 days of lactation) healthy and suffering from ketosis with a sensibility of 91 % and a specificity of 88 %.

Keywords: ketosis, detection, ketone bodies, infrared

Introduction

Ketosis is a disease caused by a negative energy balance affecting 50 % of dairy farms (Fourichon et al, 2000). Clinical and subclinical ketosis affect respectively 5 and 15 % of dairy cows (De Ross et al, 2007) with prevalence for the 2 first months of lactation. Ketosis economic losses are substantial for the farmer: 1) ketosis induces a decrease in milk yield (MY): about 300 – 450 kg of milk per lactation (Duffield, 2003), 2) a decrease of fertility performance and 3) an increase in inter-current diseases (Leblanc, 2010). The current method of detection of ketosis is based on the fat/protein ratio of milk. This method has limits: a sensitivity of 58 % and a specificity of 69 % (Duffield, 2003).
The aim of this paper is to propose a model of detection of ketosis in dairy cows using milk components and zootechnical criteria. This model is based on infrared milk analysis, easy to perform in routine, rapid and economical (De Ross et al, 2007).

Material and methods

Calibration data from 70 French commercial dairy farms are used on this study, representing 184 individual milking samples (50% of milk from the evening milking - 50% of milk from the morning milking). Dairy cows have a mean stage of lactation of 2.9, including

20 % of first lactation (primiparous). Milk analysis (fat, protein and ketone bodies) were realized with infrared method and compared to the Scalar chemistry method reference (De Ross, 2007). PCA (Principal Component Analysis) and hierarchical decision tree (software R.2.11.11) were used to determine thresholds of the discriminant variable values between healthy cows and cows with ketosis (thresholds of subclinical ketosis in milk (Scalar method): Beta Hydroxy Butyrate (BHB)>0.1 mmol/L and Acetone (Ac)>0.15 mmol/L) (De Ross, 2007). Model of detection of ketosis was validated with the analysis of a first data set of 2,500 dairy cows with the number in days in milk lower than 100 days and a second data set including 60 selected dairy cows (selected according to the model as cows with ketosis). Blood samples (BHB, glucose content (Optium XCeed), liver enzymes as aspartate aminotransferase (AST), gamma glutamyl transferase (gGT) (Vet Test, Idexx)) were realized on these 60 selected dairy cows.

Results and discussion

Ketone bodies infrared and chemistry methods are correlated ($R^2 = 0.53$) but need to be strengthened. Infrared milk analysis is also used and completed with individual zootechnical criteria. The model allows to identify healthy cows and cows with ketosis within 100 days of lactation, with a sensitivity of 91 % and a specificity of 88 %. The study of binary status of animals was then extended to six classes describing the healthiest states (class 0), doubtful or subclinical (classes 1 and 2) and clinical (classes 3, 4 and 5) states.

On the first validation data set, comprising 2,500 dairy cows within 100 days of lactation, the predicting status of the animal is: 84 % of healthy cows, 13.7 % of doubtful cows and 2.8 % of cows with clinical ketosis. These distributions are those found in the bibliography (De Ross et al, 2007). The comparison of statutes predicted by the model with the results of blood analysis (Enjalbert et al, 2001) on the 60 dairy cows indicate a decrease in blood glucose and an increase in the concentration of blood BHB with the prediction of ketosis (Cf. Figure 1).

Levels of liver enzymes AST and gGT also increase with the severity of the predicted status of ketosis.

For 2 years, this criterion called CetoDetect® is available for farmers. An overview of this indicator is conducted over the period November 2012 to February 2013. The data set is composed of 142,762 dairy cows (115,960 Prim'Holstein cows; 39,532 Normande cows and 7,250 Montbeliarde cows). Last winter (winter 2012-2013) the prevalence of ketosis, according to the CetoDetect® criterion was 27 % (classes 1 to 5) with 27 % of Prim'Holstein cows, 21 % of Normande cows and 19 % of Monbeliarde cows (Cf. Table 1). This high level of cows with ketosis is due to a lower quality of corn silage. During winter 2014 (January 2014 – March 2014) the prevalence of ketosis is 16.1 %.

Table 1. Study population from November 2012 to February 2013 – 162,742 data – 3 breeds: PH (Prim'Holstein) (115,960 data), NO (Normande) (39,532 data), MO (Montbeliarde) (7,250 data)

CetoDetect classes®	0	1	2	3	4	5
Number PH (%)	72%	16%	6%	3%	1%	1%
Number NO (%)	79%	14%	4%	2%	1%	0,3%
Number MO (%)	80%	13%	4%	1%	0,5%	0,3%
Total animals (%)	**74%**	**16%**	**6%**	**3%**	**1%**	**1%**

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The study of PH cows (lactation number 1 to 5) indicated that milk yield production is impacted by ketosis with a loss of milk production up to 6kg between healthy PH cows and PH cows in the class 5 of CetoDetect (Cf. Table 2).

Table 2: Average milk yield of PH cows according to classes of ketosis and parity

	CetoDetect®					
Average milk yield (kg)	0	1	2	3	4	5
1st lactation	27.5	26.2	25.5	25.1	23.5	21.9
dairy accumulated losses		*-1.3*	*-2*	*-2.4*	*-4*	*-5.6*
2nde lactation	33.5	32.8	32.6	32.2	30.4	27.4
dairy accumulated losses		*-0.7*	*-0.9*	*-1.4*	*-3.1*	*-6.1*
3rd lactation	35.4	34.9	34.6	34.3	33.4	29.4
dairy accumulated losses		*-0.6*	*-0.8*	*-1.1*	*-2.1*	*-6.1*

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The link between the severity of ketosis and increased cell counts is very marked (Cf. Figure 3). This relationship needs to be studied in order to identify the causal element.

The impact of ketosis on the fertility was also studied in a population of cows calved between 1st November 2012 and 1st March 2013. This population is composed of 14,587 PH cows, 5,925 NO cows and 850 MO cows. The CetoDetect® class assigned to each cow is the maximum score during the first 3 milk record. The mean interval between calving and 1st AI between healthy cows and cows in class 5 of CetoDetect® is 17 days for PH cows and 14 days for NO cows. For MO, the number of cows in note 5 is too low to calculate, but the interval average difference between 0 and 4 score is 23 days (Cf. Figure 4).
These results confirm the strong impact of ketosis on the fertility of dairy cows. A 2nd study will be conducted to study the impact of ketosis on the number of AI, on the calving feconding insemination interval, on the inter-calving interval and on the culling rate.

Conclusion

This model of detection of ketosis in livestock is built from the determination of ketone bodies (infrared method) completed with zootechnical criteria. It can be applied routinely at the herd level from milk samples collected during milk record.

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